Environmental Discourses in Science Education

Michael P. Mueller
Deborah J. Tippins *Editors*

EcoJustice, Citizen Science and Youth Activism

Situated Tensions for Science Education

Springer

Environmental Discourses in Science Education

Volume 1

More information about this series at http://www.springer.com/series/11800

Michael P. Mueller • Deborah J. Tippins
Editors

EcoJustice, Citizen Science and Youth Activism

Situated Tensions for Science Education

Springer

Editors
Michael P. Mueller
College of Education
University of Alaska Anchorage
Anchorage, AK, USA

Deborah J. Tippins
Mathematics and Science Education
University of Georgia
Athens, GA, USA

ISSN 2352-7307 ISSN 2352-7315 (electronic)
ISBN 978-3-319-11607-5 ISBN 978-3-319-11608-2 (eBook)
DOI 10.1007/978-3-319-11608-2
Springer Cham Heidelberg New York Dordrecht London

Library of Congress Control Number: 2014957129

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Endorsements

Mueller and Tippins have edited a timely book and the first one of the new Springer Book Series *Environmental Discourses in Science Education* addressing the urgent need to *bridge* environmental education and science education. This collection pulls together a diversity of reflections and experiences in a brilliant attempt to establish synchrony between ecojustice philosophy, youth activism, and citizen science: three areas that have become an important locus for critical science education at present. I believe this book can strongly contribute to the never ending debate on scientific literacy by providing new views and experiences highlighting alternative ways of doing science education.

Mariona Espinet, Science and Mathematics Education Department, Universitat Autònoma de Barcelona, Catalonia, Spain

The authors of this book are all pioneers in meaningful educational transformation. The stories they tell, and the forms these stories take, are incredibly diverse and inspiring—ranging from the pedagogies of farming in Appalachia and New England, to the politics of systems thinking in Texas just north of the Mexican border, to climate change pedagogies in Native communities. As the authors point out, each of these local stories of change has global significance. What holds it all together is an ethic of ecojustice. Here the authors skillfully demonstrate the necessity and power of bridging social and ecological vision in a wide variety of educational contexts in need of change.

David A. Greenwood, Lakehead University, Thunder Bay, ON, Canada

Ecojustice, Citizen, and Youth Activism: Situated Tensions for Science Education, the first book in the series *Environmental Discourses in Science Education*, speaks to all types of educators—teachers, students, parents, and citizens. It is a call for the restoration of curiosity, diversity, and value systems that embrace person, social, and civic responsibility for the Earth, including both human and non-human species. This collection of inspirational essays, personal narratives, and empirical research provides rich examples of how interdisciplinary and intergenerational groups engage simultaneously in meaningful learning and advocacy through projects that are situated in a range of cultures and contexts. This book undoubtedly will inspire and inform conversations about a future for science education that awakens our individual and collective critical understanding of and engagement in local, national, and global ecojustice issues.

Lynn A. Bryan, Professor of Science Education, Purdue University, West Lafayette, IN, USA

At last, science educators are breaking down the rigid walls of their discipline and embracing the world at large, developing socially responsible science curricula and pedagogies for the twenty-first century. Driven by a moral commitment to sustaining the cultural and environmental heritage of the planet, eco-conscious science educators worldwide are empowering young people to become environmental activists and stewards. The visionary contributors to this timely book present a broad range of ecojustice inspired science programs for schools, universities, and local communities. This book is a rich resource for science educators preparing future citizens with higher-level abilities for participating in the global agenda of sustainable development.

Peter Charles Taylor, Professor of STEAM Education, Murdoch University, Australia

Preface

Introducing the Book Series

Welcome to the first book for the Springer book series, Environmental Discourses in Science Education! We (Mike Mueller and Deborah Tippins) are excited about the conversations that will continue to draw together the fields of environmental education and science education. While many people already acknowledge the relationship between these two fields, these fields have continued to flourish largely independent of one another. Perhaps there was a hubris in the field of science education by positivistic scholars during the twentieth century and before modern times, but this arrogance has given way to the importance of environmental education as integral to the future of children everywhere. Perhaps environmental education was largely seen as a way of engaging children outside of schools when school science tended to emphasize classrooms. But this has given way to the ecological and environmental sciences as an important part of the curriculum of schools around the world, not to mention some related fields of experiential education, adventure education, and outdoor or place-based education involving learning outside of the typical classroom. Perhaps environmental education has focused more attention on the life span of children through adult life and peoples' relationships with nature, whereas science education has emphasized teaching children about the "scientific method", what professional scientists do, how to emulate scientific work, and, most importantly but often lost, how to use science to make informed choices. Science education has largely been devoid of teaching children to respect nature insomuch as they are taught to organize, categorize, and manage it. In contrast, ethnoscience and the traditional ecological knowledge of many Aboriginal and indigenous peoples that deemphasizes classifying and managing organisms is also relevant to science education. When acknowledged more fully, the key distinctions between discourses of environmental education and science education are beginning to wane. Although there are dissident traditions in both of these educational fields, the underlying philosophies for environmental and science education are more congruent than divergent. For example, consider the hegemony that largely follows western and largely positivistic science in school science. In many places around the world, this hegemony has been mediated with the advent of highly contextualized science education for solving local issues. In Accra, Ghana, for example, science education is more aligned with environmental education in that students are learning science to wrestle with ecological problems in the local context, but this was only after Ghanaian science educators began to take back a largely British-influenced method of teaching science (Mueller and Bentley 2009). In Malawi and Thailand, we also see examples of science education taught in ways that are largely contextualized by local issues (Glasson 2014). Today science curriculum worldwide seems to be moving towards these trends.

At the same time, let's acknowledge the difficulties inherent in bridging the two rivers of environmental education and science education until these two rivers begin to meet in confluence. There are associated tensions anytime two major fields of study begin to come together. For a long time, for example, schools of education with teacher certification programs have housed the majority of science education programs at the university, whereas environmental education may or may not be located within colleges of education. Often these environmental programs are located in schools or colleges in the sciences, conservation, tourism, or natural resources. The majority of science education happens in K-12 schools, whereas there is a smaller part acknowledged as "informal science education" that embodies museum, library, institution, aquarium, and so forth. Although we prefer the term "free-choice learning" or just "science education", the field of science-education-that-happens-in-the-larger-educational-milieu has been largely deemphasized or ignored until more recently (40 years). With the exception of Rousseau, most of the educational philosophers largely deemphasized or ignored the importance of nature in education. It took movers and shakers such as Emerson, Thoreau, and even Darwin to really foster the conversation with other more contemporary scholars such as Muir, McClintock, Leopold, and Carson. The emergence of the environmental movement in education and science education, more specifically, has taken the legacy of time and "pushing against the grain."

This era is here now and largely embraced and embodied by a critical mass of folks in environmental education and science education. We may see the confluence of schools and colleges at the university with many countries' focus on creating environmental literacy standards and norms. Not that this is the best direction for environmental literacy, but it is happening. For example, in the state of Alaska, USA, there is a new set of environmental literacy standards and a policy document, but very few schools and policymakers have done much with these standards. They may not even know what to do with these standards and how environmental literacy ought to be integrated in programs in and out of schools. This is where the compelling conversations of teachers, graduate students, and scholars across the globe will affect change in a major way through both local and international policy, theory, research, and practice. But it will also require a broader more encompassing view of education.

There are plenty of tensions that can be found in the everyday lives of children and their teachers in schools, local neighborhoods, and global corporations as they face the challenging issues situated within nature. As Derek Hodson notes,

> We need to revitalize education in the home, in the workplace, and in community centers and through advertising and public notices. We need to mobilize effective education through leisure activities; through the print and broadcast media, the Internet, and social networking media; through movies, theater, literature, music and dance; and through examples set by prominent members of the community. Unprecedented levels of cooperation, support and collaboration will be necessary among national and local governments, environmental groups, formal and informal educational institutions, the business and industrial sector, trade unions, cultural and community organizations, youth groups, voluntary organizations, schools and families. Through all these outlets, we need to focus very directly on how we live and how we should live in the future if we really want to establish and maintain a more equitable and socially just society and an environmentally sustainable lifestyle (2014, p. viii).

This is where conversations that begin to sand the rough corners of the "adjectival educations" and the proliferation of educational subfields that potentially work against the interdisciplinary and cross-hybrid learning goals of bridging environmental and science education really matter.

We want to encourage environmental discourses in science education from a broad range of international perspectives and holistic contributions to the advancement of this project, from fields such as science education, environmental education, outdoor education, experiential education, place-based education, community-centered education, culturally-responsive education, democratic education, sustainability education, health education, Aboriginal and indigenous education, critical pedagogy, social justice education, ecopedagogy, ecojustice education, humane education, imaginative education, social learning, problem-based learning, and so forth. There exists internal relationships within any given discourse (i.e., discourse of sustainability) but any discourse always exists in relation to others (i.e., discourse of globalization). Thus, we envision conversations where ideas and thoughts are exchanged among discourses that may reflect unique forms of representation, habits of language, or culturally and historically located meanings. This book series recognizes the grand challenges of wrestling with the situated tensions between cultural and natural systems and the ways that age-old perspectives in environmental and science education will change as the result of reexamining topics that have long been relevant to these fields become reexamined discourses. David Abram (2010) notes: "whenever the wild diversity of experience is twisted into a simple opposition between what's good and what's bad, whenever the heterogeneous multiplicity of life is polarized into a battle between a pure Good and pure Evil, then the Earth itself is bound to suffer at our hands" (p. 304). Thus, we must never forget to include a full diversity of voices for Earth.

We envision books for this series that uphold traditions while also challenging dualisms that were originally created to articulate particular environmental worldviews. We invite authors to contribute counter narratives which challenge the ideology of unrestrained instrumentalism where humans dominate over nature, growth is equated with progress and resources are judged in terms of their value to humans. Consistent with an ecojustice philosophy, we seek empirical research and narratives which highlight the interdependence of humans and nature, the rights of all entities, including both human and non-human species, and recognize the inherent value of diversity, complexity, integrity, and uncertainty. An ecojustice philosophy serves to deescalate the crisis narratives of gloom and doom apparently motivating individuals into action, and calls for a more holistic approach to teaching science that depends on the health of the individual, community and the environment; we see the heightened sense of awareness around the confluence of these global discourses.

In a recent book on the future of science education in the USA, the authors and contributors to *Assessing Schools for Generation R (Responsibility): A Guide for Legislation and School Policy in Science Education* argue for a more holistic metric for considering and measuring the effectiveness of schools and education more generally (Mueller et al. 2014). In this book, there are chapters on critical media literacy, assessing interdependent responsibility of youth, character development, socioscientific issues and reasoning, community service and engagement, environmental schools, elementary environmental education and nature clubs, teaching Earth smarts, digital technologies, partnerships with government agencies focused on the environment, game camps, geospatial technologies, cultural studies, environmental studies, climate change, free-choice learning, global relationships, environmental monitoring programs, education policy, the national standards, special needs students, and holistic science education. These topics and more will generate the conversations necessary to take science and environmental education to the next generation of students. Hopefully, the next generation of youth will barely notice the difference!

Citizen science, youth activism, and responsibility, to name a few, can become important and significant ways of reconceputalizing the ways that schools are organized, and the ideological roots of multi-layered phenomena such as curriculum and policy. There is now the need to recognize the tensions that exist between humans and nonhumans, but almost as important, the physical environments within the Earth, space, solar system, and the cosmos. We need to begin shifting to a cosmos mindset where our actions here on Earth are seen as relevant to consequences elsewhere in the solar system and beyond. Perhaps this sounds crazy but what we are emphasizing for this book series is the absurd, the illogical, the unconventional in addition to traditional stories, morals and ethics embedded in school science and the larger ecosystems. Conversations and new perspectives on the significance of ecojustice, defensible environmentalism within environmental and science education, and free-choice learning are just a few of the really great topics that we hope will generate nuanced understandings, and inspire action, relationship-building, hope, outrage, and transformation. Potential topics orbit the way people engage in activities in schools and communities throughout their lifetime, including the ways in which these activities bring about balance in our lives, bodies, and minds. Other contributions to the series might analyze heightened cultural attunement, geographic awareness and humility, space and place, and environmental messaging. Dancing, yoga, kayaking, photography, gardening, karate, fishing, mountain climbing, surfing, cooking, music, and other cultural arts may play a part in this project of ecological discourse. Authors might consider how the cosmos surrounding this planet Earth, the depths of the ocean, and things on the scale of the Nano are relevant to this ecological discourse. We anticipate that the mediation of science education and environmental education is just as important to this conversation as much as nurturance. We look forward to books that ask questions and generate new meanings and provoke inquiry, research methodologies, and ecological pedagogy of relevance to educators worldwide.

Anchorage, AK, USA Michael P. Mueller
Athens, GA, USA Deborah J. Tippins

References

Abram, D. (2010). *Becoming animal.* New York: Vintage Books.

Glasson, G. E. (2014). Is there an app for that? Connecting local knowledge to scientific literacy. In M. Mueller, D. Tippins, & A. Stewart (Eds.), *Assessing schools for generation R (responsibility): A guide for legislation and school policy in science education* (pp. 215–225). Dordrecht: Springer.

Hodson, D. (2014). Foreword. In M. Mueller, D. Tippins & A. Stewart (Eds.), *Assessing schools for generation R (responsibility): A guide for legislation and school policy in science education* (pp. vii–xiii). Dordrecht: Springer.

Mueller, M. P., & Bentley, M. L. (2009). Environmental and science education in "developing nations": A Ghanaian approach to renewing and revitalizing the local community and ecosystems. *Journal of Environmental Education, 40*(4), 53–64.

Mueller, M. P., Tippins, D. J., & Stewart, A. J. (2014). *Assessing schools for generation R (responsibility): A guide for legislation and school policy in science education.* Dordrecht: Springer.

Contents

Chapter 1
A Life in Relation to the Broader Stroke of Education

Princess Lucaj, Michael P. Mueller, and Deborah J. Tippins

Beginning a worldwide conversation with this first book in the new series on Environmental Discourses in Science Education is paramount for the encroaching cultural, community and environmental turbulence. This turbulence has been described by the growing needs of populations of people worldwide who depend on fewer agricultural and natural resources and the mounting environmental challenges of climate change. Facing science education in and for turbulent times, Ken Tobin (2014) writes: "The wellbeing of citizens is at stake because of events like these occurring globally, almost every day. Science affords us hearing about and learning from such events, and inevitably knowledge of science and technology are needed to understand what is happening and for others to solve the problems" (p. 293). He goes on to say that science is a "power discourse" that emphasizes disciplinary science within school settings. According to Tobin, "It is important that science educators expand the goals of science education to include science in everyday life and afford opportunities for continuous science learning including the years after compulsory schooling" (p. 298). Indeed many people never go to school and yet possess the traditional knowledge of local places that comes from living in a community that has breathed education for thousands of years. Most people, even formally educated individuals, do not recognize when they are using the science generally learned in the schools and colleges. It is not a knee-jerk reaction to think "huh, I just used science in my life". But for many

P. Lucaj (✉) • M.P. Mueller
College of Education, University of Alaska Anchorage,
3211 Providence Drive, Anchorage, AK 99508, USA
e-mail: princesslucaj@gmail.com; ak.mikem@gmail.com

D.J. Tippins
Mathematics and Science Education, University of Georgia,
Aderhold Hall 212, Athens, GA 30622, USA
e-mail: debtippins@hotmail.com

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_1

Aboriginal, indigenous, and other peoples worldwide who use traditional knowledge and skills, cultural language and ceremonies, and rely on the place-centered narratives, what might be described as science is a way of life and cannot be separated from the natural world.

Cognizant of the ways the traditional teaching of science separates the cultural world from the natural, Clayton Pierce (2013) writes, "one of modern science's distinguishing features is its epistemological allegiance to matters of the natural world and claims of purity from the sociocultural," and he continues, "the work of modern science, in other words, has been understood since modernity as taking place in objective and knowable universe out there as opposed to the messy human world that is cluttered with things like values, morality, and, above all else, politics" (p. 113). In the larger world of education outside of schools, where people espouse knowledge and skills in relation to robust Earth, modern science and science teaching is less likely to matter after school. This is not to say that people do not use what they learn in school in their everyday lives, it is only to say that the science curriculum in the schools does not nearly encompass the ways that science is lived in communities where people were the original experts in knowledge of their ecosystems. In contrast, if the power discourse of "scientific literacy" is exclusive to the ways that people use modern science in their communities, in the schools, and in sophisticated laboratories – to name a few, then as Pierce (2013) argues, "scientific literacy needs to be radically rethought in an age where the genes of an Ocean Pout (an eel fish) are spliced with those of a Chinook (king) salmon, implanted in Atlantic salmon eggs, and a corporation patents this process *and* the new species of the fish itself, all while leaving the public's only recourse to understanding such a network of exchanges and relations to the mercy of research done by the leading corporate stakeholder in the aquafarming industry" (pp. 113–114). This understanding is particularly relevant in an age where science is needed beyond compulsory schooling and when youth are at their lowest levels of civic engagement and community activism since the Civil Rights era. Youth face many tensions that their parents and teachers did not face, and dissolving the situated tensions between humans and natural habitats is the meaningful purpose of advancing a conversation around ecojustice, citizen science and youth activism.

This chapter features the Alaska Native actress, activist and educator Princess Lucaj's (first author this chapter) mythopoetic narrative of the situated tensions associated with human and nonhuman systems in her Neets'aii Gwich'in community. The way of life she describes and challenges facing her community have far reaching influences globally. Her message is that beyond the challenges associated with situated tensions, *we must make an effort* for the welfare of people and the Earth. Her story provides a metaphor and methodology for exploring science and life in relation to the broader stroke of education painted worldwide. Finally, we will weave Princess' ecojustice work with others in the book. The following section is written by Princess Lucaj.

Gwik'ee Gwiriheendaii Gwizhrii Go'aii

We Must Make an Effort

A luminous full moon appears to follow us as we cruise along La Brea Boulevard in Los Angeles. We are passing the Inglewood oil fields like we have so many times before. Pumpjacks scatter the land and I am hypnotized by their slow up and down rhythm. In my 5-year-old mind, I have determined that the oil wells are large mechanical grasshoppers – they are from a different time. They look like dinosaurs and while I see they are stationary there is something dreadful about them all at once.

It dawns on me I don't know what they are doing, these big metal grasshoppers, so I ask my mother who sits in front of me in the passenger seat. She pauses and looks at the fields with me and then responds with this story:

> Long ago Mother Earth buried these toxins deep inside of her so that they wouldn't harm the beings and all the plants that live on the surface, on the land, like we do.
>
> Those oil wells are pulling it back up.

This short explanation would forever color the way I looked at humanity's relationship to Mother Earth and instilled in me a firm understanding that plants, animals, and people needed to be protected from pollution. I had no idea at that time, in a place far away from my real home, the home of my ancestors in Alaska, how large a role the oil industry and our addiction to fossil fuels would play in my life.

Not long after this, my mother would make the decision to move us kids up to Alaska so we could be raised with our Neets'aii Gwich'in culture. That is a decision that I will be eternally grateful for as it allowed my siblings and I to have a far greater connection to the land, animals, and our people than we would have ever experienced in California.

In Alaska, my life was a belly full of translucent orange King Salmon eggs fresh from the Yukon River. It was picking sweet blueberries in the fall and doing beadwork in the winter, and helping my grandmother tan *vadzaih* (caribou) hide. It was also hiding in my room to stay away from all the drinking, being made fun of in school, and trying to adjust to transitions back and forth between rural and urban Alaska.

As my generation continues to deal with the negative ramifications of the Assimilationist policies of the United States, decolonization and healing is an ongoing process. In Alaska, it is an ever-increasing threat to the subsistence lifestyle and self-determination of our communities. We are forced to ask ourselves what is the true value of money and what of our natural resources will we extract and exploit for short-term gain?

Today I serve my community as the Executive Director of the Gwich'in Steering Committee. We are a non-profit advocacy organization formed at the direction of our Chiefs and Elders in 1988 to protect the birthing and calving grounds of the Porcupine Caribou Herd, which sustains the Gwich'in way of life. The birthing grounds are located on the Coastal Plain of the Arctic National Wildlife Refuge – the last remaining 5 % of the entire North Slope of Alaska not open to oil and gas development. For over 30 years this area has been under the threat of development. The Gwich'in Nation of Northeastern Alaska and Northwestern Canada has been working to this day for the permanent protection of these lands through a Wilderness designation of the Coastal Plain. While many have seen this movement as solely an environmental issue, at its core, this concern is inseparable from issues of human rights.

Around the world, people ask: Do any group of people have a right to their own means of subsistence? That is namely, basic, local sources of food, and food security. According to the UN International Covenant on Civil and Political Rights these rights are protected. Despite that, we continue to witness the immoral and illegal destruction of land, animals, marine life, air, water and the genocide of Aboriginal and indigenous groups as extreme extractive resource development occurs worldwide.

I grew up situated with these tensions. I observed my mother and other community members speak up for our way of life here in Alaska, in Washington DC, and all around the world. As a mother, my greatest desire is for my children to be able to appreciate and experience the land of our Ancestors – to hike up *Kiiviteiinlii* and camp at *Dachanlee* as they hunt for caribou. I hope they grow up healthy being able to understand that we are all a part of the land and entirely dependent upon it for our survival. Still, it saddens me to know that they will never see the King Salmon run up the Yukon River like salmon once did – never as big, never as abundant. It saddens me that I must travel a great distance away from my family to our nation's capitol to advocate for these seemingly simple human rights. And yet, it is my duty and honor to speak up for the caribou, the land, and all the living beings that do not have a voice.

All of this occurs during a time of severe changes in weather; changes that our Elders warned us about many, many years ago. Here in Alaska, entire coastal communities and villages are eroding away. We are experiencing flooding, changes in vegetation and wildlife migrations. The villages of Newtok, Kipnuk, Kivalina, and Shishmaref are just a few communities that must deal with the painful and incredibly costly reality of relocation. A college freshman from Kipnuk, *Nelson Kanuk*, has even brought suit against the State of Alaska to take more effective action to mitigate the effects of climate change and the court's ruling is pending. Our young people, frustrated by inaction and a largely unjust system are taking bolder measures to question and demand accountability of leaders.

In Alaska much of the economic budget comes from oil revenue. The oil is also the source of a conundrum we find ourselves in, particularly within the Arctic. We ask: As our land and ice erodes, do we continue to contribute to the very root of the problem by supplying the fossil fuels that are so destructive to our planet and atmosphere? Do we squander every square inch of our State till the wells are dry, our waters contaminated, and our wildlife endangered? We have so much to consider.

Across all sectors of education, government, industry, and agriculture, we must work and influence the transformation of these systems. There are solutions. But we must take the time necessary to think about our choices and go out on the land and listen. At our dinner tables, let us speak of where our food comes from that we eat, the water that we drink, and let us make lively debate and dialogue. Let us wake and find purpose in our words and let us see the challenges before us as an ultimate call to action. We must make an effort.

The crevice between social and ecojustice widens as our thirst for fossil fuels hammers further and deeper the wedge, which may end in our ultimate demise. Ecojustice, for me is the convergence point. It is the eddy in the river where we must face ourselves and each other, unveiled and willing to sacrifice our unsustainable culture of greed for a more conscientious and compassionate economy. We must have hope that this is possible and teach our children that the common good of all humanity is in a thriving, healthy, and vibrant Mother Earth.

Towards the Renewal of the Ecological in Science Education

Princess' story is a metaphor and methodology for engaging people of the Earth in a hearty dialogue encompassed by thought and action for health and ecological wellbeing. We must make an effort, says Princess. Ecojustice is a global phenomenon because there are stories of people wrestling with dilemmas that are similar to the Gwich'in Nation around Alaska and beyond, as Princess highlights. We have an ethical obligation to pay closer attention to these problems because they are intractably human and nonhuman rights issues. Only in an economy based on greed and human authority can we find human rights separated from the Earth. Therefore, Princess calls for a more conscientious and compassionate economy, or 'Earth democracy' as Vandana Shiva has articulated (2005). But what does a conscientious and compassionate economy look like and how will science education play a role in this redefinition of our world? These conversations are beginning to be advanced in science education, despite that the dialogue around ecojustice has ensued for a while now. As we can see from Princess' account, the situated tensions of people such as those who live in communities mitigating the effects of climate change are deeply rooted and characterized by animals and geography. These communities have basic needs and economic interests just like anywhere else. But they are not decontextualized, abstract or void of cultural narrative. Consequently, people of these places often do not see the relevance of traditional science (especially when it does not connect with the lived curriculum of places).

Ecojustice philosophy, citizen science and youth activism are three of the most interesting trends in light of these questions and situated tensions for science education today. Where ecojustice is used to evaluate the holistic connections between cultural and natural systems, environmentalism, sustainability and Earth-friendly marketing trends, citizen science and youth activism are two of the pedagogical ways that ecojustice can be enacted. Understanding the changing environment in the ways that people of the Gwich'in Nation do requires long dwelling narratives and traditional ecological knowledge acquired by monitoring what is happening and why is this happening. Environmental monitoring is one of the fastest growing trends in science education and many chapters in this book describe the nature of citizen science and problems associated with engaging youth with their teachers in ecological concern.

Princess also mentioned the youth activism beginning to quell from the effects of climate change in ocean-side villages in Alaska. Similar place-based narratives and forms of youth activism are emerging from stories of science education worldwide. Youth activism embodies ways that youth are more fully involved in decisions about things that will affect their communities. Combined with socioecological monitoring, youth have a powerful platform to advocate. When teachers, community members and students come together to evaluate science-related issues involving decisions that must be reached concerning justice and fairness, ecojustice philosophy can provide a lens.

Ecojustice has been used to expand science education for social justice agendas, science education for youth activism, and science education for the freedoms associated with protecting and conserving the prospects of future generations and their children without compromising the subsistence and economic viability of today's evolving communities. The chapters in this book are organized around themes of ecojustice, citizen science and youth activism to provide a deeper definition of what these terms embody for science education and education beyond science. Citizen science and youth activism provide excellent ways where ecojustice becomes a policy and practical part of the science curriculum both in schools and in the larger educational domain of Earth's ecologies. These ecologies are found on the micro and macro levels and not limited to neighborhoods, city parks, farms and so forth. This book comprises evidence-based practice with international service, community-embedded and embodied curriculum, teacher preparation, citizen monitoring and community activism, student-scientist partnerships, socioscientific issues, and new avenues and methodologies for research. We anticipate that this book will be used by teacher educators and teachers to garner new conversations and envision new pathways. Equally, we hope the chapters in this book promote new international collaborations around ecojustice, citizen science and youth activism. Researchers might use this book to envision new teaching, research and service agendas, if not to also imagine how their work cannot be separated from the Earth. These are the ways that a life exists in relation to the broader education. Together we must make an effort.

References

Pierce, C. (2013). *Education in the age of biocapitalism: Optimizing educational life for a flat world*. New York: Palgrave Macmillan.

Shiva, V. (2005). *Earth democracy: Justice, sustainability, and peace*. Cambridge: South End Press.

Tobin, K. (2014). Science education in and for turbulent times. In M. P. Mueller, D. J. Tippins, & A. J. Stewart (Eds.), *Assessing schools for generation R (responsibility) a guide for legislation and school policy in science education* (pp. 293–305). Dordrecht: Springer.

Princess Lucaj has worked on protecting the Coastal Plain of the Arctic National Wildlife Refuge since she was a teenager. She is the former Executive Director of the Gwich'in Steering Committee, is a graduate of the Elliot School of International Relations at the George Washington University and is currently pursing a masters in education with a focus on ecojustice at the University of Alaska Anchorage. She was raised by strong Gwich'in women and mentored from a young age to speak out on protecting the Gwich'in way of life. Lucaj is also a mother, published poet, writer, and a stage and film actor. Her most recent stage role was that of *Cordelia* in a Gwich'in language version of Shakespeare's *King Lear*. She is the recipient of the Sally A. Kabisch Spirit of the Wilderness Award and works with many groups in Alaska and across the nation who are working on education surrounding climate change, environmental justice, and engaging communities in the grassroots.

Michael P. Mueller is a professor of secondary education with expertise in environmental and science education in the College of Education at the University of Alaska Anchorage. His research includes ecojustice theory, citizen science, and youth activism. He works with teachers to understand the significance of cultural diversity, biodiversity, and nature's harmony in their pedagogy. He is the co-Editor-in-Chief of *Cultural Studies of Science Education.*

Deborah J. Tippins is a professor in the department of mathematics and science education at the University of Georgia where she specializes in science for K-8 learners. She draws on anthropological and sociocultural frameworks to study questions of social and ecojustice in science teaching and learning. Building on her experience as a Fulbright scholar in the Philippines, her current research focuses on citizen science, socio-scientific issues, culturally relevant pedagogy and sustainability education.

Part I
Ecojustice Section

Chapter 2
Together We Look for Answers

Eduardo Dopico Rodríguez

The initial pages that we call the Editorial of science outreach books, similar to this one, are not usually read. Knowing that they will find interesting and veracious information inside, readers go directly to check the Index and choose the topics that provoke their interest more. The concepts of *ecojustice*, *citizen science* and *youth activism* appear throughout chapters and give formal unity to this book. Probably, after the initial curiosity has been satisfied, readers may fancy to reading the book from the beginning. At that time their inquiring gaze may stumble with the Editorial. If it is not very long it may be read; that's why editorials are justified. We would be remiss if our book did not have it. Then the reader perceives and engages in the scientific scope that surrounds the book. S/he understands in time that our aim is to analyze critically the impact of human relations with the ecosystems. The ideas contained in the book and the specific subjects treated therein can be seen much better when approaching from the Editorial. Editorials serve for this. They heat the following chapters. They provoke reflection on the discussed matters and curiosity to investigate other related issues. Let's begin.

The results of a thousand surveys are published in the *Global Risks Report 2013* presented by the *World Economic Forum* (WEF) in Davos (Switzerland). Experts in the fields of the industry, science and civil society are asked about the 50 most important global risks to the global sustainability. In order of importance, large difference of incomes between social sectors is one of the most serious problems registered. It is followed by another big global risk: the lack of adaptation to the climate change. If we travel across the planet Earth asking different peoples and cultures about the environmental problems that they consider more pressing, we would obtain results related to groups of interest. We are the protagonists of our own movie and therefore

E. Dopico Rodríguez (✉)
Department of Education Sciences, University of Oviedo,
C/ Aniceto Sela s/n, Oviedo, Asturias 33006, Spain
e-mail: dopicoeduardo@uniovi.es

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_2

we report the reality from our unique and special perspective. The snow is very beautiful from the city windows but not so much if we live in a village in the mountains and are isolated. The environmental context determines the life experience. A native from the Amazon jungle has different environmental concerns than those perceived by a Tuareg in the Sahara. In the same way, the "green behavior" of a Norwegian does not have the same origin as the "green label" of some profit-seeking companies self-denominated "green". We see this with more clarity if we consider the issues associated with water and land. Climate change poses serious challenges for land and water management. It affects negatively those native communities whose bonds with the environment are simultaneously economic and cultural. At the same time, climate change improves the business perspectives of the companies in charge of managing water resources in zones of drought, as well as those of agricultural companies that monopolize vegetable crops for biofuels.

Let's go a bit further. At present the *fracking* technology, namely, the gas extraction from Schists or Slate by means of hydraulic horizontal fracturing of the rock, is being widely criticized by the common opinion in Europe. On the other hand, in the U.S., this technique allows for collecting up to 20 % of total gas demand in the country and generates direct employment and increasing corporate profits. However, cities like New York, Buffalo, and Pittsburg are beginning to rethink this type of exploitation. To extract the gas trapped in the rock, the ground is drilled vertically (from 400 to 5,000 m) up to the Slate layer. Several kilometers are drilled horizontally (from 1 to 3 km). Explosives are used straight away for inducing small fractures in the cap of Slate. Then thousands of tons of water at very high pressure are injected in consecutive stages through these fractures, mixed with sand and chemical additives (Benzene, Xylenes, Cyanide and other chemicals, most of them carcinogenic, mutagenic and teratogenic). Pressurized water fragments the rock releasing the gas, together with water, sand and additives that rise to the surface through the well. The gas company canalizes it and then sells it to us. Gas price is always fluctuating upwards for the consumer because the *fracking* does not cheapen the costs of natural gas extraction. Evidently, research studies now report a battery of problems associated with this type of hydraulic-based methodology: pollution of the surface and underground waters; air pollution; human health affections; and seismic risks – to name a few. Despite that, some European governments encourage the use of fracking for short-term profitability. Again, everything depends on the perception, on the interests at play. Not necessarily will these interests coincide with the criteria of sustainability of the planet. To develop the comprehension of the tensions between a devastating and ecologically unsustainable culture and the needs of the ecosystems of the Earth is the central focus of the ecojustice perspective that we will see in the following chapters of this book.

No reasonable person doubts seriously about climate change or on the impact that our actions have on it. Nevertheless it seems that we are not well prepared to adapt ourselves to this changing situation. The longer we delay in doing something the more time is wasted in lessening its effects. We need to reverse the consequences of anthropic activities on the ecosystem. A long time ago Darwin indicated that the animal and plant species had evolved over millions of years from relatively simple ancestral forms. He reminds us about the need to adapt to the environment for the survival of the species. The peculiar adaptation of the *Homo sapiens* is called *culture*. Culture includes all those ideas and tools that are acquired through learning, as well as the systems of knowledge, behaviors and utensils by means of which the human beings communicate with the external world: kinship systems, rites, myths, traditions and so forth. As far as we manage to understand, it seems that the order of appearance of cultural stages has been: gathering, hunting and fishing; husbandry and agriculture; industry and urbanization. Our evolutionary history of three million years is an incredible history of the adaptation to changing environments. Whoever adapts, wins. From an anthropological environmental approach we explain human adaptation to the environment through genetics and cultural transmission. That is, by the genes and the socialization process (teaching of cultural heritage from one generation to another). Thus, the combination of environmental natural resources and individual skills are key determinants of human adaptations. Adaptation is the adjustment of the population to environmental conditions. From the established ecological entity *subject – environment*, we can observe how the presence of humans and their complex relationships with the organic and inorganic components of the environment alter natural ecosystems and destroy their normal equilibrium. Everything seems to depend on human density and cultural phases. The human population grows, obviously, and deep cultural conceptions and practices weaken natural ecosystems and make them more susceptible to degradation. The socioeducative *ecojustice* perspective approaches the confluence of injustices in the social – environmental interaction, the oppression of human beings on Nature and subsequent ecological degradation. It can help us to see with clarity the cultural phase that we experience and our difficulties to adapt to climate change.

We must all commit ourselves to ensure an ecological sustainable future for individuals, communities and natural systems. We have to be literate in sciences and help others to understand the current ecological situation and to participate with solid criteria in decision-making processes. Those of us who are in educational contexts have even more reasons. There is a gap between what is taught in science classrooms and what students experience in the real world. The scope of the knowledge and the experience of an individual transcend the context in which learning takes place. In the classroom, we resort the deliberate use of scientific topics that students need to take part in the dialogue, discussion and ecological debate. We should also leave the classroom to see how in natural environments – still today – many human communities continue to use oral transmission as a source of teaching and learning. Outside the classroom we observe how those communities have learned their knowledge on husbandry and climatology through the direct experience inside the environmental context. Teaching transversally environmental sciences, in the curricula of all the educational levels, continues to benefit from local and traditional knowledge in educational materials. This ideal allows us also to analyze how traditional societies establish friendly relationships with the natural resources in their daily activities. Besides being instructive, it may generate new knowledge in science.

In a longitudinal study that we carried out more recently in science education, we found that too often undergraduate students face lectures that begin and end in concepts without any practical connection – repetitive, boring, and little useful lab practices disconnected from the lectures. The memory of the lab techniques that students master is as fragile as the knowledge that they acquire. If they cannot find a clear relationship between tasks proposed to them and their potential applications in real life, something fails in our didactic practice. This undermines the educational purpose of student work in laboratories. It is possible that we have an excess of theory and too few practical works in science education at the University. Students complain about it year after year, but teachers do not seem to hear them – or there is little they can do. Surrounded with educational descriptors we try to justify the tendency to give magisterial lectures, which is easier for teachers but boring and tedious for students. The challenge is to break this static process and generate an inclusive environment of learning based on practical activities. Educators have to keep alive their intention of increasing the scientific autonomy of students and helping them to develop a deeper comprehension of how science works. Hence we need to leave the space limitation of the classroom or laboratory. Citizen science and youth activism motivate the scientific and ecological literacy, the redistribution of roles to participate in scientific knowledge production. Overcoming conceptual or dialectic tension between school and citizen science is easy. It requires pushing ahead the educational contents, putting the school in the forefront of the procedural learning, and not in the rearguard of rote learning. If we consider procedural learning as a reference, we will give more attention to learning processes than to learning contents. In this way, science teachers can teach about climate change (for example) in the same way other teachers teach about English language. Of paramount importance is learning by doing. At the same time, transversality is essential because it facilitates the connection between the school learning and the natural world, establishing a link between learning contents and the space outside the school where students and their families live and are increasing their learning about biodiversity, ecosystems and the biotic and abiotic processes that occur in their surroundings. Consider the *Ecoschool*. It is frequent at the stage of the Pre-primary School to propose all children to bring a clean yogurt container – or any other recipient – to the class and plant a bean inside. After a few days of minimal care (watering if dry!), the bean germinates and a tiny plant grows in front of the students' eyes. A so-simple-activity sensitizes children about the fragility of life and ecosystems, such as when we learn about the life cycle of butterflies by rearing small silkworms in a box.

Ecosustainability can be taught inside and outside the school. It is not necessary to separate the two spaces because both constitute a spectrum of learning-continuous. The example of actions that result from a research project that use a farm as a focus for school activities, as a learning context for science classes, will give us a clear image of this idea. Learning experiences on a farm bring us closer to *permaculture* (permanent agriculture): an agricultural activity where people adjust their needs using the resources available in nature. The ecosystem itself guides and teaches us how to produce food in a sustainable, non-pollutant way. This leads us to thinking about agricultural exploitation because we know that the agriculture or land tillage devoted to vegetable production for food involves the use of large land tracts. Specialized production always accompanies urbanization and requires intensive agriculture that reduces species diversity in an extreme way with predictable results: destruction and salinization of soil, pollution by pesticides and fertilizers, deforestation, general loss of biodiversity, and so on. Against this, permaculture evidences other routes for generating food resources based on sustainability. So does what can be gleaned from horticulture, such as the mixed culture of food plants in an orchard near the house, which is an agricultural method widely employed in Central America, Africa and Asian Southeast. This allows the farmer to keep diverse species in the cultivated area isolated from the wild surrounding vegetation. Half way between horticulture and agriculture, there is the crop migratory technology, or agriculture in land plots that are cleared by felling or burning. This is practiced in some rainforest regions and represents the agricultural recovery of small, deforested zones that are then replanted with several types of crops.

From the perspective of practitioners, citizen science can be found in the analysis of narrative descriptions from people who have solid links with natural environments. A matter of pedagogic discussion arises when we evaluate if living in an "ecological" environment (what bucolically can be called *the field*) is enough to guarantee basic levels of learning about the natural world. Evidently, people learn and acquire habits depending on their experiences and interactions inside a specific community or context. If we examine the history of citizen science through the oral history we can observe how still today many human communities keep using oral transmission as a source of education. This may explain how peasants have learned their knowledge on agriculture and livestock breeding or how they manage to maintain a friendly and sustainable relationship with the environment with the ecological environment on which they depend. The agro-husbandry traditional practices orally transmitted from generation to generation have a high ecological value. This Eco- educational learning is natural and contextual learning. It takes place in a context in which people experience their reality, develop their activity through practical didactic examples observed directly in real spaces of the natural environment. The consequent axiom will be an Ecoeducative paradigm. This way, *Ecoeducation* means: an action, expressed in the activity developed in the context of work; and an effect, caused by the use of traditional education methods (oral transmission) for a set of practical knowledges necessary for living. The learning contents (what is taught and learned) are related to what is necessary for life. Let's not forget that the scope of knowledge and experience of an individual is the context in which the learning takes place, and may transcend such context. This form of learning, where everyday tasks are engaged in the exploitation and the sustainable maintenance of environmental resources, constitutes a synthesis of ecological and educational knowledge. It is an important issue for scientific education.

In the ecojustice and citizen science practices, the youth activism takes an important place. We have many points of reference to focus on. Let's go to a river of the Atlantic Arc. Environmental and biodiversity knowledge can be acquired to clean a river. Two Angler's Associations *The Banzao* of Tineo, and *Narcea Sources* of Cangas, both in Asturias – North Spain (43°28′0″N; 6°7′0″W), organize Cleaning Days in the Narcea river margins, focused on urban perimeters where the river tends to suffer attacks from urban nuclei and play the unpleasant role of garbage collector. This action is part of a social awareness campaign about river conservation called, "Rivers for All, Thinking Ahead". Developed by the *National Union of Conservationist Anglers*, its aim is to mobilize the entire population on the idea that rivers are not sewers. This project is based on the work of volunteers who carry out the activity during the weekends before and after March 14, *International Day of Action for Rivers* and March 22 *World Water Day*. It makes visible the need to maintain a respectful relationship with the river ecosystem and aquatic life. The fluvial team squads remove residues from the river and river banks. In their last action in 2012 the volunteers extracted almost 20 t of garbage from approximately ten river kilometers. The most important thing of these actions is not the quantity of garbage removed, that of course is also important, but the public denunciation of the situation of rivers used as sewers. The youth activism also provides the opportunity for analyzing the quality of water, making an inventory of macro invertebrates and vegetation of river banks, and calculating the human footprint on water. Cleaning the rivers and activating the consciences to preserve water quality, fauna and flora, encourages maintaining a friendly relationship with the ecosystem. When we use the concept of sustainability from the ecojustice perspective, we are encouraging youth to experience a fair relationship with others and with the Earth's ecosystems. We are proposing behaviors of ecological value and empirical strategies to preserve and maintain the biodiversity.

Another problem is the expansion of alien species introduced by humans that combined with the reduction of the number of autochthonous species is an environmental problem of enormous magnitude in the Biosphere. It threatens biodiversity worldwide. Taking everything into account, is it possible to regulate the recovery of the biodiversity? Can we encourage specific legislative initiatives to sanction the use of invasive species and to stimulate the recovery of biodiversity? How? An example can be *Corvera,* an Asturian little county of 46 km^2 and 16,500 neighbors. Its inhabitants want to eradicate invasive plants from its territory and forbid the implantation of non-native vegetable cover. Banning alien species helps local biodiversity to recover. This initiative stems from the deterioration of the ecosystem of the coastal forests. Years ago a massive eucalyptus forest was planted in the zone. This is an Australian native species of rapid growth and high performance for the timber industry and trees are called *ocalitos* in the local language. Corvera inhabitants also eradicate leguminous plants such as *mimosa* (*Acacia dealbata*), rhizomatous grasses such as *plumeros* (*Cortaderia selloana*), climbing plants such as *uña de gato* (*Uncaria tomentosa*), shrubs as *flor de lila* (*Syringa vulgaris*) and cannabaceae as *flor de hombres* (*Humulus lupulus*). Local authorities have also banned the use of transgenic varieties and try to extend the areas of protected habitats within the county. The owners of eucalyptus plantations have agreed to cut down the trees and sell the timber. Later, if they want, they can plant a new forest crop, but only with autochthonous species.

The world where we live faces increasingly complex problems: climate change, loss biodiversity, and environmental injustice. Together we can look for answers. In this exciting book you will read some of them. Others are on the way and will become visible soon. Some of the most important actions will be proposed ***by you*** after reading this book. We cannot stop to contemplate what happens. Hence, this Editorial is stopped here. It's the acting time. The planet Earth is yours.

Eduardo Dopico Rodríguez is a professor in the Area of Didactics and School Organization, keep lines of research related to teaching and teaching-learning contents targeting to science education at the levels of schooling and in the socio-educational environments.

Chapter 3
Put Away Your No. 2 Pencils—Reconceptualizing School Accountability Through EcoJustice

Teresa Shume

I serve on a curriculum and instruction advisory committee for one of the local school districts in the region where I reside. Nearly every page of the district's 29 page annual report includes charts, graphs, and percentages that describe changes to trends in test scores. The report also offers a three page schedule listing a litany of tests used to measure student progress. This school district's annual report is representative of the expectations placed on schools to provide exhaustive numerical evidence to measure school effectiveness.

I argue for a strong point in this chapter that the dominant discourse of school accountability relies on quantitative data to the enclosure or exclusion of other forms of measures (e.g., qualitative, sociocultural, historical, philosophical and so forth), and is replete with messages about economic competition, individualism, uncritical economic growth, and consumerism. Genuine school accountability requires that schools prepare students to undertake the profound cultural changes needed to move towards social justice and ecological sustainability. I explore an alternative vision for school accountability, embedded within ecojustice.

After describing some key tenets of ecojustice[1] theory, I examine and problematize the culture of measurement that dominates the current school accountability movement in North America and Europe, with an emphasis on the United States. Biesta's (2010) model for school functions serves as an analytical tool to envision an alternative conceptualization of school accountability, one that resonates with ecojustice principles and meets the moral mandate of schools to prepare children for the future. To conclude, I explore some implications for science educators and others interested in ecojustice.

T. Shume (✉)
Minnesota State University Moorhead, 1104 Seventh Ave. S, Moorhead, MN 56563, USA
e-mail: shume@mnstate.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_3

EcoJustice Theory—*Conceptual Framework*

Drawing on works such as Bowers (2001, 2004, 2006), and Martusewicz et al. (2011), this chapter is grounded in an ecojustice perspective which illuminates ideological, political, and cultural structures that marginalize and oppress people through race, class, sexual orientation, and gender at the root of unsustainable ecological practices. The ecological crisis unfolding on the planet is actually a cultural crisis, and it is imperative for humans to reexamine profound cultural assumptions that underpin our relationships with nature and with each other. Mueller (2009) describes ecojustice philosophy as,

> an emerging perspective that addresses the confluence of social and environmental injustice, oppression for humans and nature, and ecological degradation. The central focus of ecojustice is developing an understanding of the tensions between cultures (i.e., intergenerational knowledges and skills, beliefs and values, expectations and narratives) and the needs of the Earth's ecosystems. (p. 1033)

Ecojustice aims to unveil cultural metaphors carried by language that shape relationships with nature and impact the interdependence of social justice and environmental sustainability. It is a theory that poses thorny questions about *modernist thinking*, the *unsustainability of many current cultural assumptions and practices*, and *what it means to be educated*.

Grounded in the seminal works of Bowers (1997, 2001), Martusewicz et al. (2011, pp. 9–10) provide six interrelated elements to define ecojustice:

1. The recognition and analysis of the deep cultural assumptions underlying modern thinking that undermine local and global ecosystems essential to life.
2. The recognition and analysis of deeply entrenched patterns of domination that unjustly define people of color, women, the poor, and other groups of humans as well as the natural world as inferior and thus less worthy of life.
3. An analysis of the globalization of modernist thinking and the associated patterns of hyper-consumption and commodification that have led to the exploitation of the Southern Hemisphere by the North for natural and human resources.
4. The recognition and protection of diverse cultural and environmental commons—the necessary interdependent relationship of humans with the land, air, water, and other species with whom we share this planet, and the intergenerational practices and relationships among diverse groups of people that do not require the exchange of money as the primary motivation and generally result in mutual aid and support.
5. An emphasis on strong Earth democracies: the idea that decisions should be made by the people who are most effected by them, that these decisions must include consideration of the right of the natural world to regenerate, and the well-being of future generations.
6. An approach to pedagogy and curriculum development that emphasizes both deep cultural analysis and community-based learning encouraging students to identify the causes and remediate the effects of social and ecological violence in the places where they live.

Ecojustice rejects the dichotomy between social and environmental concerns (i.e., an exclusive focus on social or environmental justice), turning its attention instead to examining the common cultural roots of these issues. Ecojustice focuses on matters of culture and community, rather than individualism, "a belief that humans are independent autonomous units, that pursuit of self-interest leads to the greatest good, and that competition is natural" (Martusewicz et al. 2011, p. 45). Rather than concentrating solely on the needs and concerns of humans, ecojustice expands its lens to consider injustices for all forms of life.

The Culture of Measurement

The Dominant Accountability Movement

In the United States, the school accountability movement has expanded at an accelerating pace over the past several decades. Since the release of *A Nation at Risk* by the U.S. Department of Education's National Commission on Excellence in Education in 1983, high stakes standardized testing and other quantified measures such as graduation rates have emerged as the prominent if singular method for judging the success of schools. Dominating the accountability movement in the United States, the No Child Left Behind Act (NCLB) of 2001 has focused the nation's attention primarily on quantified proficiencies in reading and mathematics, which are then captured by the narrow lens of standardized tests. Beyond the borders of the United States, an array of international comparative studies such as the Trends in International Mathematics and Science Study (TIMSS) and the Organization for Economic Co-operation and Development (OECD)'s Program for International Student Assessment (PISA) rely on quantitative test scores to rank the educational performances of children around the world. At this point in our history, the dominant conception of educational accountability is firmed anchored (almost exclusively) in the realm of standardized test scores, quantified data, and competitive comparisons.

In addition to the hegemony of quantitative data that permeates the dominant conception of school accountability, a narrative of economic competitiveness pervades the discourse of school accountability. Arguments reflected in the current discourse of economic competitiveness insist that schools must produce skilled workers in sufficient numbers to fulfill the needs of business and industry to ensure a robust national economy. As I show below, it is argued that America's continued competitiveness on an international scale depends on its availability of skilled workers. Indeed the very title of the report of the U.S. Department of Education's National Commission on Excellence in Education (1983) *A Nation at Risk*, reflects this concern, as does the opening line of the report, "Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world" (p. 5). Twenty-five years later, the U.S. Department of Education produces a follow-up report entitled

A Nation Accountable that also resonates with a discourse of economic competitiveness that is reflected in the following excerpt:

> As many have noted, a number of critical factors determine a society's long-run prosperity, including: respect for ownership, a relatively open market, and ambitious entrepreneurs. But human capital is one of the most important, and a strong education system is vital to the long-term cultivation of human capital. (2008, p. 15)

The discourse of economic competitiveness also manifests itself nationally in the notion that taxpayers deserve to "get their money's worth" from the American educational system, a message that resonates in current school accountability practices.

Job readiness, global competitiveness, and workforce competence have strong presence in important educational standards documents that underpin school evaluation. As a pertinent example, consider how the emerging Common Core State Standards accepted by all but seven states and one territory are sure to provide a potent force for shaping both curriculum and assessment. The Common Core State Standards "are designed to ensure that students graduating from high school are prepared to go to college or enter the workforce" and "are benchmarked to international standards to guarantee that our students are competitive in the emerging global market place" (c.f., Common Core State Standards Initiative 2014, "Standards in Your State," paragraph 1). Within the realm of science education, the Next Generation Science Standards cite four reasons underpinning the need for new science standards, "Reduction of the United States' competitive economic edge, lagging achievement of U.S. students, essential preparation for all careers in the modern workforce, and scientific and technological literacy for an educated society" (c.f., Achieve 2012, paragraph 1). Individual and national economic competitiveness is a seminal purpose undergirding current efforts to define school success in the United States.

Problems with the Dominant Conception of School Accountability

In the United States, tests scores are collected in a relatively small number of curricular domains, especially in reading and mathematics and to a lesser extent in science. Common practices involve measuring the progress of learning in the tested curricular domains through standardized tests and using the test score data to make inferences about school effectiveness. One of the problems with the dominant discourse of accountability lies in the fact that student learning and school effectiveness are "instrumental values" (Biesta 2010, p. 13) that shed light on the quality of the processes and their capacity to dependably fulfill particular outcomes. The extent to which the particular outcomes of these processes are congruent with the general public's vision for educating its children, however, is a separate issue. To determine whether or not schools are producing outcomes that resonate with our considered educational aims, we need to rely on human judgment based not on instrumental values, but rather what Biesta calls "ultimate values" (2010, p. 14) that capture a vision of good education. Accountability focused solely on effective education or school improvement is insufficient because while the current measurements that report on a select number of curricular domains such as reading and mathematics gauge learning processes, they are silent on questions pertaining to ultimate values that underpin the meaningful purposes for learning.

This focus on process is elucidated by Biesta's concept of "learnification," which he defines as "the transformation of the vocabulary used to talk about education into one of 'learning' and 'learners'" (Biesta 2010, p. 18). Learnification shifts the focus away from the intended purposes of education and toward learning processes. It should be noted that learning is certainly an intended outcome of teaching and not problematic in itself; consider the value in questioning whether a particular concept or skill is actually learned rather than simply questioning whether or not it was taught. Learning is a term, however, that denotes process and is frequently used in ways that leave open (or empty) the specificity about content and purpose of learning. While it seems reasonable to expect schools to promote and facilitate student learning, and this idea seems to stand alone for many, it is ultimately an idea that is vapid and feckless unless we specify *what* students are to learn and *why*. At the same time, learnification of education risks confounding intended aims of education with learning processes that can appear to stand alone as suitable targets.

A second problem with the dominant conception of school accountability is that within the current climate of data-driven decision making and evidence-based policy development, there is a tendency to measure what *can* be measured with acceptable levels of validity and reliability. Siegel (2004) offers a case study of Florida's Comprehensive Assessment Test in relationship to the incontrovertible educational aim of developing critical thinking skills among students. He concedes that measuring critical thinking and other fundamental aims of education is very difficult, but insists that the shortcomings of our psychometric capacities should not truncate accountability measures. Biesta (2010) insightfully raises the question of "whether we are indeed measuring what we value, or whether we are just valuing what we (can) measure" (p. 13).

The problem of valuing what *can* be measured is further exacerbated when we sanitize human judgment from our decision-making processes in favor of relying solely on quantified, factual information. An erroneous assumption that underpins the NCLB Act is that educational reform based solely on test scores will yield a stronger American educational system (Ravitch 2010). Indeed the National Research Council (NRC)'s Committee on Appropriate Test Use cautions that,

> The important thing about a test is not its validity in general, but its validity when used for a specific purpose. Thus, tests that are valid for influencing classroom practice, "leading" the curriculum, or holding schools accountable are not appropriate for making high-stakes decisions about individual student mastery unless the curriculum, the teaching, and the test(s) are aligned. (1999, p. 3)

The NRC calls for a congruence between high stakes test validity and intended usage. In other words, using tests designed to measure individual student mastery for the purposes of holding schools accountable may diminish test validity. Such potential gaps in high stakes test score validity are especially perilous in an age of data-driven, evidence-based decision making.

A third weakness of the culture of measurement dominating the school accountability movement is the monolithic character of the discourse of economic competitiveness that not only permeates school accountability but overwhelms any voices advocating alternative ideological stances. The requirements of NCLB have stymied the use of assessments that offer alternatives to standardized testing (Neill 2012). The hegemonic character of the accountability discourse in the United States has resulted in a narrow conception of school accountability.

Problems with the Economic Competitiveness Discourse of School Accountability

Justifying school curriculum with an argument grounded in economic advancement may appear to be an entirely unassailable position. Consider the "commonsense" implicit for many in advancing the aims of the American school system that prepares children to successfully navigate an ever increasingly complex and competitive job market in a rapidly increasingly globalized world. Further, NCLB targets this panoptic need for global economic competitiveness, and subsequently, taps into concerns regarding academic achievement gaps between racial and socio-economic groups. NCLB's rationale becomes seemingly irrefutable when "the narratives of economic opportunity, global competitiveness, and equity and social justice are conflated in one slick phrase—'no child left behind'" (Gruenewald and Manteaw 2007, p. 175). American school accountability reflected in NCLB equates the political mandate of schools with preparing all children for global economic competitiveness, including those from historically marginalized social and racial groups. Such a mandate avoids messy and perhaps irresolvable questions about which "ultimate values" should be reflected in the aims of schools by appearing to be such a common sense position that it is rarely, if ever, questioned. Though this mandate of economic expansion is mainstreamed and generally accepted, it is underpinned with a number of untenable presuppositions.

First, the health of the global economy is widely regarded as contingent on continual economic expansion, which we now know is growth that cannot continue indefinitely in the finite systems of planet Earth (Meadows 1972). It is important to distinguish between economic growth and economic development. *Economic growth* depends on ever-increasing resource consumption, which is synonymous with *progress. Economic development*, on the other hand, can occur through value-added processes that do not increase resource consumption. Consider Wessels (2006) who offers an example of Vermont dairy farmers who add value to their milk by transforming it into dairy products such as cheese and yogurt. Additional land, more cows, and other natural resources are not needed to produce cheese and yogurt, yet economic development is occurring. My point is that school accountability is underpinned with an assumption that continuous economic growth is both desirable and possible despite that this position inculcates unlimited economic growth for a finite system of planetary natural resources and will eventually violate the carrying capacity of the planet's ecosphere.

Second, college and career readiness ultimately aim to situate the next generation as individual economic consumers seeking upward mobility and striving for purchasing power that confers comfortable and convenient consumerist lifestyles, which perpetuates the myth that unsustainable economic growth is possible (Orr 2004). This perspective again positions students narrowly as economic agents (Siegel 2004). When personal economic gain is offered to students as "a carrot" to motivate them to earn high test scores, hard questions about ecological sustainability and social justice are deemphasized and ignored. The justification to strive for higher test scores is described in economic terms: gainful employment can lead to upward socioeconomic mobility. From this narrow perspective, students are viewed as "little more than future 'workers' or, more generously, future 'economic agents'—that is, as little more than cogs in an all-encompassing economic engine" (Siegel 2004, p. 227). No consideration is given to relationships with nature and no questions are raised about the environmental costs of upward socioeconomic mobility, resultant social justice issues, or cultural assumptions that underpin this perspective.

Third, the economic competitiveness discourse for school accountability contributes to the taken-for-granted assumption of education as the economic transaction whereby the public is positioned as a client or customer who patronizes services provided by the school. Biesta's conception of the "new language of learning" is a useful tool for deconstructing the discourse of economic competitiveness dominating school accountability. According to Biesta (2004, p. 74), the process of education is viewed in economic terms where:

> (i) the learner is the (potential) consumer, the one who has certain needs, in which (ii) the teacher, the educator, or the educational institution becomes the provider, that is, the one who is there to meet the needs of the learner, and where (iii) education itself becomes a commodity to be provided or delivered by the teacher or educational institution and to be consumed by the learner. This is the "logic" which says that educational institutions and individual educators should be flexible, that they should respond to the needs of the learners, that they should give the learners value for money, and perhaps even that they should operate on the principle that the customer is always right.

This discourse of economic competitiveness contributes to the commodification of education, and the reduction of education to a commodity continues to be promoted, delivered, and rapidly consumed.

Fourth, the intent to equip children from marginalized social and racial groups with reading and writing skills that are intended to confer job and college readiness does not address unjust societal structures that underpin poverty, racism, and other fundamentally marginalizing social conditions. These categories represent many of the conversations on social justice that have been taken up by other scholars, but are too broad for this chapter. In light of this work, there is still a widespread belief that adequate reading skills and mathematical ability demonstrated on the high stakes tests will ultimately provide disenfranchised children with adequate relief from poverty and racism. This position is seemingly shallow and superficial in light of the current complexities and interface of schooling and society. While schools alone cannot shoulder the entire burden of injustices present in our society, it is a mistake to assume that raising the high stakes test scores among populations of marginalized children will fulfill our school system's obligations toward all students (Berliner 2009).

Need for a Different Vision of School Accountability

The field of educational philosophy has documented a myriad of rationales that underpin alternate visions or purposes for education. One might argue that coming to a consensus on the purpose of school is impossible in a democracy, that is, as a nation, our "ultimate" values represent a fundamentally irresolvable quagmire of conflicting political and moral beliefs. As a result, many politicians and educationalists have taken the easy road—instead of delving squarely with the messiness of asking trenchant questions about the ultimate aims of schools, American school accountability continues to withdraw into the safe harbor of quantitative psychometric measurements with core academic skills underpinned by shallow economic purposes for schools and education. By taking the road more traveled, however, some significant purposes for schooling have become distorted and reduced. School accountability practices should cast light on more than just literacy and numeracy skills. We must ask questions about the extent to which schools are contributing to preparing children for future success as reflected in ultimate values, not limited by instrumental ones. Consider Sirotnik's (2002) metaphor: relying on standardized test scores for determining school accountability is similar to a search for missing keys under a streetlight. The streetlight illuminates one area even though we know keys may be lost in nearby bushes where there is no light. According to Sirotnik, we ought to point the light in other directions, such as the bushes where new conceptions and discourse about school accountability will illuminate some significant aims and meaningful values for education.

An Alternate Vision for School Accountability

Ecojustice philosophy calls for a different conception of accountability, one that prepares students for meaningful and just engagement with the inseparable social and natural worlds. A robust conception of school accountability delves beyond matters of instrumental value, such as issues of learning process and school effectiveness, and digs into questions of ultimate value. These questions can trigger the discussion about valued aims for education. Next, I will explain how school accountability is a moral obligation and use an analytical tool from Biesta (2010) that provides a new vision for school accountability through ecojustice philosophy.

School Accountability—*A Moral Obligation*

Schools shape and are shaped by the cognitive, social, and character development of children in powerful ways. Organized public education is a moral endeavor that carries profound social responsibilities grounded in a deep sense of trust (Sockett

1990). The core purpose of school accountability is to verify that schools are truly meeting the needs of future generations, and preparing them for a successful future. Rather than a focus on reporting test scores within bureaucratic systems built upon political directives, a robust conception of school accountability aims to determine the extent to which schools are meeting the moral obligation of preparing children for responsible, engaged, and fulfilling lives as a citizenry in a culturally and ecologically sustainable democracy that is open, decent, and vital for our planet.

Given the ultimate purpose of school accountability to ensure children's readiness for future success, can there be a more important goal than assuring children of a viable ecological future? Orr (2004, p. 27) points out, "For the most part, we are still educating the young as if there were no planetary emergency." Future generations face unprecedented uncertainty given the present rate of ecological deterioration of the Earth's ecosphere, yet American culture is shrouded in a profound sense of denial regarding the ecological viability of our planetary systems (Bowers 1997; Orr 2004; Wessels 2006).

Teaching reading, writing, and mathematical skills is not enough. Traditional environmental education is not enough. Traditional science education is not enough. To meet the moral obligation of being truly accountable to future generations, school systems should equip citizens to undertake the culturally transformative work questioning dominant paradigms, and fostering ecological sustainability and social justice grounded in cultural ways of knowing that are congruent with justice, diversity, democracy and a sense of humility toward the Earth.

Biesta's Conceptual Model for Functions of Educational Systems

Without describing particular aims for education, Biesta (2010) divides the functions of educational systems into three overlapping categories: *qualification*, *socialization*, and *subjectification*.

Qualification of children encompasses one of the most visible functions of school systems: developing the knowledge, skills, and dispositions needed to undertake particular endeavors. Qualification reflects the day-to-day role of the academic curriculum that is widely associated with a core reason why state-funded, organized schooling exists. Socialization, the second function identified by Biesta (2010), refers to the ways that schools intentionally and unintentionally foster particular social, political, and cultural norms. Schools perform a vital role in the perpetuation of culture and tradition. Third, subjectification refers to the process of becoming a unique individual capable of autonomous thought. Subjectification is a process of individuation where students develop their own voice and emancipate from the confines of established political or social orders.[2] Subjectification can be viewed as diametrically opposed to the dominant idea of socialization in schools.

Biesta's Conceptual Model Applied to EcoJustice Theory

I now enlarge ecojustice in light of what school systems should aim to achieve in order to be truly accountable to future generations. Because an exhaustive discussion of each function necessitates a book in itself, I will confine the discussion below to the identification of some core ecojustice principles for each of Biesta's educational functions with an emphasis on the ones that resonate, in particular, with science education.

Qualification

The first component of Biesta's model, qualification, is reflected in the explicit curriculum that aims to impart knowledge, skills and dispositions that prepare students to accomplish certain roles or activities. In order to be truly accountable to future generations, critical thinking about cultural paradigms and systems thinking are vital elements of schools' explicit curriculum.

Potent critical thinking skills are paramount for the ability to question current paradigms and to recognize the existence of alternate social, cultural, and economic pathways. Without the ability to think deeply and critically about complex and thorny questions where social, economic, cultural, and ecological considerations overlap and in many cases collide, future generations of adults will not be equipped to imagine or enact creative, sound and just solutions to environmental and social problems. A prominent environmental educator Stevenson (2007, p. 280) calls for environmental education that refuses the dichotomy between inquiry-based approaches and information transmission approaches in order to make space for learning activities that focus on critical thinking to analyze complex environmental problems. While such critical thinking skills are indeed important, ecojustice in education goes further by calling for critical thinking skills that enhance our ability to reveal root metaphors that underpin dominant discourses of modernity.

Martusewicz et al. (2011, pp. 66–67) provide a succinct list of potent discursive patterns that characterize modernity:

Individualism:	The idea that we are all autonomous individuals and the concomitant separation of people and community. Root metaphor: autonomous individual is "king."
Mechanism:	The idea that the living world works like a machine. Root metaphor: the universe is a machine.
Progress:	The idea that change is linear and good. Root metaphor: change is improvement.
Rationalism/Scientism:	A particular Western view of knowing the world is the only path to true knowledge. Root metaphor: reason is knowledge.
Commodification:	Discursive practice turning living things and relationships into objects for sale. Root metaphor: land is property, living creatures are profit.

Consumerism:	Faith in the accumulation of objects as the path to happiness. Root metaphor: wealth is material.
Anthropocentrism:	Not only putting humans at the center but at the top of a hierarchy of living and non-living things. Root metaphor: humans are superior and dominant.
Androcentrism:	Putting men at the center as more valuable than and superior to women. Root metaphor: man is superior and dominant.
Ethnocentrism:	Putting some cultures or groups of people at the center as more valuable than and superior to others. Root metaphor: Caucasian is superior and dominant.

Critical thinking skills that dig beyond information about environmental concerns and seek to unveil cultural assumptions that underpin cultural and environmental issues—integrated—are paramount to the qualification function of schools when viewed through ecojustice.

A second powerful lens for perceiving the interplay between natural, social, cultural, and economic realms lies with our thinking deeply about systems. Beyond recognizing the discursive patterns of modernity embedded in western cultural practices, students need to understand how discourses of modernity interact with ecological dimensions of planetary systems and underpin many unsustainable environmental practices. Systems thinking attends to various aspects of networks including interactions among parts, inputs and outputs, system boundaries, and the notion of nested systems (American Association for the Advancement of Science [AAAS] 1989). Other dimensions of systems thinking include understanding three critical scientific laws that govern complex systems: the law of limits to growth, the second law of thermodynamics (entropy), and the law of self-organization in complex systems (Wessels 2006). While systems thinking is multifarious in character and cannot be reduced to a single set of ideas for environmental and science education, there is tremendous value in applying a systems lens to thinking about interactions within and between the natural, designed, and social worlds.

Ecojustice reminds us to be weary of regarding systems thinking with the hubris of reducing the living world to a collection of mechanical parts that can be controlled and managed by technology and human cleverness. This perception is steeped in mechanistic and anthropocentric discourses of modernity. Uncritical faith in scientific and technological progress is also at the root of many of today's environmental problems and represents a world view that is both myopic and untenable (Vitek and Jackson 2008).[3]

Socialization

As mentioned above, socialization, is conceived differently for schools according to Biesta (2010). The second component of Biesta's model, socialization, addresses the ways that schools contribute to the continuation of culture and tradition by intentionally or unintentionally inculcating certain values and norms. A robust conception of school accountability embraces the importance of developing a sense of eco-ethical consciousness among children and youth, with the particular emphasis on valuing ecological and social diversity, as well as fostering a sense of responsibility towards natural and human communities.

One reason why biodiversity is so important is because ecological communities that are comprised of a large number of different interdependent species are more resilient to environmental changes and less vulnerable to collapse. As a former high school science teacher, I know the significance of biological diversity is a complex concept, which is often difficult for students to grasp fully. Human diversity as observed through differences in gender, race, sexual orientation and socio-economic status is more familiar territory for students. The parallel idea, however, that a large number of different interdependent cultures and languages are more resilient to environmental changes and less vulnerable to collapse (due to cultural diversity) is also a difficult concept for many students. Helping students to move beyond conceptual understanding to truly valuing biological and cultural diversity is even more challenging, but is especially critical to socialization that resonates with ecojustice theory. Students need to shift their mindset to recognize that threats to ecological and cultural diversity are underpinned by the same untenable discursive patterns of modernity, and to grasp that where we draw boundary lines around communities results in certain groups of people or other living things being deemed more or less valuable.

More than a conceptual understanding, valuing biological and social diversity is an attitude that cultivates the commitment to protecting diversity in both ecological and cultural forms. A second aspect of socialization resonant with ecojustice is to foster a sense of caring and responsibility for human and more-than-human life. Martusewicz et al. (2011, p. 18) aptly say, "ecojustice is a pedagogy of responsibility, which first asks the question 'what are my just and ethical obligations to my community?'" Socializing students to care about ecological and cultural diversity and to be prepared to accept the concomitant responsibility for striving to redress historical inequities are key aspects of school socialization through ecojustice philosophy.

Subjectification

Subjectification is the third component of Biesta' model for functions of school systems. Subjectification entails the capacity for students to find their owns voices, a process for "'coming into the world'—where 'the world' stands for plurality and difference" (Biesta 2010, p. 85). Students become aware of who they are and where they stand in response to differences with others. The term "subjectification" is meant to signify more than individuality or individuation; it captures the notion that:

> Coming into presence is not about self-expression; it is about responding to what and who is other and different. Coming into presence is, in other words, thoroughly relational and intersubjective…Coming into presence is about being challenged by otherness and difference. (Biesta 2004, p. 78)

Subjectification is about students becoming autonomous thinkers capable of independent thought and action, but for whom coming into presence is only possible when they "engage with the web of plurality" (Biesta 2010, p. 85).

Key to the process of subjectification from an ecojustice perspective is to expand the concept of "other" beyond groups of marginalized human-oriented concerns into the realm of nature and all forms of life. "EcoJustice is a more encompassing paradigm which expands and enlarges social justice to consider the intertwined relationships among humans, nonhumans, and the Earth" (Mueller and Zeidler 2010, p. 105). Subjectification within ecojustice is facilitated by raising thorny questions about otherness so that students contemplate their relationships to others in the world—*not like them*. Further, it is vital to instill a sense of agency among students, or a deep belief that personal and collective actions matter. Indeed, Siegel (2004, p. 228) astutely says, "we educate so to enable the student to create her future, not to submit to it." Within the framework of ecojustice, socialization and subjectification work together to empower students to advocate for democratic and equitable local communities that do not prevent nature from renewing itself.

Implications for Accountability in Science Education

Viewed through ecojustice then, the reconceptualization of school accountability necessitates a new vision of ecological literacy which refuses the hegemony of quantitative student achievement data and seeks multiple and more holistic metrics to determine the extent to which schools are accomplishing their moral mandate to prepare students for a viable future that is culturally and ecologically sustainable.

New Visions of Ecological Literacy

In order to genuinely prepare the next generation for the unprecedented ecological uncertainties that they will inevitably face, new visions of ecological literacy are needed. The elements of qualification, socialization, and subjectification for schooling aforementioned offer a snapshot into the key components of ecojustice-oriented conceptions of ecological literacy. Environmental and science education curricula that provide opportunities for students to engage in citizen science, socioscientific issues, place-based education, service learning, environmental action and youth activism are critical to developing the types of ecological literacy that resonate with school systems' moral obligation to future generations. These instructional strategies and experiences should not simply function as embellishments to traditional environmental and science curricula, rather they should be seminal to our discussions of meaningful aims for environmental and science education.

Reject the Hegemony of Quantitative Test Scores

Ecojustice refuses scientism, a discourse of modernity asserting that science is the only legitimate way to produce knowledge and to know the world (Martusewicz et al. 2011). Similar to the way many fields of modern science reduce nature to a mechanical machine that can be controlled and managed, standardized test scores reduce learning to quantitative data that can be measured and counted. I should not be misunderstood as saying that quantitative data have no place in school accountability and should be rejected. Science provides potent ways for knowledge to be generated and quantitative test scores can offer a useful lens for educators just as science exists with the visual arts, philosophy, music, literature, traditional ecological knowledge, and a wide array of other legitimate ways of producing and preserving knowledge about the world. In the same manner, test scores can stand alongside other forms of established and emergent forms of assessment and research. The key is that test scores must supplement rather than supplant professional judgment. While the practice of standardized testing is replete with vexing problems, I have pointed out that the most troubling aspect of high stakes testing is not its essential character but rather the hegemony of its usage. In the current climate of school accountability, standardized test scores crush out other forms of assessment such as portfolios, learning records, and work sampling to name a few (Neill 2012). EcoJustice perspectives on school accountability reject the hegemony of quantitative evaluation that dominates the culture of measurement in the current climate of schools.

Diversity Principle: Multiple Measures

Diversity is a core principle for ecojustice theory. Biodiversity results in ecosystems that are stronger and more resilient when comprised of a large number of different interdependent species, and cultural diversity results in civilizations that are more resilient to environmental changes and less vulnerable to collapse. Applying this same principle of diversity to school accountability, it follows that drawing upon multiple measures and multiple perspectives will produce more robust and authentic findings. Indeed, several scholars such as Sirotnik (2002), Ravitch (2010), Au and Bollow Tempel (2012), and Neill (2012) endorse school accountability practices that draw upon multiple measures that extend beyond standardized tests.[4] Sirotnik offers this perspective,

> A responsible accountability system would be based on professional judgment using multiple indicators and assessments – both quantitative and qualitative and over extended periods of time – that are sensitive to the needs of each individual and to the purposes and complexities of schooling, including contextual conditions, schooling processes, and the outcomes of teaching and learning. (2002, p. 666)

These scholars along with others support the idea of coordinated on-site visits to schools by trained teams of professionals and public representatives who can offer multiple perspectives. Unshackling schools from the narrow snapshot of schooling provided by standardized testing, and drawing upon diverse methods and perspectives will produce school accountability practices that are more robust, authentic, and responsible.

Counterarguments—*Politics, Mandates, and Complexity of Change*

Too Politically Charged

Calling for the reconceptualization of school accountability underpinned by ecojustice principles may be regarded as a politically charged approach that prioritizes one set of values over other ideological beliefs. One might argue that shifting school accountability towards ecojustice is an overtly political act, especially in science education, and that a single ideology should not dominate public institutions such as schools.

I concur that reformulating the purpose of school accountability is a political act that is underpinned by a particular set of values. But what is not value laden in science education? Seeking job and college readiness for the ultimate purpose of economic expansion is also a highly political mandate that is undergirded by a particular set of ideological beliefs, representing the monolithic ideology that dominates the educational landscape. Because the economic ideological underpinnings resonate with mainstream perspectives on the role of school in society, these beliefs are rarely viewed as controversial or political in nature, but they are nonetheless tethered to a particular political stance. They create an either/or dichotomy for educators whereas ecojustice creates multiple avenues—many of them promising in light of the future world. In short, all education is ineluctably political. Claiming ecojustice philosophy is too politically charged and controversial denies the simple fact that the current economic growth stance is already politically charged, but taken for granted because it is masked by mainstream acceptance. Saying something is "too political" is often a tactic used by science educators who wish to avoid the discomfort of conflict or who are unwilling to assume responsibility for future populations. It may also exceed the comfort levels for some science educators in the same way that schools have recently shouldered considerable mandates.

The School System Cannot Shoulder Another Mandate

The American School System has been asked to take on additional roles and responsibilities that were once solidly within the purview of the family. Bullying prevention, sex education, character development, drug education, refusal skills, grief and crisis counseling, school nutrition, children's mental health and other mandates have demanded a redirection of financial resources and require additional education and training for educators. Some may argue that the school system simply cannot take on yet another mandate—no matter how noble or valuable.

This chapter proposes a path forward that is not simply the addition of another mandate for schools, but rather a rethinking of the purpose of school accountability in order to reformulate school accountability practices. Rather than adding to the existing structure of school accountability, this proposal recommends radically changing the existing structure. These changes bolster accountability measures in terms of teaching science through inquiry and authentic contexts, and intend to lessen the amount of standardized testing undertaken currently. Indeed, the overall impact on teachers is likely to involve less time spent on bureaucratic tasks and more time committed to classroom assessments that can be described as authentic and performance based. Shouldering the current mandates is similarly frustrating for policymakers, school administrators, and science teacher educators who believe there are better ways to move forward. These conversations are difficult and often overwhelming for educators.

Complex and Overwhelming Ideas

Ecojustice theory represents the confluence of several complex concepts that carry profound implications: value of diversity, ecological sustainability, Earth democracies, reification of cultural root metaphors, discourses of modernity, globalization, and others. Further, the scale and speed of ecological degradation penetrating a wide array of planetary systems can be as overwhelming as the rapid emergence of technology. Discussing matters of social injustices can feel depressing. Matters of environmental injustice are equally draining. How can ecojustice principles underpin the purpose for school and an accountability discourse that is comprehensible, compelling, and accessible to all?

It is useful to recognize that philosophical, ideological, and theoretical underpinnings for an educational approach are ultimately translated into developmentally appropriate curriculum and assessment practices. For example, a key outcome congruent with ecojustice for young children is to cultivate a deep sense of connectedness to nature with an emphasis on the local bioregion. While ecological deterioration and social injustices are realities from which ecojustice theory stems, day-to-day practices in science classrooms should focus on empathy for living things, appreciation for nature, discovery of the natural world, possible environmental solutions, avenues for positive changes, advocacy and student empowerment. Educators such as David Sobel (1996) have insightfully noted that we must cultivate a love of the Earth among children before they feel the burden of the responsibility to heal it. Citizen science and youth activism are just two of many pedagogical practices for embracing the responsibility for future generations before us.

Effective for What? And for Whom?

The dominant discourse in American school accountability is grounded firmly in a quantified perspective that regards high stakes standardized tests as the principal if singular lens for evaluating school accountability. Steeped in a narrative of economic progress, the dominant school accountability discourse focuses on the need for schools to prepare students to become workers and consumers in an ever-expanding economy. Further, this discourse strives to assure the public taxpayers that they are receiving a "good value" for their tax dollars.

I have raised three problems with the way school accountability is currently constructed. First, by focusing on processes such as learning and developing school effectiveness, we myopically mistake the means of educational processes for ends to be measured (Biesta 2010). Second, high stakes testing tends to measure what *can* be measured quantitatively (Biesta 2010), conceding to the limitations of statistical psychometric methodology (Siegel 2004). This problem is exacerbated by the assumption that school reform driven exclusively by test scores will yield a better educational system, an assumption that underpins the NCLB Act (Ravitch 2010). Third, and perhaps most problematic, is the monolithic nature of the economic narrative embedded in the discourse of school accountability—a narrative undergirded by a set of faulty assumptions.

The regime of school accountability in the United States, in particular, is largely a manifestation of dominant social and cultural norms of individualism, competition, uncritical economic growth, and consumerism. An economic narrative is so deeply ensconced in the current discourse of school accountability that it stands alone as a seemingly irrefutable "common sense" target for school accountability (Orr 2004), but it does not capture the most important purposes for education. Quantitative hegemony of school accountability systems results in an instrumental focus on measuring processes related to learning and school effectiveness, leaving unanswered question grounded in ultimate values. When considering school effectiveness, we should ask, "Effective for what?" and "Effective for whom?" (Biesta 2004). Standardized tests are useful for measuring student skills in specific curricular domains such as reading and mathematics, but cannot stand exclusively as the central measure of our significant aims for education (Ravitch 2010).

Ecojustice theory offers a potent framework for building an alternative vision for school accountability, which is committed to meeting the moral obligation of schools to equip children for responding to the complexities intertwining social justice and ecological sustainability. Biesta's notions of qualification, socialization, and subjectification are useful for reconceptualizing ecological literacy through ecojustice. To be genuinely accountable to future generations, schools ought to develop the following pivotal aptitudes among students: critical thinking about dominant cultural paradigms, systems thinking, eco-ethical consciousness, a sense of responsibility towards human and natural communities, an expanded conception of "other," and a commitment to advocating for democratic communities that are just and sustainable.

When the current dominant conception of school accountability fails our children, we can no longer deemphasize or ignore it. We need to reconsider what it means for schools to be truly accountable to the next generation and ensure that our children are adequately prepared to undertake transformative cultural work in an uncertain social and ecological future.

Notes

1. In this text, I deliberately use a lower case "e" for the term "ecojustice." I considered both the form "Ecojustice," and the form "(e)cojustice" similar to Thayer-Bacon's (2003) use of "(e)pistemology" signaling the possibility of either an upper or lower case "e." My intent is to convey that ecojustice is not a singular, monolithic theoretical construct, but rather a multifarious, emergent one where there is room for diverse perspectives within a common framework.
2. It should be noted that individuation is a process that results in individuals capable of autonomous thought, and should not be confused with individualism, which is a belief that the greatest good can be achieved through competition among individuals seeking self-interests.
3. See *The Virtues of Ignorance* edited by Bill Vitek and Wes Jackson (2008) for a collection of essays that questions uncritical faith in technology and scientific progress and argues that our ignorance about natural systems vastly exceeds our knowledge.
4. See *Pencils down: Rethinking high-stakes testing and accountability in public schools* edited by Wayne Au and Melissa Bollow Tempel (2012) for a collection of essays about alternatives to high stakes standardized testing.

References

Achieve. (2012). *Next generation science standards: The need for new science standards.* Retrieved January 17, 2013, from http://www.nextgenscience.org/overview-0#Surrendering%20Competitive%20Eco

American Association for the Advancement of Science. (1989). *Project 2061: Science for all Americans*. Washington, DC: Author. Retrieved January 17, 2013, from http://www.project2061.org/publications/sfaa/online/sfaatoc.htm

Au, W., & Bollow Tempel, M. (2012). *Pencils down: Rethinking high-stakes testing and accountability in public schools*. Milwaukee: Rethinking Schools.

Berliner, D. C. (2009). *Poverty and potential: Out-of-school factors and school success*. Boulder/Tempe: Education and the Public Interest Center & Education Policy Research Unit.

Biesta, G. J. J. (2004). Against learning: Reclaiming a language for education in an age of learning. *Nordisk pedagogic, 24*, 70–82.

Biesta, G. J. J. (2010). *Good education in an age of measurement: Ethics, politics, democracy*. Boulder: Paradigm Publishers.

Bowers, C. A. (1997). *The culture of denial: Why the environmental movement needs a strategy for reforming universities and public schools*. Albany: State University of New York Press.

Bowers, C. A. (2001). *Educating for eco-justice and community*. Athens: University of Georgia Press.

Bowers, C. A. (2004). Revitalizing the commons or an individualized approach to planetary citizenship: The choice before us. *Educational Studies, 36*, 45–58.

Bowers, C. A. (2006). *Transforming environmental education: Making renewal of the cultural and environmental commons the focus of educational reform*. Eugene: EcoJustice Press.

Common Core State Standards Initiative. (2014). *Standards in your state.* Retrieved October 14, 2014, from http://www.corestandards.org/standards---in---your---state/

Gruenewald, D. A., & Manteaw, B. O. (2007). Oil and water still: How no child left behind limits and distorts environmental education in U.S. Schools. *Environmental Education Research, 13*, 171–188.

Martusewicz, R. A., Edmundson, J., & Lupinacci, J. (2011). *EcoJustice education: Toward diverse, democratic, and sustainable communities*. New York: Routledge.

Meadows, D. H. (1972). *The limits to growth*. New York: Signet.

Mueller, M. P. (2009). Educational reflections on the "ecological crisis": Ecojustice, environmentalism, and sustainability. *Science & Education, 18*, 1031–1056.

Mueller, M. P., & Zeidler, D. L. (2010). Moral-ethical character and science education: EcoJustice ethics through socioscientific issues. In D. Tippins, M. Mueller, M. van Eijck, & J. Adams (Eds.), *Cultural studies and environmentalism: The confluence of EcoJustice, place-based (science) education, and indigenous knowledge systems*. Dordrecht: Springer.

National Research Council. (1999). *High stakes: Testing for tracking, promotion, and graduation*. Washington, DC: National Academies Press.

Neill, M. (2012). Multiple measures. In W. Au & M. Bollow Tempel (Eds.), *Pencils down: Rethinking high-stakes testing and accountability in public schools* (pp. 231–234). Milwaukee: Rethinking Schools.

Orr, D. W. (2004). *Earth in mind: On education, environment, and the human prospect*. Washington, DC: Island Press.

Ravitch, D. (2010). *The death and life of the great American school system: How testing and choice are undermining education*. Philadelphia: Basic Books.

Siegel, H. (2004). High stakes testing, educational aims and ideals, and responsible assessment. *Theory and Research in Education, 2*, 219–233.

Sirotnik, K. A. (2002). Promoting responsible accountability in schools and education. *Phi Delta Kappan, 83*, 662–673.

Sobel, D. (1996). *Beyond ecophobia: Reclaiming the heart of nature education*. Great Barrington: The Orion Society and the Myrin Institute.

Sockett, H. (1990). Accountability, trust, and ethical codes of practice. In J. Goodlad, R. Soder, & K. A. Sirotnik (Eds.), *The moral dimensions of teaching* (pp. 227–250). San Francisco: Jossey-Bass.

Stevenson, R. (2007). Schooling and environmental/sustainability education: From discourses of policy and practice to discourses of professional learning. *Environmental Education Research, 13*, 265–285.

Thayer-Bacon, B. J. (2003). *Relational (e)pistemologies*. New York: Peter Lang.

U.S. Department of Education. (1983). *A nation at risk: The imperative for national educational reform*. Washington, DC: U.S. Department of Education.

U.S. Department of Education. (2008). *A nation accountable: Twenty-five years after a nation at risk*. Washington, DC: U.S. Department of Education.

U.S. Department of Education. (2011). *ESEA flexibility*, Retrieved January 17, 2013, from http://www.ed.gov/esea/flexibility

Vitek, B., & Jackson, W. (2008). *The virtues of ignorance: Complexity, sustainability, and the limits of knowledge*. Lexington: The University Press of Kentucky.
Wessels, T. (2006). *The myth of progress: Toward a sustainable future*. Lebanon: University Press of New England.

Teresa Shume is an assistant professor whose joint appointment is split between the School of Teaching and Learning and the Bioscience Department at Minnesota State University Moorhead. She has been an award winning high school science teacher and has served as an educational consultant for the American Association for the Advancement of Science Project 2061 and Utah's State Office of Education.

Chapter 4
Provoking EcoJustice—Taking Citizen Science and Youth Activism Beyond the School Curriculum

Giuliano Reis, Nicholas Ng-A-Fook, and Lisa Glithero

In this three-part chapter, the authors draw on their own educational experiences to exemplify how ecojustice, citizen science, and youth activism come together to be enacted in three different (but interconnected) settings: a youth expedition to the Arctic (Part I), a class of elementary student teachers working on a media project in collaboration with a local aboriginal community (Part II), and a lesson on the social aspects of "genetic disorders" with a class of high school biology student teachers (Part III). Adopting a broader definition of education (in opposition to schooling) across all sections, we seek to illustrate ways in which teachers, students, and community members can collaboratively expand the implications of science education for promoting a society that is more socio-environmentally sound.

Amongst the many interrelated components of ecojustice philosophy, there is the recognition that its pedagogy is centered on understanding relationships within society at large and within the natural environment (Bowers 2002). In other words, our connections with other-than-human systems and also with one another are essentially the same: one does not exist without the other—this is the "web of life" (Capra 1996). That is, our very survival as a species depends not only on the health of the natural environment around us, but also on the strength of our society while diverse and democratic. Ultimately, the "destructive relationships and practices" that afflict our communities are a threat to our existence as much as any other

G. Reis (✉) • N. Ng-A-Fook
Faculty of Education, University of Ottawa,
145 Jean-Jacques Lussier, Ottawa, ON K1N 6N5, Canada
e-mail: greis@uottawa.ca; ngafook@uottawa.ca

L. Glithero
Faculty of Education, University of Ottawa,
145 Jean-Jacques Lussier, Ottawa, ON K1N 6N5, Canada

12 ch Fosbery, Chelsea, QC J9B 2G6, Canada
e-mail: diz@eyesproject.com

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_4

ecological problems of our time. More so: it can be said that the contemporary ecological crisis is both socially constructed and culturally sustained. For example, from a social inclusion theory standpoint, the (social) prejudice and discrimination that are directed toward individuals whose mental or physical capabilities are unlike those of most of us can be very destructive to one's health (Ontario Prevention Clearinghouse 2006)—just as any other current environmental issue, like climate change for instance. However exaggerated this assertion might look at first, it merely suggests that our society has been the major source of its own maladies. Climate change is known to have been displacing people around the globe to the point where now we have permanently incorporated the term climate refugee to our everyday lexicon (Bettini 2013; Scheffran et al. 2012). At the same time, climate-induced migration is a survival strategy, meaning that many do not endure long enough to make the journey or succumb to the attempt of it. Likewise, prejudice and discrimination (unfortunately already also part of our lexicon) are notoriously linked to some of humanity's darkest moments. This is the case with respect to the profound effect that eugenics exercised in the international medical and social spheres—for example, Europe, North America and Africa—drove the development of reforms in the area of mental health as well as education and social development in the last century (Ure 2009). Similarly, on a smaller scale, there is the public physical violence suffered by African-Americans and homosexuals in certain cities in Brazil. Ultimately, these examples—and there are many others—speak to the fatality of our inadequacy to care for individuals of our own species. Whether it is climate change or prejudice and discrimination, the fact is that these ecological tribulations weaken us socially and wound us psychologically. Subsequently, they pose a danger to our presence on this planet and require actions aimed to minimize their effects—and (public) education (as opposed to schooling) seems to be one of the right places to implement these changes.

Part I: Building Youth 'Change Agents' on an Expedition in the Arctic: Rethinking Science, Environmental, and Civics Education (Lisa Glithero)

How can we collectively develop in today's youth the knowledge, skills, and capacities needed to be ecologically and socially responsible community builders? What kinds of learning experiences (might) build student capabilities for deep public participation contributing to environmental and social change? These questions serve as my philosophical and pedagogical guide for developing educational programs aimed at youth environmental action. This section of the chapter looks at the learning framework, experience, and impact of the Students on Ice (SOI) program through my lens as the former education director (2004–2008), as well as from the perspective of five student alumni. Since 1999, SOI has taken over 2,500 high school and university-aged students from around the world on learning expeditions to the Polar Regions. This section seeks to examine the following two questions:

(a) How does the co-participatory and intergenerational sharing approach used in SOI's learning framework evoke a type of citizen science that contributes to youth actively engaging in public environmental action on a local and global scale? And, (b) How does this type of expeditionary and place-based learning promote a mode of ecojustice pedagogy through participants' direct experiences with the "knowledges of different cultures and cultural relationships to place" (McKenzie 2008, p. 366)? To begin with however, I offer a brief discussion on recent trends in the environmental education (hereafter EE) literature, as well as a general overview of an ecopedagogy philosophy, in the hopes of giving some theoretical context to the possibilities and limitations of the SOI experience and similar programs.

EE has traditionally been situated within a unit of the science curriculum. In turn, the environment has often been subjugated in science-based learning. Furthermore, EE practice has long focused predominantly on individual change, particularly attitudinal and behavioral change specific to environmental issues (Kool 2012). By building knowledge and pro-environmental attitudes, educators committed to environmental learning have looked to environmental literacy and positive nature-based experiences for developing ecologically responsible citizens and stewards (Hungerford 2010; Marcinkowski 2010). However more recently, environmental educators and researchers advocate a need to move beyond a central focus on individual attitudinal and behavioral changes towards collectively building a better understanding of environmental learning processes aimed at socio-ecological change (Orr 2004). To achieve deep community transformation, one emerging trend is the development of 'environmental action' or 'action competence' in youth as a critical objective of environmental learning (Schusler and Krasny 2010). As more EE research explores the learning process of developing capabilities in youth to participate in environmental action in the public sphere (Almers 2013; Arnold et al. 2009), so too are related discussions on the growing relationship between environmental, science, and civics education. These exciting discussions speak directly to the emerging trend of environmental and scientific-based learning aimed at active democratic citizenship (Gough and Scott 2007; Wals and Jickling 2009). Central to these discussions is ecojustice.

Rooted in relationships, ecojustice philosophy serves as an important theoretical bridge to environmental and science education. In perceiving these two fields as mutually symbiotic, the environment no longer becomes subjugated. Each field is dependent and informs the other.

A pioneer of the social justice-education movement was renowned Brazilian educator Paulo Freire. At the time of his death in 1997, Freire was working towards developing an 'ecopedagogy'; a now well developed ecologically-oriented practice taken up internationally by scholars including Gadotti (2004), Kahn (2008), and supporters of the Earth Charter Initiative (see, www.earthcharterinaction.org). Ecopedagogy embodies a relationship-oriented, ecologically conceptual framework that advocates for a broader planetary worldview. It adds an ecological lens to Freire's critical pedagogy's focus on social justice (considered, anthropocentric). In other words, it extends values of justice to include the environment and 'environmental racism' (Bowers 2002). Ecopedagogy, situated within broader ecojustice theory, offers a valuable pedagogical lens that helps to ground epistemological elements of ecological thinking in meaningful praxis. For Bowers (2009), the deconstruction of a perceived knowledge hierarchy that places "scientific/technological/ industrial" theories of knowing above diverse cultural knowledge and multiple ways of relating to the natural world represents one of ecojustice philosophy's main objectives (p. 199). Through ecojustice education, he asserts that students must be exposed to ecologically sustainable practices of diverse cultures and prioritizes their participation in "non-commodified aspects of community life" (2002, p. 21). Further strategies for implementing ecojustice pedagogy include: "learning principles of ecological design;" regenerating "non-commoditized skills, knowledge, and relationships [of self-reliance];" and "democratizing technology and science" (Bowers 2002, pp. 30–32). Ecojustice education also calls for time spent in "out-of-classroom spaces and places; experiencing the knowledges of different cultures and cultural relationships to place; gaining a diversity of natural history knowledge; and developing community relationships and actions" (McKenzie 2008, p. 366). It is this latter point that most resonates with the Students on Ice (SOI) program and student experience.

Students on Ice as an Experiential Learning Framework

The mandate of the SOI program is to provide participants—students, educators, and scientists—with inspiring educational opportunities at the Earth's Polar Regions. In doing so, the aim is four-fold: (a) to connect participants to the natural world; (b) to foster new understanding and respect for the planet; (c) to explore solutions to our most pressing challenges; and finally, (d) to inspire each other to take positive action. This educational approach draws on elements of experiential, expeditionary, inquiry-based, and place-based learning. In some of the most awe-inspiring ecosystems in the world, students, along side a team of international educators, polar scientists, and social change-oriented leaders, examine the natural sciences of both the local and global ecosystems, including the cultural and natural aspects of these places. Topics such as glaciology, oceanography, climate change, and Inuit history are explored through various learning formats including: lectures, workshops, and hands-on activities that are field, zodiac, or ship-based settings. Immersed in these places and experiences, students are able to situate what they learn in a very personal way. As a result, science and environmental learning—that is often abstract and/or highly complex when taught in a classroom and from a textbook—becomes much more accessible, palpable, and critically relevant to students. They are able to take this 'personal knowledge' and transfer and apply it to their everyday lives in their respective home communities, despite the geographical, sociocultural, and socioeconomic diversity.

As the 2-week expedition progresses, the ideas of uncertainty and difference emerge with a 'floating family', where friendships and connections bridge generations and diverse cultural and socioeconomic backgrounds. Curiosity and excitement guide learning and paths of inquiry. Hikes across Arctic landscapes, visits to Inuit communities, and intimate moments shared with wildlife all serve to add authentic context to two central programming foci—citizen science and youth activism. Through both 'pod teams' (small collaborative learning groups) and the learning community as a whole, many socioecological issues facing the Arctic, as well as the participants' home communities and the global community at large, are explored. One aspect of this process involves students working as co-participants with mentoring scientists in conducting evidence-based field research. For example, students conduct plankton tows focusing on marine diversity; examine new arctic plant specimens due to changing ecosystems; take ice core samples to measure various pollutants levels; conduct bird surveys; or take whale biopsies to be catalogued for migratory studies. Through these intimate opportunities to learn methods of scientific inquiry, develop preliminary research practices, and enhance scientific literacy skills, students become empowered in the process to consider pursuing science-based careers and/or to engage more readily in types of citizen science or environmental action initiatives in the public sphere post-expedition.

Another aspect of the learning experience involves students exploring ideas around how to create change, the process of community change, and what kind of changes matter most to them as youth and in their respective bioregions. Various action agendas, youth forums, and initiatives emerge by the end of an SOI expedition including: youth statements presented at international conferences; establishment of youth-activism based organizations; and conceptual frameworks for documentaries or social media-related campaigns and project initiatives. In having gained a deeper understanding of the interconnectedness and complexity of current environmental and sociocultural challenges, many students following an SOI expedition go on to demonstrate the range of youth activism possibilities aimed at societal change. Examples of youth activism initiatives carried out by a small sample of SOI participants are listed in Table 4.1 at the end of this section. These examples, generated by five self-selected program alumni, speak to the impact of the SOI program in contributing to young people's capabilities to participate in community and societal transformation.

Although supportive of the importance and pervasiveness of science in our everyday lives, the program faculty of SOI have learned firsthand over the past decade that building scientific knowledge, skills, and literacy is not enough in the pursuit of creating a more sustainable and just society. There is now the need and opportunity to foster in students the motivation and capacity to utilize their scientific and broader understandings to enact deep systemic change. For example, teaching global climate change in the context of the SOI program is not simply about building student knowledge on the science around increased atmospheric levels of greenhouse gases or related issues, such as the acidification of today's oceans. Rather, it is about knowing, doing, and looking beyond the traditional disciplinary science content to examine with students the root causes of any given environmental issue and to explore on an individual and collective level how we are connected to the issue—thus, making it personal, shared, local, and critically relevant. Furthermore, provoked by an experience that *personalizes* knowledge gained, students are, as stated by one, "more inspired to act."

Table 4.1 Example of youth who are leading the way in recent environmental action

Name (Nationality, Year of Expedition)	Citizen science	Youth activism
Cassandra Elphinstone (Canada, 2010)	Locally, Cassandra works on a salmon habitat enhancement project. Internationally, she served as a member of the SOI Youth Rio + 20 Earth Summit in 2012 and introduced the idea of a modified Environmental Currency Transaction Tax (ECTT) as a reward mechanism to aid states that act as environmental stewards.	Cassandra founded GAIAactivism, a network of student leaders from Europe, Asia, North America, and most recently Africa. GAIAactivism coordinated an environmental Global Day of Gathering in 2012.
Andrew Wong (Canada, 2010)	Andrew has a Geography and Biology double major from the University of Waterloo and believes in non-profit organizations. He is an Editorial Intern with *Alternatives Journal*, which communicates environmental issues to the Canadian public. Andrew also worked at Earth Day Canada on corporate conservation practices. He volunteers as Environment Chair of the Waterloo Students Planning Advisory, examining local environmental planning issues.	Andrew founded and led a delegation team of 14 SOI alumni youth to Rio de Janeiro, Brazil for the Rio + 20 Earth Summit in June 2012. Summit themes included examining an institutional framework for sustainable development and operationalizing a 'green economy.' The delegation was the only youth-based organization present advocating for polar sustainability.
Jenna Gal (Canada, 2009)	Jenna is currently studying Environmental Science at UBC Okanagan where she is working on a research project aimed at understanding the impacts of land use changes on the Similkameen River watershed. She volunteers for other local watershed conservation groups and interns for the Yukon Climate Change Secretariat in public education outreach initiatives.	Jenna volunteers with school groups on environmental education, a priority she feels in empowering today's youth. She currently serves as Chair of the Environment and Sustainability Society at UBC Okanagan, Chair of the Central Okanagan Foundation for Youth, and works as a youth volunteer with the BC Sustainable Energy Association.
Sun Ye (China, 2007)	While on expedition, Sun Ye discussed wanting to write a book for Chinese youth on climate change upon returning to Shanghai. Fourteen months later, a beautiful professionally published 84-page book arrived in the mail to the SOI office.	The book is being distributed to thousands of youth across China and Sun Ye continues to write, study, and advocate for climate change action.

(continued)

Table 4.1 (continued)

Name (Nationality, Year of Expedition)	Citizen science	Youth activism
Irene Shivaei (Iran, 2007)	After returning to Tehran, Irene began writing weekly columns about climate change in the national newspaper, JameJam Daily, and writes an environmental page monthly in an Iranian student magazine aimed at pre-teen readers. She also started a radio program about science and environmental issues while studying physics at the University of Tehran.	Irene played a leading role in developing the StarPeace Program launched in 2009. It is an official International Astronomy Year project aimed at bringing together people from nations with shared borders—often conflict-torn—to the actual border lines of their respective countries for public events to observe and learn about the stars, with hopes of fostering peace.

Through critical reflection on the 12-year practice of SOI, we recognized the need to broaden the scope of the program beyond science and environmental education. The foci of the education program has grown over time to include, for example, culture, politics, art and music, history, and socioeconomic fields of study. Naturally, these subjects are interconnected and we have woven them together using an inter—and trans—disciplinary approach. This broadening of programming foci, in turn, strengthens the students' science and environmental understandings, as well as serving to better inform their subsequent actions. More importantly, this 'beyond science and environment' approach has also served to engage youth participants who might not have a pure science or environmental interest or who might perceive these fields and related modes of learning as intimidating. The Inuit and First Nation youth participants, in general, are a great example. Analyses of the SOI student experience over the years has shown that for Inuit and First Nation youth, it has been the art, music, storytelling, and traditional knowledge learning circles, that provokes their connection to, and engagement in, the science and environmental issues being explored on expedition. I would suggest this is largely because 'the science' (western scientific knowledge) has/does not take into account indigenous ways of knowing about the natural world that are indeed scientific. An ecojustice pedagogy, one that bridges western scientific knowledge with traditional ecological knowledge (TEK) through critical and relational discourse, coupled with an interdisciplinary approach to learning, helps us move beyond the binary and disconnect. In turn, student engagement and student 'success' are positively impacted for *all* students.

In providing students with unique educational experiences where polar landscapes and Arctic communities become the classroom, different knowledge perspectives and cultural relationships to the polar and global ecosystems are explored. In turn, this learning experience and approach directly challenges the ways in which students perceive the world. Central to this approach are five key themes to the SOI philosophy, emergent over the past decade, that are worthy of highlighting: (a) sustainability is an imperative that should inform our decisions. By making sustainable choices and taking action, we can arrive at the best possible outcomes for the planet, humans and other living things, now and in the future; (b) change is happening rapidly in the polar regions, places of special importance to the planet. While global climate has changed over millennia, it is the rate of modern climate change that is alarming. Global climate change is happening in the context of complex cultural, governance, economic, and ecological changes. Peoples' capacity to choose, mitigate, and adapt to particular changes will inform our future collective well being; (c) creativity and innovation means thinking about new ideas and doing things differently. They are important across all sectors of society including the arts, sciences and the transition to new 'green' economies; (d) indigenous ways of knowing remain profound and relevant. Despite modern influences and conveniences, indigenous peoples in the Arctic (and elsewhere) have retained their languages, core knowledge, and beliefs. Indigenous knowledge contributes to the advancement of a sustainable Arctic and a sustainable planet; and finally, (e) youth have a key role to play in shaping the world of today and of tomorrow. Energy, idealism and innovation are the currency of youth. We need young people actively engaged as participants in different community leadership and decision-making roles where their fresh conceptions and energy can help drive positive change—what we might then call the youth effect.

If we were to look at the above five themes—i.e. sustainability; change; creativity and innovation; indigenous ways of knowing; and the youth effect—to help inform pedagogical praxis around education framed by ecojustice philosophy, how might we as educators around the world begin to engage youth in the building of a more sustainable and just society? These themes, it seems, bring together EE and science education in a way that does not subjugate one or the other, but rather works to inextricably connect what both disciplines embrace more fully (see also the forum carried in the following three papers: van Eijck and Roth 2007; Mueller and Tippins 2010; Reis and Ng-A-Fook 2010). Might this renewed interpretation—one that advocates for and supports citizen science and youth activism—serve to expand the implications and reach of science and environmental education for promoting a society aimed at socioecological well-being?

Part II: Developing Collaborative Social Action Curriculum Projects: Media Studies, Science Education and Ecojustice Activism [Nicholas Ng-A-Fook]

This section of the chapter looks at how teacher education students can utilize media studies as an approach to integrate ecojustice activism within their curriculum designs of the Ontario science curriculum. It reports on a case study where pre-service teachers from the University of Ottawa work with a First Nations community to create public service announcements that take up ecojustice issues that are important to elders, teachers, and local students. Moreover, this section addresses the following two questions: (a) How can media studies help future teachers and students to become critical consumers and producers of the scientific literacies; and (b) How might non-Indigenous researchers and teacher candidates collaborate with

First Nation teachers and students to promote a type of ecojustice activism that challenges the current colonial frontier logics embedded explicitly and/or implicitly within the Ontario science curriculum. Consequently in this section of the chapter, I discuss how global cohort students were afforded opportunities to work collaboratively with the Kitigan Zibi (an Algonquin First Nation community) to develop cross-cultural social action curriculum projects within the contexts of science education. To do so, I share some student narratives that illustrate the possibilities and limitations of their lived experiences while enacting their different social action curriculum projects (SACP) in relation to media studies, science education, and ecojustice activism.

In 2008, our Faculty of Education created its first global education cohort as part of our larger Developing A Global Perspective for Educators (DGPE) program (www.developingaglobalperspective.ca). The primary goal of this unique program is to establish collaborative partnerships with local schools, community leaders, and NGOs in order to re-imagine and re-articulate familiar curriculum concepts across different subject areas such as—but not limited to—science education. Moreover, the DGPE program seeks to develop critically reflective teaching professionals who personify an ethic of caring, knowledge of, and commitment to, their eco-civic responsibilities through public education (Ng-A-Fook 2010). In turn, students are invited to understand, among other things, how they can imagine curriculum development in relation to international cooperative development, social justice, peace education, and environmental sustainability. To do so, teacher candidates learn to design and implement different SACP over the course of the academic year.

Although not a novel concept, SACP are reermerging as a conceptual framework for conducting action research in subject areas like science education. The *Project Method* itself, is more than 100 years old. During the turn of the last century, progressive educational researchers like John Dewey and William Heard Kilpatrick designed and implemented some of the first action research projects within the broader field of education at the Chicago Lab School and within Teachers College at Columbia University (Kilpatrick 1918). Today a SACP still affords educational researchers, teacher candidates, teachers, students and their communities opportunities to identify relevant and pressing issues, work through possible solutions, and engage in contingent action planning to address social inequities (Schultz and Baricovich 2010). Much like the tenets of participatory action research, it requires that each participant put the practices, ideas, and assumptions about institutions to the test, while questioning and making critical analysis of their own experiences as a political process (Macdonald 2012, p. 39). SACP enables researchers, teachers and students with educational opportunities not only to learn more about the possibilities and limitations of their praxis, but also practice social justice-orientated modes of democratic citizenship (Westheimer 2005). And yet, what might these modes of citizenship mean for science education programs and/or for developing science curriculum with teacher candidates and First Nation communities? In response to this question, I share two short stories about how teacher candidates enrolled in our DGPE cohort work with Kitigan Zibi teachers and students on different SACP within the contexts of science education.

Over the course of the last 3 years, students enrolled in our program have volunteered to participate in a community service-learning placement—a key component of the overall DGPE initiative—that enabled them to travel and work with First Nation teachers at the school Kikinamadinan (which means "place of learning" in Algonquin). The school is located on the Kitigan Zibi reserve, which is 90 min north of the University of Ottawa in the province of Quebec. Although the school is funded by federal grants, the Band Council is responsible for administering the funding as well as developing the various programs for the school. On the other hand, the Kitigan Zibi community receives two-thirds of the funding children off reserve get through taxation to support their livelihoods as learners within public education. Consequently, they must work to develop innovative pedagogical and curricular strategies to provide the same services their students would receive at any other publically funded schools across Canada.

In 2010, a primary/junior cohort of students in our teacher education program made three field trips to work collaboratively with elders to develop lesson plans that sought to address different Algonquin traditional ecological knowledge and values across the Ontario curriculum as an approach for teaching ecojustice activism (Kulnieks et al. 2012; Martusewicz et al. 2011). In that context, one group of teacher candidates decided to examine what they (and Kitigan Zibi students) could learned from animal scat as a form of science literacy and as a language for rereading eco-literacies of place (Brody 2000). During that specific lesson plan, students were asked to examine fake animal scat in terms of size, shape, and contents to determine which animal it would have come from. They reproduced animal scat using oatmeal, water, and cocoa powder for their peers to identify based on an animal scat identification poster. They had opportunities to develop their traditional ecological knowledge as well as science literacy, Algonquin language, and understanding of the differences between herbivores, omnivores, and carnivores (including their diets and the flow of energy between them), aspects of digestion, and how human impact on the environment can affect an animal's eating habits. The teacher candidates learned how to live within the relational spaces of cross-cultural collaborations on a social action curriculum project to arrive at the final version of the lesson plan put forth.

During our first trip to the reserve, the Director of Education (Anita Tenasco) provided an orientation to the educational infrastructure of the community and some cultural background information about the students who attend both their elementary and secondary schools. The principal (Shirley Whiteduck) also spoke to the global cohort about the various school programs in place as well as the socioeconomic, cultural, and psychological dynamics of their students. During our second trip, elders advised student teachers about how they might further incorporate an Algonquin conceptual framework in terms of the cultural and narrative dynamics of their proposed teaching and learning activities. The collaborative work with elders also provided a unique learning opportunity about the historical narratives that remain at present absent from school textbooks. Together, elders and teacher candidates made the content of their lesson plans more culturally relevant for their student body (Kanu 2011). Moreover, we were asked to create lesson plans that integrate emergent technologies like Smart Boards, writing and art activities, games and quizzes, and promote traditional ecological knowledge as science literacy.

As part of their SACP, I asked students to develop, what Aikenhead (2006) calls cross-cultural science curriculum while still addressing the overall expectations of the government curriculum policy documents. In other words, teacher candidates are invited to reconsider how they might teach scientific concepts taken up within the curriculum policy documents in relation to working with First Nation elders, teachers and students to develop science curriculum that they can teach at Kikinamadinan School. The underlying principles of locality and contextuality applied in the process can be also implemented in the development of teaching pedagogies at any other school across the province. In response to such curricular and pedagogical invitations, students in one group established the following question to frame their lesson plan for Grade 4 students: What is scat and what can it tell us? As a result, their lesson addresses the following two overall expectations from the Ontario science curriculum: (a) analyze the effects of human activities on habitats and communities; and, (b) demonstrate an understanding of habitats and communities and the relationships among the plants and animals that live in them (Ontario Ministry of Education 2007).

As their professor, I supplemented what they are learning from Kitigan Zibi elders, teachers, and students with various readings that examine the possibilities and challenges for non-indigenous teacher candidates to teach subject areas like science within First Nation, Métis, and/or Inuit communities across Canada. We studied the historical colonial politics of residential schooling as a conceptual framework to discuss the historical narratives put forth and/or absent within the Ontario curriculum (Battiste 1998; Kirkness 1998). Likewise, we examined the possibilities and limitations of nonindigenous teachers working with indigenous communities (Taylor 1995). At the end of the term, I then invited each teacher candidate to write a newsletter article about their lived experiences during the SACP. One student writes the following:

> This experience allowed me the chance to reflect, re-examine and question some of the existing pedagogical issues that I among other teachers will face in the classroom. I begin to question the traditional model of teaching, which assumes students are sitting receptacles of information rather than inquisitive explorers of their learning (Freire 1970/1990) … As I reflect on the stories told by the Elders during my visit to Kitigan Zibi, I contemplate if there is room for different types of knowledge within our curriculum. One that does not adhere to the banking model of education… I felt a sense of shift from my linear Eurocentric lesson delivery. I experienced an epiphany that would change the way I viewed myself as a teacher.

Overall, teacher candidates learned from First Nation teachers and students how to develop placed-based science curriculum that addresses the local contexts of their communities (Chambers 2006). More importantly, learning to teach within such cross-cultural hyphenated relational spaces provoked some teacher candidates to reconsider their subjectivities as future teachers and to decolonize their pedagogical approaches for teaching science curriculum. Such contextual reconsiderations enabled future teachers with opportunities to re-imagine how they can combine traditional and conventional modes of teaching science education as a form of critical ontology.

"An important dimension of critical ontology," as Kincheloe (2006) reminds us, "involves freeing ourselves from the machine metaphors of Cartesians" (p. 182). In order to expand the multiplicity of knowledges (multiple literacies) put forth in science education, we were able to incorporate some key concepts from Hampton's (1995/1999) conceptual framework for working with Aboriginal students into their curriculum designs: spirituality, service, diversity, culture, tradition, respect, history, relentlessness, vitality, conflict, place, and transformation (see also MacIvor 1995/1999). The broadening of what constitutes science literacy in Ontario classrooms, I would argue, is part of an ecojustice activism conceptual framework for teaching science education in twenty-first century.

In the second story, I would like to focus on a media studies social action curriculum project that we develop with elders and Grade 5 and 6 students. This time our teacher candidates had to develop two different SACPs: Hula-Hoop (Llyod 2012) and Public Service Announcements. Much like the year before, during the first trip teacher candidates were introduced to the community and tour the school. Then, teacher candidates and elders watched "The Invisible Nation" (Loumède et al. 2007), a documentary film that examines the historical and ongoing displacement of Algonquin communities due to European colonization. Prior to returning to the community for our second fieldtrip, teacher candidates organized themselves into small groups and tentatively developed an action plan that facilitated a 1-day program for Kitigan Zibi elementary students and elders to create and film student-driven public service announcements (PSAs). Teacher candidates provided support for students to write up the storyboards as well as with the filming and editing of the final products. Prior to beginning the second visit, an elder conducted the opening prayer and smudge ceremony in order to welcome us and bless our work. Once again, elders advised teacher candidates how they might further incorporate an Algonquin conceptual framework in terms of the cultural and narrative dynamics of their proposed PSAs.

Upon our return to the University of Ottawa, teacher candidates edited the filming to create 90 s PSAs, which we share with elders, teachers, parents, and students during our final fieldtrip. One of these PSAs was titled, Water is Life. It stressed the importance of understanding the impacts of the types of relationships that we as humans choose to foster with the different environments that we inhabit. In the final version of the PSA, an elder shared the following wisdom tradition story about water:

> I'm proud of it [my indigenous relation to this place]. When I was young, maybe 8 or 9 years old, my sister had two children. They were small and she was sick. She could not wash anything. She was too sick and she was running out of diapers. She asked me, "Would you go and wash the diapers? Rinse them, wash them." I said, "o.k." And I thought to myself, "I am going to do it the easy way." I took the diapers and took a pot, and went down the hill by the river. And, I started washing diapers and rinsing them off in the river. It was the easy way. Then I heard somebody on the hill, "What are you doing?" It was my mom. She said, "Oh no, you don't do that!" I realized this is the way…you have to keep the water clean. Life is water.

Throughout the PSA activity students shared some of the extrapolated lessons they learn from the elder's story in order to rethink our existing relationships with the environment—for example, current practices around production, consumption, and waste management and the polluting affects they have on the water systems that give life to different ecosystems either here in Canada or abroad. The PSA ended by stating, "worldwide one billion people lack access to safe drinking water," followed by a Grade 5 student who points to the camera with his finger and says, "don't abuse water, or else I will come for you." The teacher candidates, elders and students created three other PSAs titled, Protecting Animals (Animal Rights), What will you Choose (Drug Prevention), and Dear Fellow Canadians (First Nation Youth Advocacy for Access to Equitable Education on Reserves). Although this SACP was quite different from the first year, teacher candidates still experienced several epiphanies. After the project was completed a teacher candidate shared the following testimonial:

> My colleagues and I had the opportunity to work with grades 5 and 6 First Nations students from students to create public service announcements (PSAs) that enabled Algonquin youth to voice their concerns about an issue that was important to them, exchange ideas with education students, and learn techniques to create effective PSAs. In turn, we would have an opportunity to get to know interests and concerns of First Nations youth, develop our teaching practices, run small group activities, integrate technology, and develop a connection with the community…The experience of this project allowed me to reaffirm my commitment to addressing issues of diversity and equity. However, it also developed my awareness of the importance of building bridges–partnerships that allow for better understanding within and between our communities, as well as building capacity for creating positive social change.

The PSAs provide an exemplary way to think about how teacher candidates can collaborate with elders to reconceptualize curriculum development that takes at its heart all the educational vision and mission of the Kitigan Zibi community—namely, the development of individual talents and abilities, provision of opportunities to develop the skills of effective communication, creation of relational spaces for different cultures, reaffirmation of diversity and equity, and understanding of their responsibilities and privileges as members of local families and global and communities (Kitigan Zibi 2012). Finally, creating PSAs provides a pedagogical space for students to express and enact their multiple literacies (cultural, media, digital, ecological, etc.) within the science classroom as a form of ecojustice activism.

Part III: Advancing Citizen Science and Youth Activism Through Ecojustice—The Story of Marianna [Giuliano Reis]

This section of the chapter focuses on science education as a point of entry for ecojustice in teacher education programs and high school curricula. Specifically, it draws on a lesson about the sociocultural aspects of Trisomy 21 (i.e., Down Syndrome [or DS]) with a class of high school biology student teachers. The activity originated from an uncomfortable classroom situation and as such it was designed to challenge inaccurate (simplistic) representations of the terms 'normal' and 'natural'. It aims to promote a more comprehensive and action-oriented conception of genetic disorders by situating them at the intersection of natural and sociocultural systems. It also exemplifies how youth activism can be originated in schools to produce citizen scientists in our communities who are committed to disseminate and denounce the un-scientific basis of prejudice and discrimination. (That's right: citizenship science is not only about collecting and analyzing hard data about bird migratory routes or new plant species.) This framework for citizen science in science education is important for everyone (researchers, teachers, students, community leaders and parents) as it contributes to the realization that the overall physical and mental health of individuals in our society is the responsibility of all. This is but one ecojustice principle by which we would measure achievement [and sustainability by extension] more properly (Mueller and Tippins 2012).

The natural (biological) aspects of genetic disorders commonly make up small sections in high school biology textbooks. Consequently, their sociocultural implications—for example, prejudice and discrimination, social inclusion in school and the workforce, economic impact on health care system, effect on family structure, and so forth—are expected to consume little time of classroom instruction (and what a miss this is!) Alternatively, science education for ecojustice confronts teachers and students with the responsibility and opportunity to promote critical conversations to plan appropriate actions regarding the importance of respecting and caring for those of us carrying a genetic build that varies from what has been arbitrarily defined as 'normal.' As humans, our sense of 'normality' is always evolving. Concomitantly, we need to appreciate how language contributes to create and sustain a taken-for-granted description of reality that favours specific attitudes toward particular cultural norms of acceptance (Bowers 2001; Cox 2010; Wilson 2012).

> An eco-justice pedagogy places on understanding that language is not a conduit for communicating objective knowledge. Rather, language carries forward culturally specific ways of thinking—and the student is connected, often in unconscious ways, to this symbolic ecology (Bowers 2001, p. 414).

Otherwise, the politics of knowledge that shape and validate certain privileged narratives in school science will continue to ignore the voices of the already marginalized by ignorance, discrimination and prejudice. In exemplifying a strategy to minimize the costs of our actions to our social (and natural) surroundings, I seek to find out "whether or not science leads to reducing human (and nonhuman) suffering" (Stonebanks 2010, p. 374). I equally anticipate rekindling the discussion around the possible ways that science teachers can ethically approach the conflicts emerging from learning of the existing differences amongst living beings, especially humans. This is akin to the theoretical underpinnings of human ecology (Bates and Tucker 2010).

Brushing Up on Biology

A cell can be defined as the basic structural and functional unit of living things. In other words, all known living organisms, though markedly diverse when viewed from the outside, are essentially similar inside as all their cells share the same machinery for their most basic functions (Alberts et al. 2008). The latest count suggests that there are about 8.7 million species on the planet (we are definitely not alone!) (Mora et al. 2011), and yet they reproduce themselves faithfully—or as faithfully as possible—according to information handed down by parent organisms that specify, in amazing detail, the characteristics that the progeny will inherent. As a result, individuals belonging to the same species see—more commonly than not—their numbers increase exponentially. Whether or not this is the work of "selfish genes" (Dawkins 1976), the fact remains that the phenomenon of heredity is central to the definition of life itself.

In the case of humans, our hereditary material (genome) is passed onto newer generations when two opposite-sex individuals bear children who will then carry a mix of their parents' information—that is, one half from the male fuses with another half from the female. In addition, these halves are transported in highly specialized cells called gametes, which are produced in a cell division known as meiosis. In some cases, the sorting of information that takes place during meiosis can go unplanned—what many deem a 'mistake' or 'error'. This section of the chapter challenges the reader to understand the school practice of ecojustice from the perspective of one of these peculiarities. Her name is Marianna Reis.

When Past and Present Meet Up

Circa 1866 Dr. Langdon H. Down had his attention directed to the possibility of making a classification of "congenital mental lesions" (Down 1866, p. 259). His classification system was an attempt to assist medical doctors of his time with the diagnostic and prognostic of a particular "defect which may have come under their observation" (p. 259). The subjects in his study were generally referred to as "feeble-minded," "idiots," and "imbeciles." In addition, and perhaps inadvertently, he created another meaning to the term 'mongoloid': "A very large number of congenital idiots are typical Mongols" (p. 260). Although Dr. Langdon's description of the syndrome was not the first one (Genes 2005), his name is now forever linked to it. Today, Down syndrome is a very common genetic condition and occurs in about 14 in 10,000 live births in the US alone (Dierssen 2012). In Canada, the numbers indicate an estimated 40,000 individuals with DS (Public Health Agency of Canada 2003).

Back to the present, it is now the winter of 2010. I am in my science methods class for high school biology pre-service teachers at the University of Ottawa. One of my course requirements is for groups of students to demonstrate how to effectively teach a lab activity. As part of their usual presentation ritual, students often provide some theoretical groundwork before proceeding to the hands-on aspect of their demonstration. I watch the performance of one group on the topic of cell division when one of the members mentions DS as an example of when meiosis "goes wrong." That last sentence provokes me to end my evaluation writing mode momentarily and throws me back to all those times when people asked me what had happened to my sister and whether or not 'what she had' was contagious. Although my brother and I were children back then, the typical ignorance of people about her condition is something that I have never forgotten. Her physical appearance is telling of the differences she carries—or maybe telling of the ones that we carry by contrast—and that might have made people feel uneasy. Curiously, I sensed—although not with absolute certainty—that most students in my class feel troubled by the comment made by the young yet-to-be teacher. This teacher's perspective may be changed after all, I optimistically thought to myself.

The following week, I mention the incident in class in order to make my students astutely aware of it. I question (without scolding) the inappropriateness of that type of language—unscientific, to say the least. At the same time, I recognize that this bias is not (entirely) their fault. Existing biology textbooks are filled with the same depreciating semantic imagery used to describe DS. For several examples: "errors and exceptions in chromosomal inheritance" (Campbell et al. 1999, p. 271), "non-disjunction disorder" (Miller and Levine 1991, p. 235) and "abnormal meiosis" (Ritter et al. 1993, p. 556). Likewise, the words 'syndrome' or 'mutation' themselves are synonyms with 'anomaly.' Although all these words are (probably) meant to indicate that the cell division does not generate a faithful progeny, I sincerely doubt that anyone enjoys being called any of them. This language consciously signifies undesirable adjectives.

Aside from the negativity assumed in those descriptors, the Ontario high school biology curriculum document mandates that "whatever the specific ways in which the [high school science curriculum] requirements outlined in the expectations are implemented in the classroom, they must, wherever possible, be inclusive and reflect the diversity of the student population and the population of the province" (Ontario Ministry of Education 2008, p. 16). Correspondingly, when aiming at the provincial curriculum goals, teachers can choose how to best meet them as long as they do not lose sight of their students' existing cultural and cognitive multiplicity. This inclusion is not an easy task when it comes to DS. (I deliberately omitted a discussion on the "wherever possible" part since I have difficulty conceiving a situation or place where the policy would not apply.) Oddly, the curriculum has 12 instances where the word "meiosis" appears, two where the word "trisomy" is used (keep in mind that Down syndrome is but one type of trisomy) and none for DS. Despite this, DS remains part of the fifth most common "developmental disabilities or disorders" between children aged 5–14 in Canada (StatCan 2001), which is one of the signing countries (Foreign Affairs and International Trade Canada 2010) to the UN's Convention on the Rights of Persons with Disabilities (2006).

In class, we also do the "mitosis square dance" as one example of how to hook or make introducing cell division fun for students (YouTube has numerous videos on this activity). Next, I invite Marianna (my sister) and our mother (Carmen Reis) to talk with my beginning teachers. Together, we are people whose biographies intersect with both DS and schooling. Marianna, although rejected by many schools, was able to finish her secondary education. (Mom feels that she was rejected too, every time schools said "no" to Marianna. However, when she looks back she feels it was worthwhile—her parental persistence has certainly paid off.) Marianna is not capable of explaining the inheritance laws of Mendelian genetics, but she understands well that she is different—or that we are different from her. She is not afraid to tell other people that she has Down syndrome and that she is special. Although her first language is Brazilian Portuguese (which she speaks fluently), she greets my students in English. (This is something we had to rehearse the night before the class, because of her insistent requests to learn some English.)

Marianna was only 6 weeks old (!) when she started what my brother (Felipe Reis) and I know as 'the treatment.' Although we were younger, we remember the treatment involved a lot of exercising but no drugs (we had a monkey bar inside the garage at some point!) Perhaps because we grew up with Marianna around us, we never perceived her as anything else but our sister—and we never teased her more than any other brothers would their own sisters. Maybe because Marianna is our family, we always felt strongly that prejudice and discrimination were both undeserving and unjust. (Curiously, my brother is now a physical education teacher with a number of qualifications in special education). As for Marianna herself, she went on to be a Special Olympics medalist in 1991 (2 gold, 2 silver, and 2 bronze in gymnastics!) and has been employed full time ever since she finished high school. She is not a "genetic disorder," let alone an "error." She is also more than an illustration in a biology textbook in the Down Syndrome section. She is a daughter, a sister, friend, girlfriend, employee, and a human being. She is what books cannot embrace in their pages: she is a member of our society, who deserves the same mental and physical happiness that anyone else longs for. More so: she deserves the right to live—isn't social/ecojustice also about mental and physical wellbeing? In class, Marianna is excited that my students have questions for her—she likes that she's getting the most attention in the room. My wife (Juliana Reis) and children (Ana-Julia Reis and Maria-Luiza Reis) are also present. What was supposed to be a lesson has now become a family event. Now cell division has a new face for my students—Marianna. There are many others like her in schools everywhere the world over. I wrap up the presentation by challenging my students to get to know these other 'special people.' Moreover, I suggest they invite their own high school students to do the same—maybe make it a classroom project on the sociobiological aspects of discrimination? This is at the core of the cut-deep-and-travel-far and the reach-outside-biology principles for effective biology teaching put forward so eloquently by E.O. Wilson (2007). Other stories emerge: cousins, brothers-in-law, neighbours, friends, etc. My students seem to get the message. We all pose for a group picture at the end of class. After all of my students are dismissed, a few stay behind to congratulate my mom and sister for their courage and example. Mom asks them to use what they have learned to become better teachers, to do things right. They all commit to make a difference. One even decides to write a paper for another course inspired by Marianna's story. Another calls the whole lesson an inspirational act of courage (certainly not mine, I must say). To this day, we still run into people who recognize Marianna long after that class. We tell ourselves that increased contact indeed leads to decreased prejudice, something that research has already established (Fishbein 1996).

Lessons (L)earned

It is a popular belief that biology has taught us that our genes (i.e., DNA) contain information that specifies all living beings. Therefore, many students and other non-professional scientists still hold the idea of genes as objects containing the plans for executing the development of an entire organism. This is conceptually wrong for two reasons: (a) it ignores the influence of the social, cultural and physical environments (or ecological, somatic or genetic [Williams 1966]) on the development of individuals, and, (b) confuses the essential participation of genes in one's developmental process with their reportedly (but non-existent) unique responsibility to one's abilities (Maturana and Varela 1998).

There is a need to move from a structural approach to discrimination to a systemic one. The former would insist that DS individuals are destined to a life of misery and suffering imposed by their cognitive and physical limitations. On the contrary, the latter will state that genes are complex enough to make it difficult to predict and control (Wray et al. 2007). As a social species, our behaviours are only partly determined by our genetic makeup (Wilson 1980). If my mom (and all of us for extension) had adopted a structural approach to understand Marianna, she would have never achieved such great personal success in her life. It was our 'systemic stubbornness' that helped Marianna get where she is now. This is the same tenacity I hope to nurture in my students, so that they can help others with whom they cross paths in their classrooms to excel, no matter what their genes say. Even though that might not affect DS individual's life expectancy—which has been increasing anyway (see, Center for Disease Control at http://www.cdc.gov/ncbddd/features/keyfindings-dS-survival.html)—it has the potential to improve the quality of their lives and help reduce abortion rates, which would promote life as one of the fundamental human rights (Universal Declaration of Human Rights, article 3). That too is part of a just society. Changing discrimination and prejudice require people to be more actively involved in embracing the 'different from themselves' at the earliest age. It also means changing the language currently used to refer to those individuals. According to Halliday (1993), "language is the essential condition of knowing, the process by which experience becomes knowledge" (p. 94). Once our knowledge changes, it should also change our language.

On the other hand, some might argue that genetic counseling (Sheets et al. 2011) and genetically modified organisms (eventually applied to humans) carry the potential to correct and/or prevent any 'anomalies' like DS. A similar example would be the cochlear implants for infants and the arguments from the proponents of the Deaf culture that they are losing their culture (Tucker 1998). What if we all looked the same? Isn't diversity part of our human nature? Although an interesting discussion—one that could branch out into the fields of bioethics, child adoption and even religious morality—it is out of the scope of this chapter. The considerations made here are meant to provoke the rethinking of current approaches to life as it happens to exist *after* a child is born.

Our survival "is dependent on many key issues such as economic justice, human rights, peacekeeping and conflicts, social and political movements, and ecological balance" (Watt et al. 2000, p. 108). Marianna's story is but one example of how our society can confront the most crucial issues facing our times and work towards a more sustainable and just society. It remains "immensely important that we do not make presumptions about a person's health or ability on the basis of their genotype, but rather look to see what they can actually achieve. It is a matter of fundamental human rights [and social justice]" (Sulston and Ferry 2002, p. 251). Moreover:

> The purpose of public schools ought to be to develop citizens who are prepared to support and achieve diverse, democratic and sustainable societies because these are keys to our very survival. Further, these principles support ways of living with each other that are the most fair to all living beings. That means that we must help to prepare students at all levels to think critically and carefully—that is to say ethically about the patterns of belief and behavior in our culture that have led to destructive relationships and practices harming the natural world as well as human communities (Martusewicz et al. 2011, p. 8).

Even though there exists support for a (evolutionary) basis for discrimination (Nguyen 2006), the same is true that "most, if not all creatures live in an environment of choice to some degree or another" (Nelson 2000, p. 12). Whether our discriminatory actions are 'innate' or 'social' (learned) behaviours, culture seems to play a major role in how modern human societies respond to differences between members of our own species. Therefore, our most vulnerable individuals may continue to endure suffering as the result of misinformed decisions, miseducation, and opinions that the general public might have on their uniqueness. And an ecojustice philosophy allows one to argue against the progressive trend in science and technology that advocates that fixing all living organisms considered 'error' is natural and desirable.

Sharing Our Efforts to Promote Ecojustice

According to Dalke and Grobstein (2007):

> Humans continue to create binaries, and with them an associated belief that they represent conflicting stories, one of which must prevail at the cost of the other. At a time in history when the price of such conflict is measured in terms of the suffering of very large numbers, and potentially in the extinction of the human species, there may be no more important classroom task than to help students develop and appreciate an alternative perspective: different stories need not be oppositional. It is our task, as educators and world citizens, to help our students and ourselves develop the skills needed to continually create and recreate a human story from which no one feels estranged (p. 111).

In other words, the narratives of our educational experiences—whether in the Arctic, a Canadian Native Reserve, or within Ontario teacher education—are meant to challenge the type of 'binary thinking' that suggests that our choices or ways of perceiving are limited. In co-creating learning experiences with our students that aim to (re)create educational narratives that embrace alternative and multiple perspectives, we become more mindful of the "floating signifiers" of culturally generated meaning (Hall 1997). Beyond developing an enhanced understanding that we are "diverse people living together in one finite world" (Greenwood 2009, p. 278), our three stories collectively shared in this chapter highlight what is learned through intersubjective experiences, including "spaces of collective youth engagement" (McKenzie 2008, p. 361). In sharing our efforts to promote ecojustice through our professional actions, we aspire to advance the belief that it is possible to live curricula outside school in ways to promote citizenship science and youth activism to / with whom they matter the most.

References

Aikenhead, G. S. (2006). Cross-cultural science teaching. In Y. Kanu (Ed.), *Curriculum as cultural practice: Postcolonial imaginations* (pp. 223–248). Toronto: University of Toronto Press.

Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). *The molecular biology of the cell*. New York: Garland Science.

Almers, E. (2013). Pathways to action competence for sustainability—Six themes. *The Journal of Environmental Education, 44*, 116–127.

Arnold, H., Cohen, F., & Warner, A. (2009). Youth and environmental action: Perspectives of young environmental leaders on their formative influences. *The Journal of Environmental Education, 40*, 27–36.

Bates, D., & Tucker, J. (2010). *Human ecology: Contemporary research and practice*. Dordrecht: Springer.

Battiste, M. (1998). Enabling the autumn seed: Toward a decolonized approach to aboriginal knowledge, language, and education. *Canadian Journal of Native Education, 22*, 16–24.

Bettini, G. (2013). Climate barbarians at the gate? A critique of apocalyptic narratives on "climate refugees". *Geoforum, 45*, 62–73.

Bowers, C. (2001). Toward an eco-justice pedagogy. *Educational Studies, 32*, 401–416.

Bowers, C. (2002). Toward an eco-justice pedagogy. *Environmental Education Research, 8*, 21–34.

Bowers, C. (2009). Educating for a revitalization of the cultural commons. *Canadian Journal of Environmental Education, 14*, 196–200.

Brody, H. (2000). *The other side of Eden*. New York: North Point Press.

Campbell, N., Reece, J., & Mitchel, L. (1999). *Biology*. San Francisco: Benjamin-Cummings.

Capra, F. (1996). *The web of life: A new synthesis of mind and matter*. Hammersmith: HarperCollins.

Chambers, C. (2006). "The land is the best teacher I ever had": Places as pedagogy for precarious times. *Journal of Curriculum Theorizing, 22*, 27–37.

Cox, R. (2010). *Environmental communication and the public sphere*. London: Sage.

Dalke, A., & Grobstein, P. (2007). Story telling in (at least) three dimensions: An exploration of teaching reading, writing, and beyond. *Journal of Teaching Writing, 23*, 91–114.

Dawkins, R. (1976). *The selfish gene*. Oxford: Oxford University Press.

Dierssen, M. (2012). Down syndrome: The brain in trisomic mode. *Nature Reviews Neuroscience, 13*, 844–858.

Down, J. (1866). Observations on an ethnic classification of idiots. *Clinical Lecture Reports, London Hospital, 3*, 259–262.

Fishbein, H. (1996). *Peer prejudice and discrimination*. Boulder: West-view Press.

Foreign Affairs and International Trade Canada. (2010). *Canada ratifies UN convention on the Rights of Persons with Disabilities*. Retrieved March 17, 2013, from http://www.international.gc.ca/media/aff/news-communiques/2010/99.aspx?view=d

Freire, P. (1970/1990). *Pedagogy of the oppressed*. New York: Continuum Press.

Gadotti, M. (2004). *Education for sustainable development: What we need to learn to save the planet?* Instituto Paulo Freire. Retrieved March 17, 2013, from http://www.earthcharterinaction.org/invent/details.php?id=368 on 21 Nov 2012.

Genes, N. (2005). *Down syndrome through the ages*. medGadget. Retrieved March 17, 2013, from http://medgadget.com/2005/11/down_syndrome_t.html

Gough, S., & Scott, W. (2007). *Higher education and sustainable development: Paradox and possibility*. London: Routledge.

Greenwood, D. (2009). Place: The nexus of geography and culture. In M. Mckenzie, P. Hart, H. Bai, & B. Jickling (Eds.), *Fields of green* (pp. 271–281). Cresskill: Hampton Press.

Hall, S. (1997). Representation, meaning and language. In S. Hall (Ed.), *Representation: Cultural representations and signifying practices* (pp. 15–64). London: Sage.

Halliday, M. K. A. (1993). Towards a language-based theory of learning. *Linguistics and Education, 5*, 93–116.

Hampton, E. (1995/1999). Toward a redefinition of Indian education. In M. Battiste & J. Barman (Eds.), *First nations education in Canada: The circle unfolds* (pp. 5–46). Vancouver: UBC Press.

Hungerford, H. (2010). Environmental education (EE) for the 21st century: Where have we been? Where are we now? Where are we headed? *The Journal of Environmental Education, 41*, 1–6.

Kahn, R. (2008). Towards ecopedagogy: Weaving a broad-based pedagogy of liberation for animals, nature, and the oppressed people of the earth. In A. Darder, M. Baltodano, & R. Torres (Eds.), *The critical pedagogy reader* (2nd ed., pp. 522–540). New York: Routledge.

Kanu, Y. (2011). *Integrating aboriginal perspective into the school curriculum*. Toronto: University of Toronto Press.

Kilpatrick, W. (1918). The project method. *Teachers College Record, 19*, 319–334.

Kincheloe, J. (2006). Critical ontology and indigenous ways of being: Forging a postcolonial curriculum. In Y. Kanu (Ed.), *Curriculum as cultural practice: Postcolonial imaginations* (pp. 181–202). Toronto: University of Toronto Press.

Kirkness, V. (1998). Our peoples' education: Cut the shackles; cut the crap; cut the mustard. *Canadian Journal of Education, 2*, 10–15.

Kitigan Zibi. (2012). Retrieved December 15, 2012, from http://kzadmin.com/KZESKikinamadinan.aspx#tpsec

Kool, R. (2012, May). *What do we talk about when we talk about 'change' in environmental education?* Paper presented at EECOM conference, University of Waterloo.

Kulnieks, A., Ng-A-Fook, N., Stanley, D., & Young, K. (2012). Reconsidering Canadian curriculum studies: Framing an approach to ecojustice. In N. Ng-A-Fook & J. Rottmann (Eds.), *Reconsidering Canadian curriculum studies* (pp. 107–136). New York: Palgrave Macmillan.

Lloyd, R. (2012). Hooping through interdisciplinary intertwinings: Curriculum, kin/aesthetic ethics and energetic vulnerabilities. *Journal of the Canadian Association for Curriculum Studies, 10*, 4–27.

Loumède, C. (Producer), Desjardins, R., & Monderie. R. (Directors). (2007). *Invisible nation*. Canada: National Film Board.

MacDonald, K. (2012). Understanding participatory action research: A qualitative research methodology option. *Canadian Journal of Action Research, 13*, 34–50.

MacIvor, M. (1995/1999). Science education for aboriginal students. In M. Battiste & J. Barman (Eds.), *First nations education in Canada: The circle unfolds* (pp. 73–98). Vancouver: UBC Press.

Marcinkowski, T. (2010). Contemporary challenges and opportunities in environmental education: Where are we headed and what deserves our attention? *Journal of Environmental Education, 41*, 34–54.

Martusewicz, R., Edmundson, J., & Lupinacci, J. (2011). *Ecojustice education: Toward diverse, democratic, and sustainable communities*. New York: Routledge.

Maturana, H., & Varela, F. (1998). *The tree of knowledge: The biological roots of understanding*. Boston: Shambhala.

McKenzie, M. (2008). The places of pedagogy: Or, what we can do with culture through intersubjective experiences. *Environmental Education Research, 14*, 361–373.

Miller, K., & Levine, J. (1991). *Biology*. San Francisco: Prentice Hall.

Mora, C., Tittensor, D., Adl, S., Simpson, A., & Worm, B. (2011). How many species are there on earth and in the ocean? *PLoS Biology, 9*(8).

Mueller, M. P., & Tippins, D. J. (2010). van Eijck and Roth's utilitarian science education: Why the recalibration of science and traditional ecological knowledge invokes multiple perspectives to protect science education from being exclusive. *Cultural Studies of Science Education, 5*, 993–1007.

Mueller, M. P., & Tippins, D. J. (2012). Citizen science, ecojustice, and science education: Rethinking an education from nowhere. In B. J. Fraser, K. Tobin, & C. J. Campbell (Eds.), *Second international handbook of science education* (pp. 865–882). Dordrecht: Springer.

Nelson, J. (2000). *The biology of discrimination: An evolutionary approach*. Unpublished M.S. thesis. Mankato: Minnesota State University.

Ng-A-Fook, N. (2010). An/other bell ringing in the sky: Greenwashing, curriculum, and ecojustice. *Journal for the Canadian Association of Curriculum Studies, 8*, 41–67.

Nguyen, C. (2006). *A study of the evolution of discrimination using Artificial Life Simulations*. Retrieved March 17, 2013, from http://www.csse.monash.edu.au/hons/se-projects/2006/Chung.Tue.Nguyen/Thesis.pdf

Ontario Ministry of Education. (2007). *The Ontario curriculum grades 1–8: Science and technology*. Toronto: Queen's Printer for Ontario.

Ontario Ministry of Education. (2008). *The Ontario curriculum grades 11 and 12: Science*. Toronto: Queen's Printer for Ontario.

Ontario Prevention Clearinghouse. (2006). *Count me in! Inclusion: Societies that foster belonging improve health*. Toronto: Ontario Prevention Clearinghouse.

Orr, D. (2004). *Earth in mind*. Washington, DC: Island Press.

Public Health Agency of Canada. (2003). *Canadian congenital anomalies surveillance network: national data on Down syndrome*. Retrieved March 17, 2013, from http://www.phac-aspc.gc.ca/ccasn-rcsac/ct2003/dsdata-eng.php

Reis, G., & Ng-A-Fook, N. (2010). TEK talk: So what? Language and the decolonization of narrative gatekeepers of science education curriculum. *Cultural Studies of Science Education, 5*, 1009–1026.

Ritter, B., Coombs, R., Drysdale, B., Gardner, G., Lunn, D., & Samiroden, W. (1993). *Biology*. Scarborough: Nelson.

Scheffran, J., Brzoska, M., Brauch, H., Link, P., & Schilling, J. (2012). *Climate change, human security and violent conflict*. Dordrecht: Springer.

Schultz, B. D., & Baricovich, J. E. (2010). Curriculum in the making: Theory, practice, and social action curriculum projects. *Journal of Curriculum Theorizing, 26*, 46–61.

Schusler, T., & Krasny, M. (2010). Environmental action as context for youth development. *The Journal of Environmental Education, 41*, 208–223.

Sheets, K., Crissman, B., Feist, C., Sell, S., Johnson, L., Donahue, K., Masser-Frye, D., Brookshire, G., Carre, A., LaGrave, D., & Brasington, C. (2011). Practice guidelines for communicating a prenatal or postnatal diagnosis of down syndrome: Recommendations of the national society of genetic counselors. *Journal of Genetic Counselling, 20*, 432–441.

StatCan (Statistics Canada). (2001). *Profile of disability among children*. Retrieved March 17, 2013, from http://www.statcan.gc.ca/pub/89-577-x/4065023-eng.htm

Stonebanks, C. (2010). On critical thinking, indigenous knowledge and raisins floating in soda water. In D. Tippins, M. Mueller, M. van Eijick, & J. Adams (Eds.), *Cultural studies and environmentalism: The confluence of ecojustice, place-based (science) education, and indigenous knowledge systems* (pp. 357–376). London: Springer.

Sulston, J., & Ferry, G. (2002). *The common thread: A story of science, politics, ethics, and the human genome*. London: Bantam Press.

Taylor, J. (1995/1999). Non-native teachers teaching in native communities. In M. Battiste (Ed.), *First nations education: The circle unfolds* (pp. 224–242). Vancouver: UBC Press.

Tucker, B. P. (1998). Deaf culture, cochlear implants, and elective disability. *Hastings Center Report, 28*, 6–14.

United Nations. (2006). *Convention on the rights of persons with disabilities*. Retrieved March 17, 2013, from http://www.un.org/disabilities/convention/conventionfull.shtml

Ure, G. (2009). *Mental health care in South Africa (1904 to 2004): legislation influencing ethical patient care*. Unpublished master's thesis. Johannesburg: University of the Witwatersrand.

van Eijck, M. W., & Roth, W.-M. (2007). Keeping the local local: Recalibrating the status of science and traditional ecological knowledge (TEK) in education. *Science Education, 91*, 926–947.

Wals, A., & Jickling, B. (2009). A framework for young people's participation in sustainability. In P. B. Corcoran & P. Osano (Eds.), *Young people, education, and sustainable development: Exploring principles, perspectives, and praxis* (pp. 77–84). Wageningen: Wageningen Academic Publishers.

Watt, J., Sinfield, I., & Hawkes, C. (2000). *Civics today*. Toronto: Irwin.

Westheimer, J. (2005). Schooling for democracy: Our schools, our selves. *The Canadian Centre for Policy Alternatives, 15*, 25–39.

Williams, G. C. (1966). *Adaptation and natural selection*. Princeton: Princeton University Press.

Wilson, E. O. (1980). *Sociobiology: The new synthesis*. Cambridge: Harvard University Press.

Wilson, E. O. (2007). *The creation: An appeal to save life on earth*. New York: WW Norton.

Wilson, E. (2012). *The social conquest of earth*. New York: Liveright.

Wray, N., Goddard, M., & Visscher, P. (2007). Prediction of individual genetic risk to disease from genome-wide association studies. *Genome Research, 17*, 1520–1528.

Giuliano Reis is an associate professor of science education at the Faculty of Education at the University of Ottawa. He the co-author of *Authentic Science Revisited* (2008) and a member of the editorial board of Cultural Studies of Science Education (CSSE) and the Journal of Research in Science Teaching (JRST).

Nicholas Ng-A-Fook is an associate professor of curriculum theory within the Faculty of Education at the University of Ottawa. He is the acting director of a Canadian Curriculum Theory Project and co-President of the Canadian Association for Curriculum Studies. He is the co-author of *Reconsidering Canadian Curriculum Studies* (2012).

Lisa Glithero A former school teacher, **Lisa Glithero** currently teaches at the Faculty of Education at the University of Ottawa where she is a full time doctoral student. She is the Founder and Director of the EYES Project (www.eyesproject.com) and served as Education Director for Students on Ice (www.studentsonice.com) from 2004 to 2008.

Chapter 5
The Sustainable Farm School—Waldorf Philosophy and EcoJustice Theory in Aesthetic Contexts

Kurt A. Love, Audra King, Katie L. Love, and Kimberly Gill

A Little Sprouts student in a field at the Sustainable Farm School. Kimberly Gill © 2013

K.A. Love (✉) • A. King • K.L. Love • K. Gill
Central Connecticut State University, Barnard Hall,
Room 226, 1615 Stanley St, New Britain, CT 06050, USA
e-mail: drkurtlove@gmail.com; kingaul@ccsu.edu;
lovekal@ccsu.edu; k@kimberlygill.com

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_5

The Sustainable Farm School in Connecticut (SFS) is an independent school for children 3–18 years old that draws in part from the pedagogical framework and philosophy used in Waldorf schools around the world, while aiming for transformative learning. Transformative learning is at the foundation for the creation of sustainability in nature-human communities. Transformative learning occurs at the nexus of peace (as a result of social justice and ecojustice), deeper levels of imagination (as a result of broadening one's thinking with possibilities and multiple perspectives), and reciprocity (as a result of strengthening our ties with the Earth and aiming for sustainability) (Love 2011). SFS advances the traditional Waldorf model by incorporating ecojustice theory as an equally important framework because of how the teaching and learning intersects with culture and ecology in a current world context. SFS's mission is to provide an educational experience that helps students become community members who critically examine local and global practices that compromise social, cultural, and ecological sustainability, as well as developing the knowledge and skills to be able to creatively produce and support sustainability. The aim of all programs and courses is to help students develop deep relationships with nature and to understand and be able to develop practices of ecological, social, and cultural sustainability. The curriculum for each program and course is rooted in our connections to the Earth. As the conceptual basis for the Farm School, this chapter demonstrates how the aforementioned relationships can be accessed through (a) meaningful play; (b) story-telling; (c) art that connects us with nature, to each other, and to our inner spirits; (d) feminist philosophy with a global perspective; (e) a critical examination of history; (f) a multicultural approach to understanding nature that questions human-over-nature perspectives; (g) food preparation that explores food politics and food growing practices; and, (h) holistic health and wellness. Let's begin with a brief history of Waldorf philosophy and education.

Rudolf Steiner's Vision and Waldorf Education

Rudolf Steiner developed the pedagogical and instructional models for the first Waldorf School that opened in 1919 in Stuttgart, Germany at the Waldorf-Astoria Cigarette Company. The Waldorf educational philosophy can be simply described as the development of the child's heart, hands, and head. This concept references an inherent connection in all courses to a general Earth-based spirituality, physical movement, and academic study. Subsequently, this form of education may be one of the most complex because it focuses on a student's development as being holistic, intuitive, emotional, mental, nature-based, and spiritual.

After witnessing widespread death and destruction in Europe during World War I, Steiner argued for the creation of a more explicitly compassionate, spiritual, and caring society where schooling would reflect his ideals. He focused on the foundations of schooling and its potential for positive impacts in the local community, if not the whole country. Steiner envisioned educational experiences for students that would be reflexive of their individual and shared needs and development. He described learners as moral and spiritual beings who could build a more balanced, safe, and interconnected society (Easton 1997). This philosophy can be compared with the philosopher Martin Buber (1987), who may have called Waldorf education grounded in "I-Thou" relationships of interconnection and care, which ultimately are the source of a healthy and balanced society. Steiner (2005) argued that the "healthy social life is found when the mirror of each human soul the whole community finds its reflection, and when in the community the virtue of each one is living" (p. 117). He believed that the schooling process needed to be based on meaning, morality, and holism.

Steiner (1995) was also a prominent voice in the development of anthroposophy, which argues that we can understand our spiritualities through scientifically based investigations and with the use of our intuitive experiences. Steiner (1995) asserted that (a) our process of thinking is not just cognitive, but that it is deeply embedded in our higher spiritual consciousness or from Eastern philosophy, our "higher self"; (b) it is necessary to not only be aware of our own energetic state, but to also create a balanced center in order to live a healthy life; and (c) our lives are in constant interaction with karma (the ebb and flow of energy throughout the universe that responds to our own actions and thoughts). Steiner developed his argument for Waldorf schooling from a spiritual perspective, while incorporating a scientifically and philosophically based inquiry processes to describe spirituality. Explicitly incorporating spirituality as part of the educational process and anthroposophy more specifically in U.S. public schools is a standpoint for many people (including the vast majority of educational researchers [see Rawson 2010]) which remains inappropriate and unsettling because of the apparent "separation" between church and state. Although strict adherence to anthroposophical views may not be preferred by some, many U.S. Waldorf schools use it as a guiding principle for developing a consciousness of holism and interconnection.

Waldorf philosophy follows children through their developmental stages of learning. Rather than rushing through the curriculum with the generally accepted idea that children are empty vessels to be filled, Waldorf Schools introduce age-appropriate skills through lessons that honor the child's naturally eager and curious spirit (Petrash 2002). Examples of Waldorf type lessons include having children learn to prepare a simple vegetable soup from scratch, creating paint colors from red, yellow, and blue with water color, and studying the life cycle of a leaf before they learn to read. While Waldorf teachers do not hold children back from reading, they are more interested in developing a child's sense of love, respect, beauty, and creativity, before introducing reading and writing tools.

Waldorf philosophy also integrates the natural world within the classroom as much as possible, including field trips outdoors. A beautiful and "Earthy aesthetic" can be observed, touched, smelled, heard, and tasted in a Waldorf classroom setting. Classroom materials, from wooden building blocks, to modeling beeswax, to recycled paper and hand-knit woolens are sustainably sourced and handmade whenever possible.

Exploring Spirituality and Interconnectedness

An educational experience that supports students' holistic development is widely supported by SFS faculty, staff, parents and students. A holistic educational experience, which we define as one that fully supports freedom, creativity, and imagination, cannot exist if social injustice persists (Greene 1995). In general, teaching and learning are described by well-respected scholars for over a century as a process that ought to be rooted in social justice. Consider the following examples. In 1901, Francisco Ferrer-Guardia (1913) created the *Escuela Moderna* (*Modern School*) in Spain using anarchist and democratic philosophies in order to critically examine issues of power and social injustice. W.E.B. DuBois argued in 1915 that an equal education can create a crucial bridge for Black Americans into society. Carter Woodson (2005), founder of Black History Month, claimed in 1933 that school curricula in the U.S. was deliberately Eurocentric, which acted as a continuing form of social dominance. Brazilian scholar, Paulo Freire offered in 1970 that teachers and students working together in a dialogic experience could pedagogically examine and create socially liberating paths to challenge oppression. James Banks in 1995 and Sonia Nieto in 1996 both offered paths towards multicultural education, rather than a Eurocentric one. Gloria Ladson-Billings argued in 2006 that the historical relationships in the U.S. have not created a learning gap as much as it has created an "educational debt" through slavery, segregation, and reinforced poverty, meaning that institutional and systemic practices of subordination and domination have deliberately slighted Black Americans.

U.S. schools have routinely produced learning experiences that are not very joyful or fulfilling; however, happiness and care are certainly possible and have a profound effect on the learners (Noddings 1992). Learning experiences can even be deeply rooted in compassion, inspiration, and interconnectedness (Palmer 1998). Although well intended, these arguments are regularly located within the social and cultural contexts of schooling with a seemingly deliberate separation from the development and/or significance of spiritual (non-religious) consciousness. While Steiner's philosophy is not taken up by the vast majority of scholars, it is quite regularly sought after by parents who seek out Waldorf schools (Rawson 2010). Perhaps, Steiner is often neglected because his work argues that the spirituality of students is a primary focus and foundation for the development of curriculum and instruction. Doing so in societies that inextricably link spirituality and religion while simultaneously upholding the separation of religious institutions and government might be a reason why spirituality of students is not explored in research literature as routinely as are race, class, sexuality, and gender, for example, which are linked more to hegemony and historically institutionalized forms of oppression.

Non-religious forms of spirituality may be emerging with more understanding, acceptance, and ultimately a possibility for a more common presence in schools. Gary Bouma (2006) argued that there has been a fundamental shift in western culture regarding the cultural assumptions undergirding spirituality from the traditional to rationale (authoritative to protestant approaches) and rationale to emotional and experience (protestant to individual spiritualities) since the mid-1970s. It is with this understanding that we have created the framework of spirituality for the Sustainable Farm School.

At the Sustainable Farm School, teachers support the inclusion of spirituality, especially as it is expressed through interconnectedness in coursework. Divorcing our spirituality from learning experiences implies an inappropriate separation from engaging "all of our being." We work from the starting point that we are physical, emotional, intellectual, natural (a part of nature) and spiritual beings. This position reminds us that deliberately creating learning experiences that deemphasize or ignore spirituality will hinder one's spiritual growth just as de-emphasizing any other human or natural domain would inherently make it less developed. At the same time, this philosophical underpinning for our school does not mean that we are supporting any one explicit form of spirituality from dominating in the school. We are not secular. We support students (and teachers) so they will have freedom to define spirituality for themselves and bring it to the fore of learning experience on their own terms. While we focus on the interactions of individual-community-nature-spirit, a climate of openness allows for interpretation and freedom. Students are free to reject as much as they take up different spiritualities that they are familiar with or that they might develop too.

The teachers at SFS have an understanding that creating an aesthetic context for spiritual exploration is necessary in their work, and this context provides the exploratory space needed for individual growth. In Carper's *Fundamental Patterns of Knowing* (1978), aesthetic knowing reflects being aware of the present situation with all senses. Aesthetic knowing involves a deep appreciation for the meaning of the situation, involves transformative art and action, and brings together all of the elements that make meaning whole. Our learning community, which is locally and globally interwoven with other schools, offer an overarching basis for aesthetic knowing as the teacher/student experience transformative learning and gain a holistic appreciation of the interconnectedness of the natural world. This learning experience ties together the health of our communities and development of a skill set which lends toward achieving what is most healthy for communities—sustainability (Kaminski 2008).

We use art, literature/mythology, farming/gardening, play, and community wellness as aesthetic contexts for the exploration of spirituality. Inspired by the Waldorf philosophy, we believe individuals prosper and deeply explore their individual paths more successfully in a simple, beautiful, and natural aesthetic. Therefore, we have programming on organic farms throughout the year. As part of this organic schooling experience, all aspects of tending to the land and animals are included as a significant part of the school curricula. As students begin to see deeper connections and become aware of interconnectedness that naturally occur at these farms, we invite them to explore the intersections of sustainability and spirituality, and it is the organic-farms-as-aesthetic-contexts that provide the space, because each of them provides different approaches and connections with spirituality.

Farms and gardens provide deeply aesthetic contexts for connecting and relational learning, as well as interpersonal, spiritual growth. Interestingly, Steiner (2011) is, not only an educational philosopher, but also an early philosopher of what we now call "organic bio-dynamic farming," which contrasts with commercial, large-scale farming practices. There are a few exceptions, but Steiner argues that we should understand the needs of the plant not only from the perspective of material needs (phosphorus, nitrogen, calcium, etc.). Additionally, there is a spiritual connection or *dynamic* condition of the plant-"being." Steiner (2011) argues, "inorganic forces breed only inorganic substances. Through a higher force at work in living bodies, of which inorganic forces are merely the servants, substances come into being which are endowed with vital qualities and totally different from the crystal" (p. 9). This way of viewing the plant offers a different mindset resulting in a paradigm of farming practices that takes into consideration the unique context and set of relationships that are present in every farm. Working within the context of unique relationships for every farm, rather than having a blanket approach regardless of the conditions (commonly done with fertilizing practices in the 1920s in Europe), means that the organic farmer must have a deep knowledge of their farms in order to create healthy growing conditions. In biodynamic gardening and farming, the very act of growing plants is a process that taps into one's spirituality because of the need to intimately know the Earth in relation.

Pedagogy of Sustainability, Eco-critical Examination, and Eco-imagination

A pedagogy of holism, fulfillment, and eco-social and eco-cultural visions are a logical compliments to Steiner's philosophy of spirituality and connection to nature. A combination of Waldorf and ecojustice approaches to teaching form the core foundation for the Sustainable Farm School. Ecojustice is also a pedagogicial approach that upholds the creative cultural and ecological commons as its primary unit of analysis (Gruenewald 2005). This philosophy is grounded in an understanding that nature and culture are not separate, as is often viewed in mainstream, western industrialized culture (Bowers 2006; Martusewicz et al. 2011). Ecojustice theories and pedagogies critically examine root mindsets that form and perpetuate anthropocentric, or human-centered, views in everyday practices. Ecojustice calls into question (a) practices of eco-racism and eco-classism whereby people of color and working class poor are disproportionately the recipients of pollution; (b) the western industrial culture's exploitive practices of non-westernized or increasingly westernized countries; (c) revitalizing the cultural and ecological commons; (d) critically examining root sources of cultural hubris that lead to anthropocentric mindsets and practices; and, (e) ending the mindset of human-over-nature relationship that makes the Earth contingent upon culturally constructed values and practices (Martusewicz et al. 2011). Ecojustice theorists argue that much of what is considered to be "living sustainably" is enclosed by private, for-profit interests, which largely change from local, commons-based living practices to long distance, large scale production that are wasteful and that compromise the health of the planet (see also, Shiva 2005).

The resulting pedagogy brings into the classroom critical examinations of western industrial culture, globalization, transcontinental business practices, soil depletion, farming practices, and food politics. These teaching practices can connect with community gardening, urban gardening, organic gardening, permaculture gardening, exploring one's community for sites of sustainability and cultural commons, and increasing knowledge of artistic, carpentry, botanical, farming, culinary, and homesteading practices that create more self-reliance and a reestablishing of local community relationships that lead to localized development and economies. Ultimately, these teaching practices recontextualize curricula so that the learning experiences are more connected to local knowledges, practices, and patterns of living that are more ecologically sustainable, supportive of cultural diversity, and that create a conscious of reciprocity between each other and nature.

Waldorf philosophy and ecojustice have common goals of connecting people with the Earth and developing an eco-emotional, eco-interpersonal consciousness. In Waldorf philosophy, the intention is to build an intuitive sense of connection of the self with nature and through nature. As students interact with nature as an aesthetic context and a source of inherent spirituality, students can gain inner balance, a sense of beauty of self in connection with nature, and a sense of peace that can transcend all academics. Similarly, ecojustice has a primary goal of developing a heightened consciousness with a strong sense of being part of nature and having a significant role in the reciprocity and nurturance of nature. However, ecojustice has a more explicit relationship with issues of social justice in community that Steiner implicitly engages with. Steiner argues that caring, holistic individuals in a community would inherently develop a more caring, holistic community, whereas ecojustice may implicitly agree, but it foregrounds the analysis of these issues, practices, and tensions in community. It is this partnership of the natural aesthetic from Waldorf philosophy with the justice-oriented analysis of ecojustice that provides a firm foundation for the Sustainable Farm School.

The Sustainable Farm School—Mission and Vision

The Sustainable Farm School's mission is to provide an educational experience for children ages 3–18 years old that inspires a lifelong love of learning, especially in terms of creating sustainable life skills. These skills are inquiry-oriented, contextualized socio-culturally and ecologically, and aesthetically/spiritually connected. SFS offers core academics and holistic personal development as a vehicle for helping students develop a plan for sustainable living inspired by aesthetics and a sense of interconnectedness. SFS aims to cultivate the skills and virtues needed for personal success through a balance between instruction, exploration, and discovery that lead to creating individual lives and communities that are more sustainable.

SFS provides learning experiences that foster independence, self-sufficiency, and collaboration with people of all ages and levels of ability. The overall trajectory of the school begins with a focus on developing relationships with nature through art and play. Students are gently and progressively introduced to academics within the context of aesthetics and nature. SFS students participate in daily farm/gardening chores in each of their programs. Learning to successfully interact with the land and animals prepares them with advanced skills and a love for nature. As the students move into the last 5 or 5 years, they do more social, cultural, and ecological analysis still in the context of aesthetics and nature, but with an added emphasis on indigenous and Earth-based mythologies, while simultaneously investigating sustainable technologies. We believe this will prepare students for their effective futures as community members.

We do not believe that providing a traditional and mainstream science educational experience will lead to a more sustainable world. In fact, the heightened, exclusive focus on observation, inquiry, experimentation, and objectification of nature may be a significant contributor to societies that are unsustainable. We do not believe that science education is being accountable to the health of the planet or nature-human communities (See Love 2012). Industrialized/post-industrialized societies tend to use scientific processes largely for profit (thereby, perpetuating consumerism and increasing waste), weaponry, and to perpetuate reliance upon large-scale farming, genetically modified foods, corporate farming of animals, and wide scale use of pesticides and antibiotics. SFS teaches the importance of scientific skills and problem-solving processes, but it is a school that includes critical examination of science (and by extension, technology) as being accountable to the Earth. Science is taught with great care and in accordance with the cycles of the Earth in order to move more successfully towards sustainability.

Waldorf philosophy aims for learning experiences that involve the head, heart, and hands. While some courses emphasize one or two of these over another, all courses find ways to implement all three learning modes. For example, from the very start in pre-school, children learn to finger knit, model beeswax, bake, sing simple mathematical verses, recite poetry, perform music, and they participate in classroom chores. As they get older they take on more advanced tasks and skills. In the middle and upper years, Science or Mathematics will include varying amounts of artistic drawings from the basic parts and functions of the Circulatory System and hand drawn representations of fractals found in nature. Students act out the pumping heart, the churning stomach, and the flowing blood in a rhythmic performance they will remember for years.

The school occurs at many diverse locations ranging from a fully operational organic farm to individual residences in suburban settings to a commercial space in a downtown area of a small post-industrial city, New Britain—still reeling from the massive job loss of the last 40 years. It also serves as a key part of the mission of the school because being at different types of locations means that students can see first-hand that growing food can happen in almost any living space no matter how restrictive the amount of land available might be. We also want students to see that even if they are not able to grow significant amounts of food in their immediate living space, they can be a very important member of their communities helping their local farms, being involved with community supported agriculture (or CSA), and community gardens.

A Sapling and a Solutionary student working together in large organic garden. Kimberly Gill © 2013

SFS teachers value the academic tradition, many of them holding university degrees in their field, while maintaining a natural connection to the Earth. Teachers are hired because they are visionaries in their fields, and the curricula of the school is formed largely by who is able to teach there, rather than having static curricula that instructors have to adhere to. SFS has general expectations for students at various stages, but these can be met in any given content and learning context. The content is shaped by the know-how, not the other way around. Each instructor, whether new to teaching or a seasoned veteran, is at the school because they offer learning experiences that are contexts for envisioning a balanced, creative, diverse, inspired, and sustainable society. Teacher selection process involves inviting community members or receiving requests from interested community members who are gifted in their fields. The director and assistant director vet the potential teacher through an interview process, share the overall framework of the school, and ask for a course title and description. The director and assistant director review the course information and decide whether or not to include the course. The assistant director provides ongoing support to the teacher throughout the duration of the course. Assistance usually involves working with content alignment and teaching methods within the overarching framework of the school. As the trimester continues, collaborations often turn towards making the content even better so that it matches the developmental levels and interests/needs of the students.

Selection of teachers is also connected to the teacher education program at Central Connecticut State University. Pre-service teachers who demonstrate a genuine interest and passion for this kind of educational environment are invited by the Assistant Director, Kurt Love, who is also a faculty member in the department. SFS has a mission of helping public schools to better incorporate a focus on an integrated approach to sustainability, as well as helping public school teachers to see possibilities and advance their own pedagogical practices. SFS utilizes interns from CCSU as some of its teaching staff in order to help them build their own teaching practices in connection with the framework of the school so that they can be more prepared to teach towards sustainability wherever they may go after teaching at SFS. CCSU pre-service teachers are generally willing to put in the extra time for this internship (which is additional to their programmatic field experience requirements) because they not only have an opportunity to design and teach their own course, but having the actual experience with this framework as an instructor is the best kind of preparation to help them in their future classrooms to teach an integrated approach to sustainability.

There are six programs at SFS: *Little Sprouts*, *Saplings*, *Explorers*, *Visionaries, Solutionaries*, and an after-school program for urban public school students. The Little Sprouts and Saplings focus on providing children with free play, artistic exploration, and farm/garden chores. The Saplings programs involve some introductory academic work, but the primary focus/work is largely incorporated through art and story-telling. The Explorer, Visionary, and Solutionary programs are organized by topic-driven courses that meet once per week over a 12-week trimester during autumn, winter, and spring. These courses include permaculture, organic farming, whole food preparation, handwork, mythology, herbology, music, art, science-fiction literature, sustainability and nature, history/civics, Capoiera, math of sustainability, research and presentation, yoga, and philosophy. Each term focuses on a different interdisciplinary cultural theme, unifying lessons and creating a diversity of understandings. During its first 3 years, students came from homeschooling environments, as well as those who recently left public schools. Students range in abilities with some having diagnosed learning disabilities. In total, the school served about 40 students per year, the majority being White, followed by American Indian, Black, and multiracial respectively. The largest numbers of students are in the Little Sprouts program.

The Little Sprouts program is for children ages 3–5 years old. This program offers children with a simple and natural rhythm that welcomes community work, play, and learning together. The program begins with a morning greeting song, after which the children begin their morning garden or farm chores depending on which site they are at. This time involves working together, whether it includes feeding the barnyard animals, watering the plants, sorting vegetables, or tidying up. Next we join for a snack, say a blessing of gratitude to honor and connect with our fresh vegetables, fruits, and crackers, and then proceed into “circle time.” During circle time, the Little Sprouts teacher draws simple math, science, and language principles into a few songs and poetry verses. Children sing along, get up and move through the gesture games and finger plays. This is their first introduction to simple academics in school. Circle time concludes with a story told, not read, by the teacher. Stories are theatrical and come with natural props and creatures to teach a value-centered lesson, such as practicing patience or sharing. After circle time, the children gather to create a handcraft, paint a watercolor picture, finger knit, model beeswax, or bake bread. The activity rotates through many different mediums, each one offering a new opportunity to build fine motor skills and inspire creativity. After tidying up together, the children have free play, where they can "make believe" and experiment with dollhouses, a wooden kitchen set, musical instruments, and many more natural and often handbuilt toys. When the weather is cooperative, children spend much of their free playtime running through wide-open fields or exploring a nature path near the school with their teacher.

The Saplings program is for children ages five to seven. The Saplings follows a similar routine to the Little Sprouts, with age appropriate garden chores, songs, and activities. The primary difference is that the Saplings have a main lesson instead of circle time. The main lesson is an hour-long academic lesson that incorporates science, language arts, history, math, and multiculturalism. The Saplings begin to learn more skills for homesteading (garden to table, homemade recipes, and handmade objects) during their chore and activity time. For instance, they prepare soups, more complicated bread recipes, learn to sew and knit.

The Explorer program is for children ages seven to ten. At this age, students may explore a variety of academic subjects including language arts, science, math, and history. In addition to the traditional subjects, we offer herbology, circus arts, whole food preparation, Capoeira, homesteading, and handwork, amongst others. Students explore the relationships of their content area classes with relationships to the real world, focusing especially on empowerment. Gardening and farming experiences remain present, and act as an important intellectual and aesthetic "anchor" for the curriculum at this stage. To do so, instructors continuously provide learning experiences that involve students in connecting academic skills with real world possibilities and first-hand experiences that create a real sense of confidence with abilities to work with others. The curriculum is deeply contextualized to allow for meaningful work that has a purpose because it is seen immediately in our communities.

The Visionary program is for students ages 10–13. This program helps students develop their visions of sustainable communities of wellness. As students become more comfortable with critical issues that affect sustainability and wellness within these communities (local, as well as global), they are encouraged to examine potential solutions. Develop ever-growing visions of healthy, happy communities that are working to become more and more sustainable. There is an increased focus on academic subjects within real world, first-hand learning contexts such as farms, gardens, and democratic experiences with local municipalities.

Students preparing soups with vegetables from an organic garden. Kimberly Gill © 2013

The Solutionary program is for children ages 13–18. Students build their visions so that they can develop skills and strategies for solutions that are sustainable, peaceful, and democratic. Students intensify their work in academics like literature, mathematics, art, history, and science, but with a goal to use these as a base for critical examinations and experimentations with creating practices of sustainability in their own lives and working with local and global communities. They learn public speaking, debating, critical forms of analysis of social and ecological issues, volunteering, and connecting with public officials to share experiences and opinions. Instructors in this program focus on developing deep contexts for learning that are immediately connected to the real world and provide first-hand experiences.

Students of different programs at SFS often come together for courses and various activities in order to have experiences across age groups that can promote stronger relationships, mentorship, and appreciation of difference. They may spend part of the day participating in farm and garden chores and also during lunchtime. Some classes such as Capoeira and herbology are combined for Explorer, Visionary, and Solutionary students.

SFS students do not receive grades in their courses; rather, they are held accountable for their classwork, homework, projects, or presentations based on goals that they set with their instructors and families. The aim is to provide aesthetic, meaningful, and critical contexts for learning while strengthening core academic work that helps students develop meaningful experiences that genuinely help them grow cognitively, emotionally, artistically, and as a member in community. Connections to the community are often the reason for a lesson, and academic rigor comes from having a real world reason to study content.

Visionary and Solutionary student working with farm manager, Loren Pola at Sun One Organic Farm in Bethlehem, Connecticut during their Farm Economics course. Kimberly Gill © 2013

There are two after-school programs: one in New Britain, and one in New Haven. Each program has its own independent structure, and it meets once or twice per week throughout the year. The focus in both programs is urban gardening. A partnership with Central Connecticut State University's community outreach center works with New Britain High School students. Since urban organic gardening is the focus, the after-school program has its own small garden located right on Main Street in downtown New Britain. The high school students design and maintain the urban garden, while also learning about issues of sustainability and diversity. In New Haven, students work on a residential site that is converting over to a more permaculture-oriented space.

Three Courses at SFS

Urban Gardening, Philosophy, and Holistic Nutrition

There are many courses at SFS that reflect the framework of the school, and each would be appropriate to describe in this section. Three courses, Urban Gardening, Philosophy, and Holistic Nutrition, are described below to provide three different approaches of how aesthetics, culture, and ecojustice are explored.

Urban Gardening

Students from New Britain High School in New Britain, Connecticut come to an after-school program that focuses on enrichment experiences.

They meet at Community Central, which is a community outreach program operated by Central Connecticut State University. The course starts in February and meets every Monday and Friday until the end of the school year in June. The course has three main objectives: explore issues of social and ecological sustainability, design and create a small urban garden right on Main Street where Community Central is located, and help students who are interested to plan their own gardens at their homes.

After-school high school students building a raised bed garden with course instructor, Jenny Naes, in downtown in New Britain, Connecticut. Kurt Love © 2013

New Britain is a post-industrial city with about 73,000 people with about 48 % White, 37 % Latino, and 13 % African-American with about 49 % speaking a language other than English at home and about 21 % below the poverty line according to the 2010 U.S. Census. New Britain has a range of supermarkets regarding cost. New Britain is also unique because it is the only small city in the state that has a small organic farm. Most students, however when asked, do not know about this farm.

Since February and early March in Connecticut tend to still be cold and snowy, there is very little gardening work that can be done outside. Therefore the first month of the course focuses on issues of sustainability and intersections with culture, social justice, and food security issues. Students look at how work around the country is being done to provide fresh foods in areas that have little access to fresh food, such as Growing Power in Milwaukee and Chicago, and community gardens in Detroit and in Hartford. We discuss the importance of having a vision of balance and wellness in any community and how that applies to their own communities. The focus then turns to an introduction to gardening and planning for the $3' \times 12'$ raised bed that is adjacent to Community Central, as well as what the students want to do in their own living spaces including some container gardening or small gardens with their families. Students choose the plants that they want to grow, and they do some initial plantings inside with small containers and trays while there is still a threat of frost. The garden is planned such that early season plants like lettuce and strawberries available before the end of the school year. When students return in September, they have late season plants like tomatoes, peppers, more lettuce, jalapenos, and cucumbers. The focus then turns towards food preparation with organic, seasonal foods into late autumn. The intention of this program is provide an education of the cycle of garden-to-table processes and delve into the issues of food accessibility and politics in urban environments.

Philosophy

Students learn in a philosophy class that the lives and actions of individual human beings, at all times, both shape and are fundamentally shaped by their relationships not only with one another, but with all other living things in this world (Young 2000). How these relationships are structured and the ways in which they function have profound impact on the possibilities for and well-being of all of life, both present and future. When our relationships with other human beings, with non-human animals, or with nature as a whole, are shaped by ideologies of domination and systems of power, the results are not only oppressive for those subordinated by such systems, but they also are destructive for those who stand in the positions of power, not to mention the impact such relationships have for future generations of life (Shiva 2005). This is apparent when we note the inescapable interconnectedness of all living things—a reality that means harm to some means harm to all. If we are to flourish, as human beings and, more importantly, as part of an interconnected whole, then it is crucial that we begin to question and work to transform the many hierarchical relations of domination that define much of contemporary reality, including those that arise among human beings—such as those based on nationality, race, gender, ethnicity, and the like—as well as those structuring the relations between species, especially humans and non-human animals. It is precisely this aim—to question dominant relations of inequality and the ideologies that foster them—that serve to motivate our conversations on animal welfare.

This class is open to Upper School students and designed to promote students' abilities to critically engage with and reason about moral and philosophical questions. The first unit focuses on moral issues and concerns surrounding animal welfare. Specifically, students examine the character of human-animal relationships in the contemporary world. They begin the course with a brainstorming activity in which they identify common social practices involving animals, with particular emphasis on the treatment of animals in the United States. Among the items on the list are: zoos, farms (factory and other), butchers, circus, service dogs, dog fighting, puppy mills, pets, and research. The students examine the items on the list, and then are asked to describe each practice in terms of its purpose, its assumed 'value' or justification, as well as identifying any initial moral concerns that it raises. The aim of this activity is to spend time as a class reflecting on the key assumptions and values underlying the treatment of animals within contemporary western society (Grasswick 2004). This provides the basis for examining dominant ideologies and how these shape the relationship between humans and non-humans.

The students spend the next four class periods examining three specific practices involving animals: factory farming, medical research, and other types of animal research, such as for testing the safety of cosmetics. For each practice examined, students are asked to describe the lives of the animals involved in those practices, and tell stories from he perspectives of the animals. In so doing, they seek to connect empathically with animals, thereby challenging dominant ideological views that serve to disconnect us from other living things; and which present 'human' interests as the only interests. Students express their emotional reactions to this activity in ways that foster deep moral reasoning, enabling them to draw from our discussions of specific practices, broader moral principles for and lessons about the treatment of animals. Thus, in the fourth class, we examine some general moral lessons that we might take from our discussions of factory farming and animal research. Among the questions we address are: What types of relationships do these practices promote between humans and animals? What is morally wrong with these realities? How should these relationships be transformed so they are more in balance with justice and morality (Grasswick 2004)? Based on student's answers to these questions, we create a chart outlining what they perceive to be more harmonious and moral relationships between relevant beings. The students also discuss the implications of the lessons for our own lives and actions, as well as for society as a whole.

The final classes for this philosophy unit focus on reconnecting the students to their communities. Thus, we begin by discussing ways we might put our knowledge to use so to promote a healthier, more just community (Hoffmann and Stake 1998). Ultimately, the students decide that they would use the mediums of art and writing to become advocates for social change. Toward this end, the students each create posters in which they illustrate their moral perspectives on particular practices involving animals. One student, for instance, creates a comic strip while another student draws a monkey who had been subject to medical testing. To accompany these pictures, the students also write letters to companies in which they argue against the use of animals in research and propose alternatives that the company might use in the place of animals. These activities are of critical importance to eco-justice in that they re-connect students and knowledge to their communities and foster their participation as democratic citizens and change agents (Shiva 2005).

Holistic Nutrition

The health of a community, both place and people, is a way of approaching human health and wellness that supports the main tenets of ecojustice including an analysis of culture, politics, and assumptions, and offering a holistic and place-based pedagogy (Bowers 2001). The holistic nutrition course is developed for the students in the lower school, but open to the students in the upper school when their excitement and interest become apparent. This course incorporates ecojustice pedagogy through the utilization of the ecological commons as a unit of analysis, exploration of eco-injustice through exploration of food labeling, and the revitalization of cultural commons through shared origin stories.

Each class has three components: food preparation and eating, story-telling, and nutritional analysis. The class starts with a simple recipe that the students will help prepare and eat. A main ingredient from the recipe is the focus of story telling during food preparation. The stories shared are origin stories or folktales from all over the world surrounding that one food item. For example, when preparing coconut rice and beans stories about the coconut were shared including a tale from Myanmar about how a mischief maker got stuck in a coconut and that is why sloshing is heard when it is shaken. Another tale from India is about a girl who falls in love with the God of the eels, and as a gift he gives her a coconut. The story teaches about how all parts of the coconut are useful for food, water, and fiber, and also explains the "face" on a coconut as the two eyes and nose of an eel.

Katie Love teaching Explorer students during a holistic nutrition class. Kimberly Gill © 2013

These stories reinforce Waldorf philosophy by connecting the children to the food they are working with in a deeply meaningful and spiritual way through understanding the people, places, languages, and cultures that surround it. Lincoln (2000) describes this approach as aligned with ecospirituality, and considers it to be of paramount importance for youth. Ecospirituality is the intuitive awareness of all life, which reflects our responsibility within this relationship, and the deep sense of unification that exists in this level of interconnectedness. It helps to support students' journey as global community members, and increases their desire to be more adventurous with nutritious foods. Conversation also continues during mealtime about the nutritional science of their meal. The students learn to critically read food labels, where food comes from, clarification about terms such as "low fat," or "heart healthy", and finally, what macronutrients the food contains in the form of carbohydrates, protein, and fat.

An educational experience should holistically support a student's "heart, heads, and hands" as mentioned above, and this format for the holistic nutrition course supports all three aspects of self. In addition to the structure of the course, the students are also supported as spiritual beings through self-reflection, journaling projects, and meditation. Students who are viewed as spiritual beings find validation and empowerment to be successful learners (Delany 2006; Dudlt-Battey 2004). "Teaching about holism is not the same as teaching holistically" (Love 2008, p. 263), and students are in a classroom space at the SFS where they can experience both. At the beginning of class the group sometime engages in deep breathing exercises and a brief guided meditation to focus the group collectively to the learning tasks to be accomplished during the period. On days when more controversial issues are discussed (in one case for example, religious restrictions on eating, genetically modified organisms, or political vegetarianism) the class is also guided to create a safe space of disclosure and open mindedness. This process is repeated at the end of class as a way of creating closure, encouraging relaxation, and reconnecting, which fosters a sense of community within the SFS.

Cultivating Caretakers of Their Community

We are purposefully trying a different approach to education that directly addresses the larger ecological issues we are all facing. However, instead of just taking a mainstream environmental education approach, we have created a school that is formed around the concept of interconnectedness and reciprocity with nature. Another common thread present with the parents, students, instructors and directors is that public schools are restricted sites of empowerment and exploration, which has been written about extensively in academic literature. These two concurrent conditions are dangerous for the whole of a society. Our hope with this school is to develop it well, help grow students who become caretakers within their communities and have a consciousness of sustainability and reciprocity.

For more information, go to: http://sustainablefarmschool.com and you can see our artwork at: https://www.facebook.com/SFSCT

References

Banks, J. (1995). Multicultural education and curriculum transformation. *Journal of Negro Education, 64*, 390–400.

Bouma, G. (2006). *Australian soul: Religion and spirituality in the 21st century*. Cambridge: Cambridge University Press.

Bowers, C. A. (2001). *Educating for ecojustice and community*. Athens: University of Georgia Press.

Bowers, C. A. (2006). *Revitalizing the commons: Cultural and educational sites of resistance and affirmation*. New York: Lexington Books.

Buber, M. (1987). *I and thou*. New York: Collier Books.

Delany, C. (2006). Facilitating empowerment and stimulating scholarly dialogue using the world cafe model. *Journal of Nursing Education, 45*, 46.

Dudlt-Battey, B. (2004). Using the holistic paradigm in teaching. In *Development of students, nurses, and teachers* (pp. 345–355). New York: Springer Publishing Company.

Easton, F. (1997). Educating the whole child, 'head, heart, and hands': Learning from the Waldorf experience. *Theory Into Practice, 36*, 87–94.

Ferrer-Guardia, F. (1913). *The origin and ideals of the Modern School* (J. McCabe, Trans.). New York: G. P. Putnam's Sons/Knickerbocker Press.

Freire, P. (1970). *Pedagogy of the oppressed*. New York: Continuum.

Grasswick, H. (2004). Individuals-in-communities: The search for a feminist model of epistemic subjects. *Hypatia, 19*(3), 85–120.

Greene, M. (1995). *Releasing the imagination*. San Francisco: Jossey-Bass.

Gruenewald, D. A. (2005). More than one profound truth: Making sense of divergent criticalities. *Educational Studies: A Journal of the American Educational Studies Association, 37*, 206–215.

Hoffmann, F. L., & Stake, J. E. (1998). Feminist pedagogy in theory and practice: An empirical investigation. *NWSA Journal, 10*(1), 79–97.

Kaminski, J. (2008). EcoNurse: Using ICTs to weave ecological activism into the tapestry of nursing curriculum. In *WRCASN conference*, Victoria, British Columbia on 23 Feb 2008.

Ladson-Billings, G. (2006). From achievement gap to educational debt: Understanding achievement in U.S. schools. *Educational Researcher, 35*, 3–12.

Lincoln, V. (2000). Ecospirituality. A pattern that connects. *Journal of Holistic Nursing, 18*, 227–244.

Love, K. (2008). Interconnectedness in nursing: A concept analysis. *Journal of Holistic Nursing, 26*, 255–265.

Love, K. (2011). Enacting transformative education. In C. Mallot & B. Porfilio (Eds.), *Critical pedagogy in the twenty-first century: A new generation of scholars* (pp. 419–453). New York, NY: Information Age.

Love, K. A. (2012). Politics and science textbooks: Behind the curtain of "objectivity". In H. Hickman & B. Porfilio (Eds.), *The new politics of the textbook: Critical analysis in the core content areas* (pp. 133–150). Rotterdam, The Netherlands: Sense.

Martusewicz, R., Edmundson, J., & Lupinacci, J. (2011). *Ecojustice education: Toward diverse, democratic, and sustainable communities*. New York: Routledge.

Noddings, N. (1992). *The challenge to care in schools: An alternative approach to education*. New York: Teachers College Press.

Palmer, P. (1998). *The courage to teach*. San Francisco: Jossey-Bass, Inc.

Petrash, J. (2002). *Understanding Waldorf education: Teaching from the inside out*. Beltsville: Gryphon House.
Rawson, M. P. (2010). Sustainable teacher learning in Waldorf education: A socio-cultural perspective. *Research on Steiner Education, 1*, 26–42.
Shiva, V. (2005). *Earth democracy: Justice, sustainability and peace*. Cambridge: South End Press.
Steiner, R. (1995). *Anthroposophy in everyday life*. London: Rudolf Steiner Press.
Steiner, R. (2005). *Verses and meditations* (G. Adams, Trans.). London: Rudolf Steiner Press.
Steiner, R. (2011). *Agriculture course: The birth of the biodynamic method* (G. Adams, Trans.). London: Rudolf Steiner Press.
Woodson, C. G. (2005). *The mis-education of the negro*. Mineola: Dover.
Young, I. M. (2000). *Inclusion and democracy*. Oxford: Oxford University Press.

Kurt A. Love has a Ph.D. in Education from the University of Connecticut. He specializes in science education, ecojustice theory and pedagogy, and curriculum and instruction. He is the Assistant Director of the Sustainable Farm School and an assistant professor in Department of Teacher Education at Central Connecticut State University. He is an advocate for permaculture, community gardening, fossil fuel divestment, and localization of economies and education.

Audra King has a Ph.D. in Philosophy from the University of Colorado at Boulder. Her main areas of specialization social and political philosophy, global justice, and feminist philosophy. She is currently teaching Philosophy, Reasoning, & Social Justice at the Sustainable Farm School and serves as assistant professor of Philosophy at Central Connecticut State University.

Katie L. Love is an assistant professor of Nursing at the University of Saint Joseph and director of the Multicultural RN-BS program. She is the director of sustainability in Health and Wellness at The Sustainable Farm School and teaches holistic nutrition. She is also mother to a 2-year old and twin infants.

Kimberly Gill is the founder and director of the Sustainable Farm School. Kimberly completed her undergraduate work in Sociology and Economics at Westmont College and postgraduate work in fine art at Pratt Institute. She worked as a private teacher for children from various alternative and Waldorf schools in California, New York City, and Poland. Kimberly created SFS because of her lifelong dream to provide children and families of all backgrounds with a holistic education and a model for sustainability.

Chapter 6
Building Teacher Leaders and Sustaining Local Communities Through a Collaborative Farm to School Education Project—What EcoJustice Work Can PreService Teachers Do?

Patricia Bricker, Emily Jackson, and Russell Binkley

As the third graders approached the pumpkin patch, their excitement grew. Each of them set off to search for the just right pumpkin to pick for Mr. Shelton, the farmer and our field trip host. An inquisitive girl stopped to admire a bright yellow flower and said to her teacher, "I wonder how this flower got into the pumpkin patch." A few moments later, two boys discovered green pumpkins. Screams of "They're deformed!" rang through the field. A plan began to brew in my mind. After a brief chat with Mr. Shelton to make sure my plan wouldn't interfere with his farming efforts, I asked the girl who discovered the flower to pick a few to bring back to our meeting area for a group discussion, and I asked the boys to bring a green pumpkin as well. We continued on our farm tour, stopping to observe and learn about a beaver dam on the edge of the field, all while the students excitedly carried their pumpkins and field findings. Back at our meeting area a little while later, we gathered together and I presented our field discoveries. "In the field people found orange pumpkins, yellow flowers, and green pumpkins. What do you think the story of these objects is? How did they all wind up in the same field?" In small groups that included a blend of 3rd graders and undergraduate preservice teachers, they observed, discussed, and journaled. We gathered together again and groups began to share. With help from each other and some scaffolding from me, we collectively created the story of the pumpkin life cycle—from flower to green pumpkin to orange pumpkin. Mr. Shelton jumped right into the discussion by cracking open

P. Bricker
School of Teaching and Learning, Western Carolina University,
120B Killian Building, Cullowhee, NC 28723, USA
e-mail: bricker@email.wcu.edu

E. Jackson
Appalachian Sustainable Agriculture Project,
306 West Haywood St, Asheville, NC 28801, USA
e-mail: Emily@asapconnections.org

R. Binkley (✉)
School of Teaching and Learning, Western Carolina University,
224B Killian Building, Cullowhee, NC 28723, USA
e-mail: rbinkley@email.wcu.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_6

a big orange pumpkin so everyone could see the seeds inside and reminded us all about the importance of the seeds and the green plant that produces the flowers. (Patricia Bricker, Teacher Educator, October 2011. A Community of Practice in Action)

William Shelton, the aforementioned host of the farm field trip, is a fourth generation farmer in Whittier, a small community in Jackson County, North Carolina. William describes the challenge of farming and retaining the culture of agriculture:

Whittier is not a farm area anymore. We're just a kind of fringe zone in a larger tourist area now. That being sadly the case, those of us in these fringe areas need to work together to gain recognition as an integral part of the total local culture. This will be something of an uphill battle when the public perception of farmers is somewhat dubious and when there is such a huge gulf between farm and non-farm populations and when the youth are completely out of touch with rural farm life. Why most of the young people, even around here, wouldn't be able to say 'sooey' if a sow bit 'em! (Crowe 2002)

Western North Carolina is home to almost 12,000 family farms like William Shelton's (Appalachian Sustainable Agriculture Project [ASAP] 2009). Most of the land in Western North Carolina is privately held and provides a beautiful back drop for the number one industry today— tourism. But for too long, farmers have not benefited from the tourism dollars while it is the farmland (and the lovely mountains) that holds the attraction for tourists. Farmers need to be able to stay on the farm, to earn their livelihood, or at least a part of it, from the land.

Collectively these farms generate more than $500 million in sales. These sales support farm jobs. The phrase 'farm jobs' is not heard much, and when it is used, typically describes any labor force the farm may employ as opposed to the entrepreneurs who own and run the farm. (ASAP 2009, p. 5)

Agricultural land provides food and jobs but also something equally important – our mountain ways and culture – the "culture" of agriculture. Food traditions brought over with the Scottish and Irish remain today; farmers and their families not only growing and eating the crops that were from their traditions, but engaging in the traditions of that food. That's why Western North Carolina (WNC) is not known for its "southern" food but its "Appalachian" food, such as sorghum molasses and greasy beans.

WNC farms are small (half the state average, a quarter of the national average). Due to their size and challenging growing conditions it is still difficult to eke out a living farming. These tough living conditions are slowly changing but global influences are strong and ever-present. In the mid-1990s, with the looming elimination of a tobacco quota system that kept prices high, there is real concern that the culture of agriculture in WNC will be significantly impacted. Burley tobacco, long the staple of the farming community, provides a stable and resilient crop that keeps many mountain farms in production. But the tobacco buyout in 2004 removes much of the support for growers. The 2004 tobacco buyout is the final straw and by 2007 we have lost more than three-quarters of the tobacco growing income our region enjoyed just 5 years earlier.

Appalachian Sustainable Agriculture Project (ASAP) begins its work in response to the changing climate of farming. Knowing that the loss of small family farms is already a growing problem, ASAP begins to explore a "buy local" campaign.

Consumer surveys indicate that WNC residents are eager to purchase locally grown food and even willing to pay a bit more if they knew the food came from local farms. In 2002, ASAP becomes a nonprofit and creates the first Local Food Guide. It begins providing business planning and other services that promote local food and farms.

Another pivotal piece to the puzzle is added in 2002; ASAP begins its Growing Minds program. Beyond a vibrant agricultural community, ASAP is concerned that children in WNC and the Southern Appalachians are growing up without a connection to their agricultural heritage. Though raised in predominantly rural settings, children are quickly becoming distanced from where their food comes from and knowledge of food production. What starts as a school garden program at an elementary school in Haywood County quickly morphs into a full-fledged Farm to School program. In addition to school gardens, Growing Minds also provides resources and training to teachers, Child Nutrition Directors, farmers, and parents so that area children are exposed to farm field trips, cooking with local foods in the classroom, and school lunches that include food from local farms. These place-based strategies are key to developing healthy relationships with food while enriching the overall educational experience. Today, and for the past 7 years, ASAP continues to be the Southeast Regional Lead Agency for the National Farm to School Network.

In 2009, rather than relying on classroom teachers to embrace the Farm to School concept, ASAP decides to take an "upstream" approach. With funding from the Blue Cross Blue Shield of North Carolina Foundation and in partnership with Western Carolina University, a Farm to School preservice project is initiated. Farm to School is integrated into the science methods class and into the Community Nutrition class in the Health Sciences Department. Rather than relying on the classroom teacher to become interested in integrating Farm to School into their classroom instruction, ASAP reaches out to beginning teachers. Getting university students excited about school gardens, farm field trips, and cooking with local foods begins to offer a much more sustainable model.

EcoJustice and Farm to School

We approach this work using an ecojustice framework rooted in Orr's (1994) call for education to instill "biophilia" or a love of life. Ecojustice helps students understand their role as stewards of the natural world (Mueller and Pickering 2010). It prepares teachers and students to develop what Lowenstein et al. (2010) call "place consciousness," or an awareness of what beliefs, practices, and activities make up the places they inhabit. The central focus of ecojustice is reaching an understanding of the tensions between cultures (i.e., intergenerational knowledge and skills, beliefs and values, expectations and narratives) and the needs of the Earth's ecosystems (Mueller 2009).

Ecojustice is more significant than the mere material advancement of the world's underclasses by creating a place for the "cultural commons". The commons is both the ecosystem (water, air, soil, biomes) and the knowledge and wisdom passed down through generations (indigenous medicine, arts, and ceremonies (www.ecojusticeeducation.org). Chet Bowers notes that,

> the traditions of intergenerational knowledge and patterns of mutual support that enable people to live in ways where market forces do not dominate everyday life have been around since the beginning of human history … all of the forms of knowledge, values, practices, and relationships that have been handed down over generations that have been the basis of individual and community self-sufficiency—and that have enabled members of the community to be less dependent upon a money economy. (2010, p. 1)

A commons-based society will place as much emphasis on democratic participation and environmental protection as it does on economic competitiveness and private property (Walljasper 2010).

Ecojustice education analyzes the threat to survival of the world's diversities: nature, languages, and cultures, which consumer culture incubates; ecojustice education advocates a revitalization of the commons and a commitment to its sustainability. The foundations for ecojustice theory extend from ecofeminism (examining the relationship between nature and women with emphasis on the challenges that women face), indigenous education (seeing humans as dependent upon living in harmony with nature), and earth-based spirituality (Love et al. 2010).

Martusewicz and Schnakenberg (2010) advocate coupling usually discrete school subject areas with science. For example, social studies content can be used to analyze how some of our values lead to social violence and ecological devastation. We can reinforce the local and global cultural commons, not just socializing children into exploitation of nature and overconsumption. Rubenstein et al. (2006) also advocate for education that taps into what used to be common knowledge—plants' life cycles (and their parts), gardening in different zones, why it matters where our food comes from, what plants are appropriate, and following traditional recipes.

Mueller (2009) cautions that ecological 'crisis thinking' should be tempered, as it leaves little room for hope and that pessimism may inadvertently perpetuate 'ecophobia' or fear of nature. In the same vein, Tatarchuk and Eick (2011) advocate for nature as a place for exploration and appreciation. Nature is an important 'outdoor classroom' and powerful tool within the context of our test-driven era. Locally, schools ought to reflect their communities and demonstrate concern for how they affect their surroundings. Moreover, schools might teach ways of living that offer minimal ecological impacts (Bartz n.d). Correspondingly, the Farm to School program values highly the surrounding communities and this was a major reason why farmers have been attracted to participate. Farmers are not solely interested in selling their products; they join Farm to School programs to promote social good, healthy food for children, and to promote agricultural education (Izumi et al. 2010).

EcoJustice Through Communities of Practice

Our project is also guided by Wenger's (2006) vision for communities of practice in which the Farm to School focus brings together a range of people with diverse experiences to participate in joint activities and discussion through sustained interactions over time. Three elements define a community of practice: *domain*, commitment to the domain and a shared competence that defines its members; *community*, a group of practitioners who act together, help each other, and share information (members must interact at times); and *practice*, practitioners develop a repertoire of resources, experiences, and ways of solving problems. In education, the community of practice reaches into all aspects of living and learning in the outside world—the school or class is not the center of that learning. All participants, practicing teachers, university faculty, and preservice teachers "become communities of practice when learning occurs through peer interaction" (Enfield and Stasz 2011, p. 113). As preservice teachers form their identities, those who participate in communities of practice, both in schools and in the wider community, realize the learning inherent in *becoming* a teacher (Carter 2012).

The ASAP/WCU Project: Values and Curriculum

Our project begins with 49 junior-level university students enrolled in an elementary and middle grades education science methods course. There are a few middle grades and special education majors, but most of the participants are elementary education students. We dedicate one three-hour class to a Farm to School workshop led by ASAP educators, in collaboration with the course instructor. The workshop begins with a 45 min whole group interactive session that introduces ASAP and its mission, provides an overview of Farm to School programs, highlights curricular connections, describes resources available, and explains this pilot project—including the possibility that students can apply to be part of the phase two implementation stage to be conducted in the following academic year. Students split into groups and for approximately 90 min actively participate in activities at three centers focused on cooking, seeds, and soils/rocks and designed to meaningfully integrate required goals and objectives across the curriculum. The workshop ends with a whole group debriefing session and reminders about ways to be involved in the ongoing Farm to School project. All students receive CDs with a large collection of Farm to School materials including background information, lesson plans, integration ideas, book lists, field trip support, gardening resources, and recipes. The workshops are supplemented by a required Farm to School reading and an optional Farm to School Open House targeted towards the university community, local public school educators and nutrition staff, and local farmers.

Students are surveyed before and after the workshop (one-group pretest-posttest design, n = 49), observational notes are taken during the workshop, and we analyze documents used such as PowerPoint slides and handouts. We discover that students are highly engaged throughout the workshop. As shown in Table 6.1 and Fig. 6.1,

Table 6.1 Comparison of students' thoughts about farm to school, pre and post

	Pre		Post				
	M	*SD*	*M*	*SD*	M_{diff}	95 % CI	*d*
Awareness	2.12	1.09	3.98	0.88	1.86	1.46–2.26	1.88
Interest	3.58	1.01	4.29	0.76	.71	.35–1.07	.79
Importance	3.34	1.03	4.41	.67	1.07	.72–1.42	1.23

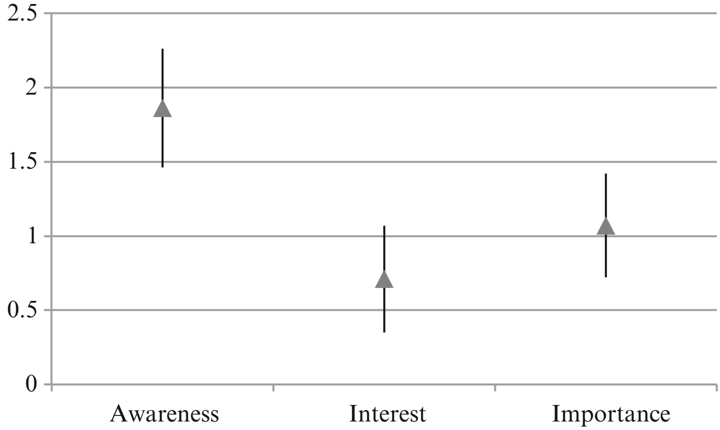


Fig. 6.1 Mean difference (post-pre) and 95 % confidence interval

survey results indicate that workshop participation is associated with increased awareness ($M_{diff}=1.86$ on 5 point scale), sense of the importance ($M_{diff}=.79$), and personal interest ($M_{diff}=1.07$) in local food and farm-based instructional options.

Open-ended survey comments and observational notes provide additional insight into the impact of the Farm to School activities and two themes are identified. The first theme, *Values*, refers to ways in which participants found Farm to School to be worthy or of importance. Many participants mention the larger Farm to School vision of making a difference for students and communities. As illustrated in Table 6.2, participants specifically note their attention to healthy children, environmental stewardship and community connections, and the engaging aspects of the program for teachers. Their interest in healthy children frequently emphasizes concern about obesity in a general sense but also on a personal level as observed when a participant shares: "I have a ten-year-old old sister and I noticed a lot of her classmates are a bit overweight for their age. I want her to have a healthy life so I'd like for her to be influenced more at school." One participant says that Farm to School "helps form a community through working together. It also helps the environment." Still others explain that Farm to School encourages students to think about the importance of local agriculture and where their food is grown, helps the local farmers, and supports the economy. The second identified theme is *Curriculum*. Participants say that a variety of curricular topics are included in Farm to School and pay particular attention to science, health, and integration. They also focus on teaching methods and describe Farm to School as engaging, hands-on and minds-on, and authentic.

Curricular Issues, Affect, EcoJustice, and Agency/Leadership

A subset of phase one participants is selected to move onto phase two of the project in the subsequent academic year. Educators from ASAP and WCU collaborate with five university students in elementary and middle grades education and five

Table 6.2 Impact of farm to school activities: Themes, subthemes, and illustrative quotes

Theme	Subtheme	Illustrative quotes
Values	Healthy Children	*I have a 10 year old sister and I noticed a lot of her classmates are a bit overweight for their age. I want her to have a healthy life so I'd like for her to be influenced more at school.*
		Because of the current epidemic of obesity and diabetes I believe a teacher's role in nutrition should be a significant component of the curriculum.
		…helps children eat healthier, be more active, get outside more.
		I like this type of instruction [because it] will hopefully inspire children to be healthier.
	Environmental Stewardship and Community Connections	*It helps form a community through working together. It also helps the environment.*
		It is a great way to get the students thinking about the importance of local agriculture.
		Helps the local farmers, cuts down on transportation costs, lets students know where food comes from.
		Helps support local economy.
	Engaging Aspects for Teachers	*I love to garden and so I would love to incorporate it into the classroom.*
		Also, it's fun for the teacher!
Curriculum	Topics: Science, Health, and Integrated Curriculum	*It opened my eyes to new ideas about teaching science and nutrition.*
		I think this will be great for the students and can play a huge role in the science curriculum.
		Gives them a chance to learn about plants and how important they are to us.
		Also, while we're "playing" in the dirt it's a great way to incorporate other things we find in the soil.
		Provides students with more knowledge of the environment they live in.
		It is a great way to get the students thinking about the importance of local agriculture and eating healthy.
		Can be an excellent topic to use in an interdisciplinary way, i.e. incorporating social studies, math, science, literacy.
	Methods: Engaging, Hands-On and Minds-On, Authentic	*Fun, hands-on, engaging for students*
		This is great for hands-on minds-on learning.
		It involves the community.
		This is a great opportunity to allow students the chance to make connections between what they're learning and their lives.
		Active and authentic learning for students.

additional university students majoring in nutrition and dietetics. The students are chosen through an application process that follows the in-class presentations which took place during our first phase. Incentives for participation include being part of a new innovative project, receiving support through both group and one-on-one meetings, and receiving teaching materials to use during the project and to keep after the project is over. As faculty review applications, staff and participants are selected based upon their expressed interest and commitment to the program as well as their internship placements for the upcoming year. The students meet approximately once each month with the project team in a professional learning community and also receive one-on-one support upon request. The university students respond by implementing Farm to School projects with elementary students in a rural southeastern public school district. Each education student is an intern and implements project activities in her assigned internship classroom with the goal of teaching two Farm to School lessons each month. An on-farm workshop is offered to the preservice students, their cooperating teachers, and other area classroom teachers and dietitians. In addition to the engaging farm environment, the workshop includes an opportunity for preservice students to collaborate with classroom teachers, farmers, dietitians, and experience the Farm to School program in an authentic way. Despite pouring rain and reverberation on the tin roof overhead, participants are lively and connected. They leave the workshop energized and eager to implement ideas they learn.

A data-driven approach (Boyatzis 1998) is used for thematic analysis and code development. In Stage I, decisions are made regarding sampling and design issues. Data subsamples include pre-and post-interviews with each of the five education students, lesson plans with related reflections, student work samples from each of the five education students, and team meeting notes from seven sessions across the academic year. In Stage II, a qualitative research peer group uses subsamples of data to develop themes, and in Stage III the themes are applied to the collection of data, validity is assessed, and the results are interpreted. In addition, we conduct an overall analysis of the lessons' content and connections to required curriculum, while paying particular attention to patterns within the science lessons.

Through the data analysis process aforementioned, we identify a variety of ways in which participants are able to implement Farm to School activities as well as ways the implementation process impacts the preservice teachers. Four themes emerge from the data including Curriculum, Affect, EcoJustice, and Agency/Leadership.

Curriculum

Participants use Farm to School activities as a context for science lessons that connect to state standards as well as lessons that integrate multiple elementary subjects. The open-ended requirement of teaching at least two Farm to School lessons a month allows individuals to go in different directions based upon their comfort levels, areas of interest, and unique settings. In order from most common to least, the 24 analyzed lessons include a blend of Farm to School components including cooking, taste tests, gardening, and farm field trips. Again, in order from most common to least, the lessons also incorporate a range of subject areas including science, mathematics, language arts, healthful living, social studies and informational skills/ technology. As one participant so clearly says, "Making it work with curriculum is really important."

Ninety-six percent of the lessons integrate more than one subject. In final interviews all participants comment on Farm to School and integrated curriculum, as illustrated in the following quotes:

> Farm to School is a way to teach healthy living and eating but also a way to tag team subjects such as math that might not be as exciting. I connected to required curriculum in every single possible way I could. Every single content area was touched on throughout the semester… Almost like a little goal I made up for myself. (Kari, 12/13/10)

> Anything that integrates and makes things more real for students, I am all for. This experience has given me more of a big idea of ways to integrate. You're told to do this but it's hard to do. This gives a pathway into integration. Looking at what you need to teach and ideas you have for Farm to School, they lend themselves to each other for a lot of things… I could make this [one Stone Soup lesson] into an entire unit. Every content area can be addressed by this activity. Math—measuring, graphs, addition and subtraction, symmetry, data analysis, and probability. Language Arts—writing stories, compare/contrast, reading a variety of Stone Soup stories. Social Studies—becoming a responsible citizen, working in soup lines, relating community differences in recipes, using natural resources to meet needs. Science—States of matter, physical and chemical changes, conducting observations, making predictions. There are so many possibilities. (Samantha, 12/13/10)

In addition, every participant states that children's literature is a key element in their Farm to School work.

When looking more closely at the 17 lessons that list science goals and objectives, we find a range of topics that encompass life science, earth science, and physical science. The life science topics of biodiversity and plant needs, growth, and adaptations are a natural fit for Farm to School in addition to the earth science topic of soils. The lessons that include physical science topics focus on properties of objects, states of matter, mixtures, and changes in properties. Lessons incorporate scientific inquiry as well as numerous science process skills including questioning, predicting, observing, experimenting, describing, measuring, comparing, recording, analyzing data, conducting secondary research, and discussing.

Affect

Our data indicates many positive contributions to participants' affect with related codes such as "loved this," "enjoyed," "enthusiastic," "good energy," and "joy." Preservice teachers repeatedly say that their students love Farm to School activities and how rewarding it is to have such enthusiasm, energy, and fun connected to their teaching. The essence of this is captured when one participant states, "It is a complete joy for me to work with them on it." She continues to say, "It was rewarding to have the school system's child nutrition director talk about how proud he is of the Farm to School interns, including me." She concludes her interview with us by exclaiming, " I've really, really enjoyed it. Just a really positive experience."

EcoJustice

Regular reference is made to helping public school students from diverse backgrounds eat right as one example of helping the local community. In reflecting upon the importance of this work, participants consistently discuss the local obesity problem and the need to help students establish a healthy lifestyle. One participant shares her hope to grow a garden with future students and to donate the food to people in need at places such as a homeless shelter or domestic violence safe house. There is a collective interest in "making a difference in our own area."

There are many layers of connections between participants and their peers, public school personnel, families, university faculty, community partners, farmers, and local businesses. In post-interviews, every participant repeatedly emphasizes the positive impact of connecting in the monthly meetings and follow-up emails and phone calls between preservice teachers, university faculty, and ASAP staff, as illustrated in the following quotes:

> It helped to hear different work people were doing; learn about different age groups; gain knowledge from university education and nutrition faculty, ASAP staff, and peers… Sharing ideas and collaborating while implementing an idea was rewarding. You often hear about good ideas but don't have this level of support in trying them out… In addition to monthly meetings, communication was great through emails, wiki, and phone calls—always someone available for questions, concerns, and support. (Jenn, 12/13/10)

> It's really, really, nice to have other people, other interns, regroup, meet with people in the same boat, challenges, successes, share ideas, and get ideas for improvement and expanding upon it. Wouldn't have been possible without the support… So beneficial to bounce ideas off each other… Meetings keep you focused and accountable too. They provide reassurance. Sense of where you are compared to others. Beneficial. Enthusiasm rubs off and is contagious. (Kari, 12/13/10)

Participants also say that co-teaching with another Farm to School intern is both helpful and fun. One, in particular, states that she does not think she would have tried some of these activities if she didn't have the support from this Farm to School project and connections to this team.

Agency and Leadership

The project provides a way for each of the preservice teachers to develop their sense of agency or ability to act. As seen in the examples provided below, they are able to take risks, reflect on their learning, share their work with others, develop as professionals, grow more confident, and conjecture about their next steps.

One participant shares that her first Farm to School lesson is the first lesson she instructs in her internship classroom and that she is "nervous and shaky." She observes that the activities get the students excited about school and having fun. She is encouraged to "have at it" with her Farm to School ideas and at the end of the year anticipates that in her future teaching she will have a garden, cook local foods frequently, possibly donate foods grown to local shelters, and take her own field trips to visit gardens at her students' homes.

Another participant reflects that she is not sure how to "do this" at first, but in getting to know people in the community, participating in professional development, and actual experience teaching the Farm to School activities, she is able to envision how they work. She has great hopes for the future and hopes her future school will allow her to implement Farm to School activities.

A third participant notes that monthly meetings have, "helped me develop a vision for the type of teacher I want to be. It's OK to not know everything. Kids are curious. We can do research. I can learn along with them."

All participants have interest in incorporating Farm to School in their future teaching. They plan to enact the program through gardening, cooking, taste tests, and farm field trips. One participant demonstrates professional growth and confidence by expressing her future plans and also her reasons for them: "I want to do some cooking and taste tests to expose students to different foods, a class garden as there is so much to integrate, and a field trip for students to see where food comes from."

At the same time, all participants express the realistic need to continue learning. One participant, for example, shares that she now feels pretty comfortable with cooking but "has a lot to learn about gardening."

One of the most promising aspects of agency is the level of problem solving and reflection that the participants develop throughout the project. When meetings begin, university faculty and ASAP staff often help participants work through problems and challenges. Over the course of their time with the program, participants take on more of a problem solver role and by the end of our pilot study they are regularly helping each other think through situations and possibilities. For example, a participant shares that her cooperating teacher is excited about Farm to School but is also aware of the time constraints, that "every moment needs to be learning and doing" and that it is hard "to reconcile gardening in light of these things, because it is more exploratory and time consuming and slow." This preservice teacher continues to say that her cooperating teacher helps her "come to a balance with it." She is hopeful that when on her own, she can spend more time in the garden. She has seen how engaged students can be and how much they can learn.

What EcoJustice Work Can Teachers Do?

Throughout this project, we observed a three-hour Farm to School workshop in a junior-level Elementary and Middle Grades Education science methods course consistently increase preservice teachers' awareness, sense of importance, and interest in local food and farm based instructional opportunities. It helped participants identify both the value of such efforts in making a difference for students and communities as well as the curricular connections and related teaching methods.

Through our implementation phase, senior year elementary education interns involved in a community of practice were able to implement Farm to School activities in a variety of ways that included all components of Farm to School and connections to required curriculum across multiple subject areas. We observed positive contributions to their affect, the positive impact of multiple layers of connections, attention to ecoJustice issues and making a difference in the world, and preservice teachers developing their sense of agency and leadership abilities.

The participating preservice teachers truly became leaders. North Carolina recently began to require our teacher candidates to demonstrate leadership skills. While some of our university students were searching for ways to show they met this required competency, the Farm to School participants had numerous examples of authentic leadership. In her first month of internship, one preservice teacher planned the first Farm to School field trip ever done at her school and they traveled to a farm that had never participated in the program with school groups. She worked with the farmers to plan the day and set up all the logistics for the entire grade level. Another intern planted her school's first garden despite having to wrestle several problems along the way such as getting permission from the principal to put in a garden, dealing with extremely compacted soil as well as a well-entrenched weed cloth in the provided site, and determining plants that could grow despite the quickly approaching winter season.

For successful programs involving preservice teacher education and Farm to School initiatives, we recommend the following:

1. In a manner similar to phase one of our project, introduce a large number of preservice teachers to Farm to School. Involve community support through groups such as ASAP.
2. As part of the introductory sessions, invite interested preservice teachers to become involved in a community of practice focused on learning together about implementation of Farm to School in public schools.
3. Strive to have the community of practice include diverse parties to allow people to learn from each other and benefit from collaboration, for sustainability purposes. Potential partners include staff in Farm to School agencies; university faculty from a variety of disciplines such as education, nutrition, and plant sciences; schoolteachers, instructional coaches, and administrators; farmers; cooperative extension agents; and preservice teachers at different points in their programs.
4. Give preservice teachers general requirements but allow room for diverse approaches.
5. Meet regularly as a community of practice, at least once a month and more if schedules allow.
6. Consider an open-ended approach to meetings. Despite training in a variety of potential protocols, we were quite successful by simply letting people, one at a time, describe and reflect upon a lesson they had taught. Sometimes people

brought student work samples and photographs. We would ask authentic questions, problem solve, make connections, and share ideas. Students shared that the simple, open format helped with comfort levels.
7. Have a structure such as a website in place to share lesson plans and ideas.
8. Use the meetings as a time to enjoy healthy local food together. Highlight what the food is and where it comes from. Participants appreciate the good food and have some social time while they continue learning about Farm to School possibilities.
9. Work closely with cooperating teachers to help allay fears about time to do this work. As teachers are required to do more and more, it can seem overwhelming. With thoughtful planning, there are ways to integrate subject matter into the context of Farm to School. Integration helps to alleviate this discomfort.
10. Do not try to create a whole new infrastructure from scratch to support Farm to School. Instead, tap into existing resources. In our case, it was Honors College research projects, service learning requirements, beginning teacher organizations, and faculty research, service, and teaching interests.

As the Farm to School and preservice teacher education program moves forward, we recognize areas in need of further study. We see a need to systematically conduct classroom observations of preservice teachers to accompany their plans, reflections, and discussions. We are interested in and already beginning to expand the community of practice with the hopes that preservice teachers will complete this work alongside cooperating teachers who are also invested in the project—within schools that have system-wide supports. Future studies might follow preservice teachers over time in order to assess long-term impacts. There is a need to study the impact on elementary students in terms of health knowledge, attitudes and behaviors, but also in terms of knowledge, attitudes, and skills across the curriculum and engagement in school. We also suggest studies that might consider the impact of Farm to School communities of practice on teacher satisfaction and retention levels.

Our project indicates that Farm to School is a topic with the potential to address larger societal goals while also providing a motivating context for teaching required curriculum, including but certainly not limited to science. School gardens, farm field trips, and cooking with children provide concrete experiences that have a natural fit with inquiry and might ease teachers into science education, especially reluctant, new elementary teachers. Elementary preservice teachers often enter science methods courses worried about teaching science. They are insecure in their own science abilities. A cohesive Farm to School project has the potential to help build interest, confidence, and leadership and research skills. The integrated curriculum will help teachers find time to devote to science and mirror real world ways that science blends with mathematics, language, social studies, health, and technology. Farm to school activities provide numerous opportunities for inquiry and hands-on, minds-on learning and also demonstrate where science exists in their personal lives and society.

As a final note, the community of practice framework helped the participants in this study grow from novices on the periphery of the practice towards more central participation, especially in the commons. They are invested in the domain, have been part of a sustained learning community, and have a shared practice. Upon conclusion of this project and graduation from the university, their regular community interactions have changed. Our hope is that they will connect with or perhaps even create new communities of practice to sustain and grow their work.

References

Appalachian Sustainable Agriculture Project (ASAP). (2009). *Farm promotion and support*. Retrieved January 8, 2013, from http://www.asapconnections.org/farmpromotionandsupport.pdf

Bartz, S. (n.d.). *Using ecojustice principles in an elementary school world cultures curriculum (part 1)*. Retrieved January 8, 2013, from http://www.ecojusticeeducation.org/index.php?option=com_content&task=view&id=56&Itemid=47

Bowers, C. A. (2010). Rethinking social justice issues within an eco-justice conceptual and moral framework. *Journal of Educational Controversy, 4,* 1. Retrieved January 8, 2013, from http://www.wce.wwu.edu/resources/CEP/eJournal/v004n001/a006.shtm

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Thousand Oaks: Sage.

Carter, B. (2012). Facilitating preservice teacher induction through learning in partnership. *Australian Journal of Teacher Education, 37*, 99–113.

Crowe, T. R. (2002, February 6). Keeping the dream alive: William Shelton labors to make family farm work. *Smoky Mountain News,* pp. 6–9.

Enfield, M., & Stasz, B. (2011). Presence without being present: Reflection and action in a community of practice. *Journal of the Scholarship of Teaching and Learning, 11*, 108–118.

Izumi, B. T., Wright, D. W., & Hamm, M. W. (2010). Market diversification and social benefits: Motivations of farmers participating in farm to school programs. *Journal of Rural Studies, 26*, 374–382.

Love, K., Mower, T. P., & Veronesi, P. (2010). Engaging the environment: Relationships of demography, ecojustice, and science teacher education in response to Wolff-Michael Roth. In D. J. Tippins, M. P. Mueller, M. van Eijck, & J. D. Adams (Eds.), *Cultural studies and environmentalism: The confluence of ecojustice, placed-based (science) education, and indigenous knowledge systems* (pp. 83–104). New York: Springer.

Lowenstein, E., Martusewicz, L., & Voelker, L. (2010). Developing teachers' capacity for ecojustice education and community-based learning. *Teacher Education Quarterly, 37*, 99–118.

Martusewicz, R. A., & Schnakenberg, G. R. (2010). Ecojustice, community-based learning, and social studies education. In A. DeLeon & E. Ross (Eds.), *Critical theories, radical pedagogies, and social education: New perspectives for social studies education* (pp. 25–41). Boston: Sense Publishers.

Mueller, M. P. (2009). Educational reflections on the "ecological crisis": Ecojustice, environmentalism, and sustainability. *Science & Education, 18*, 1031–1056.

Mueller, M., & Pickering, J. (2010). Bee hunt! Ecojustice in practice for earth's buzzing biodiversity. *Science Activities, 47*, 151–159.

Orr, D. (1994). *Earth in mind: On education, environment and the human prospect*. Covelo: Island Press.

Rubenstein, H., Calabrese Barton, A., Koch, P., & Contento, I. R. (2006). From garden to table: Rural or urban two effective strategies that teach students about where food really comes from. *Science and Children, 43*, 30–33.

Tatarchuk, S., & Eick, C. (2011). Outdoor integration: Looking to nature to accentuate science and language arts connections. *Science and Children, 48*, 35–39.

Walljasper, J. (2010). *All that we share: How to save the economy, the environment the internet, democracy, our communities, and everything else that belongs to all of us*. New York: New Press.

Wenger, E. (2006). *Communities of practice: A brief introduction*. Retrieved January 8, 2013, from http://www.ewenger.com/theory/communities_of_practice_intro.htm

Patricia Bricker is an associate professor of science education at Western Carolina University. Her research interests include inquiry-based science education, integrated curriculum, experiential education, and teacher professional development. She began her career as an environmental educator and has taught both elementary and middle school.

Emily Jackson is the founder and director of the Growing Minds Farm to School program of Appalachian Sustainable Agriculture Project. She serves as the Southeast Regional Lead for the National Farm to School Network. Emily lives on a farm in beautiful Western North Carolina.

Russell Binkley is an associate professor of social studies education at Western Carolina University. He writes about the intersections of race, class, gender, sexuality, and religion in education. Before involvement in teacher education, he was a sixth grade teacher trying to teach democratically.

Chapter 7
The Local as the Global: Study Abroad Through Place-Based Education in Costa Rica

Cori Jakubiak and Paula J. Mellom

> At best, study abroad programs are expected to do no harm to the communities in which they are located; rarely is the question raised as to how they can actually do good (Tonkin 2011, p. 193).

In the current historical moment, efforts to *globalize* U.S. higher education abound. To judge from the language of institutional mission statements and strategic plans to the proliferation of new, globally-oriented centers, programs, and majors on U.S. college and university campuses, a central concern of U.S. higher education today is to equip students with the tools, knowledge, and dispositions for engaging in a globalized world. Yet what, exactly, institutions mean when they evoke the term, *global*, is often unclear. Learning goals across institutions may include "preparing students for global citizenship"; "increasing students' global competencies"; or "educating students for global awareness," among others (e.g., Lewin 2009). However, within these same learning goals, the *global* is rarely operationalized.

This failure to fully define the global has implications for the programs, classes, and objectives that operate in its name. The global is often defined as in tension with or opposition to the ways in it is used in other contexts. Efforts to educate students to understand, participate in, or challenge features of an existent globalized world in one course or program may be at odds with what they do in another. With an eye to this issue—and sensitive to the ways in which English language teaching draws upon globalist discourses (Phillipson 2003)—we engage 11 teacher education students in a short-term study abroad program entitled, "Language and Culture Service Learning in Costa Rica" (LCSL) and describe our experience in this chapter. Under

C. Jakubiak (✉)
Department of Education, Grinnell College, 1120 Park Street, Grinnell, IA 50112, USA
e-mail: jakubiak@grinnell.edu; cori.jakubiak@gmail.com

P.J. Mellom
The University of Georgia, 125 Aderhold Hall, Athens, GA 30602, USA
e-mail: pjmellom@uga.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_7

the auspices of a large, southeastern U.S. university (and, indeed, aligned with the university's goals of preparing students for a globalized world), we deliberately design our program to focus on the *local*. Drawing upon what Sobel (2004) calls "a 'pedagogy of place,' a theoretical framework that emphasizes the necessary interpenetration of school, community, and environment … to prepare students to solve the problems of today" (pp. 11–12), our program emphasizes *place-based education* in study abroad rather than viewing our host site as a global venture. We use this pedagogical approach not only to draw students' attention to global/local (or "glocal") connections between the U.S. and Costa Rica, but also to situate our program within the tenets of ecojustice theory.

According to Mueller and Bentley (2009), ecojustice theory "emphasize[s] the holistic relations between social justice and environmental justice" (p. 58), and ecojustice education—what Bowers (2006) calls *commons education*—stresses renewing and revitalizing the commons as a main goal of all education. Place-based education, as a pedagogical strategy, corresponds with ecojustice education when it connects local communities and residents (of all cellular types) and their knowledge uses to wider questions of social and environmental justice. High school students in an ecojustice-informed, place-based science class in the U.S. state of Iowa, for example, might monitor local water quality in streams adjacent to hog confinements. Yet, ecojustice ethics takes this class further: they might study the international trade agreements that allow for lax oversight of agribusinesses or interview nearby migrant workers to discuss labor conditions and the treatment of animals in meat processing facilities. Ecojustice theory thus augments traditional environmental and place-based education, which Bowers (2006) argues remain human-centered and exacerbate existent economic and social paradigms at the expense of the commons. Mueller (2009) also notes that traditional environmental education relies on crisis modes of thought that distance rather than connect youth to ecologically sound social action.

While place-based education uses the assets and problems of a local community to drive curricular development (Tomkins 2008), ecojustice education extends place-based education and asks students to consider how and in what ways local (and glocal) knowledges, practices, landforms, and organisms stand in relation to one another, the vitality of the commons, and to broader questions of ethics. Using a place-based educational approach that is informed by ecojustice theory, then, the people, flora, fauna, and social realities of one, small Costa Rican village shape LCSL's goals and student learning outcomes. We also teach our students to attend to the cultural assumptions and thought patterns that undergird all place-based knowledge systems (Mueller and Tippins 2010), both those systems in the Costa Rican cloudforest or home in the Southeastern U.S.

Noddings (2005) writes that educators must "recognize the power of the local in building a global perspective" among students (p. 122). We agree. Using our short-term study abroad program as a platform, we argue for a paradigm shift in higher education's myopic focus on the global—particularly in study abroad programs. Berry (1990) suggests that the idea of anything 'planetary' is useless in its abstraction; similarly, Gruenewald and Smith (2008) call for practices of "new localism" in the face of global economic development patterns that disrupt rather than support community life (p. xiii). In concurrence with these place-based education scholars, we offer that it is through intense engagement with the specificities and dynamics of *local places* that students can come to realize the specificity and interconnectedness of *all places*. The global, as a scale, does not produce or subsume the local; rather, scales of place interweave, are in relation, and are deployed for various purposes (Herod 2008). Higher education, though, often restricts its attention to the global. To offer some perspective on why this is so, it is to a discussion of the global in higher education that we now turn.

Framing "the Global" in Higher Education

The concept of the global is undoubtedly part of the Zeitgeist. One can barely turn a U.S. corner without confronting the global in some way, be it through a sighting of one of the ubiquitous "Think globally, act locally" bumper stickers or an admonition to care for "the planet" by buying a green or eco-friendly product (Jakubiak and Mueller 2011). Despite a rampant, often personally encroaching, nationalism that has gripped the U.S. over the last three decades (Berlant 1997), the global as a point of reference, scale, or orientation remains salient in U.S. daily life.

Scholarly attention to globalization, however, takes a more nuanced approach. While some work characterizes globalization as increased time-space compression under late capitalism (Harvey 1989), other work explores how cross-border flows of people, ideas, money, language, and art are contributing to the deterritorialization of the nation-state and producing hybrid cultural forms (Kearney 1995). Marxist-leaning scholars define globalization as a process of top-down economic restructuring led by supranational organizations such as the World Bank. Their scholarship examines how multinational corporations consolidate massive amounts of wealth and power at the expense of the world's most vulnerable (e.g., Graeber 2010). Related perspectives on globalization interrogate the effects of fast-footed capital in realms like labor (e.g., Wright 2006). As manufacturing centers—*maquilas*—on the U.S.-Mexico border relocate to cheaper locales, for example, migration to the U.S. rises. This migration produces new, gendered forms of care work as paid childcare, domestic cleaning services, and even manicures become more affordable to the U.S. middle class (Kang 2010).

Other research on globalization investigates the phenomenon's discursive power. This literature base can be synthesized to evidence that talk about, reference to, and expectations of globalization generate new material conditions, which are then treated as referents for the process (e.g., Doerr 2012a, b; Herod 2008). As more native English language speakers teach abroad in the name of development, for example, local language shift becomes "evidence" of globalization (Jakubiak 2012). Similarly, the relative ease of travel to places like Tanzania has increased demand for English-speaking tour guides. In response, competitive-minded, East African guide schools now import *National Geographic* videos and Global North travel literature as curricular documents. These schools then teach their guides to be conversant in the Global North-produced discourses of wildlife, exoticism, and adventure that Western tourists seek through safari (Salazar 2006).

Given the breadth and depth of scholarship on globalization (only a fraction of which is illustrated here), it is extremely difficult to discern which definitions of or ideas about globalization U.S. institutions of higher education are employing in their mission statements, strategic plans, and learning goals. That said, many institutions appear to abide by *New York Times* journalist Thomas Friedman's (2005) "the world is flat" thesis, which posits that nation-state borders are eroding, goods and services now move freely around the globe, and new technologies and mass media are generating a universal culture. This version of a globalized world centers largely on economics: the globalized world is one large, expansive marketplace in which people compete internationally for jobs and interact with consumers near and far.

Preparing students for a globalized world, in the Friedman frame, may mean teaching cross-cultural competencies (for successful interactions in business); world language instruction (for ostensible work in international settings); or increased technology use across the curriculum (for "international communication"). Nolan (2009) offers an example of this perspective. He argues that *global competence* should inform the goals of U.S. higher education, writing that "you can be a heck of an engineer, for example, but do you know how to work with the Germans, the Japanese, or the Brazilians to develop the next generation of fuel-efficient vehicles? You might be a whiz at growing corn or soybeans, but can you show the people in Africa how to do this?" (p. 268) In Nolan's conceptualization, the globalized world assumes a homology between nation-people-language-culture (i.e., Germans, Japanese, and Brazilians) and the expectation that U.S. individuals will be increasingly interacting with others across these same (stable) categories. Noteworthy is Nolan's construction of "the people in Africa" as uniformly in need of agricultural instruction from abroad. *Global competence*, in this depiction, seems to move knowledge in one way.

Dissatisfactory as Nolan's description of global competence may be, many U.S. study abroad programs find root in this Friedman-esque discourse. These study abroad programs frame the globalized world as a corporate arena in which people engage with increasing frequency across nation-state lines to secure their own, largely material, assets (Zemach-Bersin 2009). Kiely (2011), discussing the recent expansion of study-abroad programs in U.S. higher education, notes that

> [f]rom WWII through the Cold War to September 11, 2001, and to the present day, the movement to internationalize higher education has been very much a matter of satisfying national interests in order to compete more effectively with other nation-states in an increasingly interdependent, and sometimes contentious, world (p. 245).

The *global* in U.S. study abroad programs generally relies on a "globally competitive worker" ideology that takes for granted a U.S./global binary. This binary conflates *international* and *global*, and suggests that any experience outside of the U.S. automatically renders one global (Woolf 2006). This U.S./global binary also assumes that the people whom U.S. students will encounter while studying abroad are parochial—in place—and not themselves already cosmopolitan (Doerr 2012a).

U.S. study abroad programs' adoption of the globally competitive worker ideology is problematic for other reasons, too. For one, it elides transnational diversity *within* nation-states, such as the large and growing Latino population that lives, works, and is schooled in the U.S. without legal status (Zúñiga and Hamann 2009). It is not necessary for U.S. students to go abroad in order to experience linguistic and cultural diversity. Second, and more profoundly, the globally competitive worker ideology avoids discussions of what new social or ecological obligations people might have in an increasingly interconnected world. Speaking to this point, Kiely (2011) asserts that

> [t]he rhetoric of intercultural competence (i.e., language proficiency, tolerance, openness, empathy, intercultural sensitivity), and more recently, transformation in study abroad promotes very little dialogue regarding the role of study abroad in fostering socially responsible action to address global injustice and inequality (p. 264).

Learning about global problems that originate in or are sustained by one's home country is rarely a focus in study abroad. If and when students view injustices or live (temporarily) through material scarcities, these experiences are more likely to be commodified as adventuresome cultural capital than examined for their links to structural problems (Mowforth and Munt 2009).

Observers also opine that U.S. study abroad programs' active acceptance of (or acquiescence to) the globally competitive worker ideology frames the world outside of the U.S. as an undergraduate classroom. Akin to the Grand Tour of the nineteenth century, when young American men of means traveled to Europe to visit historical sites and return home cultured (Mowforth and Munt 2009), study abroad is often cast as a liminal time during which U.S. students become global through simple "immersion" in another country. This discourse of immersion implies that sitting in Parisian cafes, getting lost in the streets of Valencia, or making small talk with fruit sellers in Quito constitute steps toward global citizenship (Doerr 2012b). Tonkin (2011), addressing this concern, notes that there exists a

> painfully widespread view in many study abroad circles that the study abroad enterprise exists to serve an American purpose, namely, the liberal education of the student passing through it. It is but one step from this belief to the damaging notion that the larger world exists as a kind of classroom where the American student can learn values or skills that can be transferred to the United States and that student's adult life (p. 193).

Relatedly, study abroad programs' construction of the world outside of the U.S. as an undergraduate classroom is often buttressed by links to colonialism. Study abroad marketing campaigns frequently use words such as "discover," "explore," and "adventure" in their promotional literature, which casts the globe as ripe for American sojourning and links present-day study abroad to colonial conquest. "Even under the banners of global citizenship and cross-cultural understanding, [study abroad] advertisements endorse attitudes of consumerism, entitlement, privilege, narcissism, and global and cultural ignorance," Zemach-Bersin (2009) writes. "[M]any students study abroad as a commodity, an entitlement, and a non-academic adventure" (p. 303). In this view [t]o become global through conventional study abroad is to venture outside the U.S. and repatriate the experience home for one's own, primarily economic, benefit.

Dissatisfied with this limited, consumerist view of a globalized world, some institutions of higher education are augmenting their curricula and traditional study abroad programs with other offerings. Redefining the global, though, is challenging for numerous reasons. Not the least of these reasons is U.S. K-12 schooling.

Challenges to Confronting Dominant Global Discourses

As discussed above, some institutions of higher education have begun to reject Friedman-esque global discourse and implement alternative visions. Higher education programming taking this more cautious, less celebratory, approach to a globalized world may offer courses and study abroad programs that do one, or more, of the following: promote critical discussions about the rising role of non-governmental organizations in civil society (cf. Fisher 1997); interrogate the recent rise in ethnic nationalisms (cf. Kearney 1995); or examine how cross-border flows of ideas, goods, and services affect indigenous peoples and create new forms of ethnic solidarity (cf. Brosius 1999). Institutional mission statements, strategic plans, and learning goals may evoke the ways in which information communication technologies, international trade agreements, and failed development initiatives have resulted in uneven standards of living across the globe (e.g., Bringle et al. 2011). Additionally, issues such as climate change, resource depletion, and public health problems may be a focus of a global agenda on other campuses (e.g., Bringle et al. 2011). Alternative off-campus study options such as international service-learning, service-learning in diverse domestic settings, and international field research reflect some of this new thinking (e.g., Bringle and Hatcher 2011).

Nascent challenges to “the world is flat” version of globalization, then, are being posed in and through various higher educational programs. An obstacle to these programs’ effectiveness, however, is the entrenched point of view of many recent high school graduates. Despite its claims to increasing educational opportunity, a primary result of the 2001 No Child Left Behind legislation was to codify individualistic, careerist notions of the globalized world across K-12 curricula. As detailed above, these notions promote rather than interrogate increased economic and social disparity at all scales and countenance widespread ecological destruction in the name of U.S. economic progress (Pyle 2008).

Many contemporary U.S. college and university students have been immersed throughout their K-12 schooling in the idea that education is for human capital alone (Spring 2004). For these students, to do well in school is to accept and reproduce particular globalist logics as measured by standard tests. In the words of Kiefer and Kemple (cited in Sobel 2004),

> Most contemporary school restructuring efforts—be they called ‘systemic school change’ or ‘standards-based education’—are essentially programs for retooling students to become efficient workers, designed to make children more competitive in the national economy, or more recently, in the emerging global economy. Absent from the debates has been … critical discourse on the responsibility of schools to the communities that support them and to the planet’s life-support systems (p. 16).

No Child Left Behind's focus on leveling educational access, holding schools "accountable," and creating globally competitive workers has left little room for teaching students to question the broader purposes of K-12 schooling. Even the recent Race to the Top legislation limits the contours of educational debate to testing, school funding, and achievement goals (Darling-Hammond 2012).

Having been educated in No Child Left Behind's priorities, many newly matriculated U.S. college and university students arrive on campus with an uncritical "the world is flat" perspective. Ideas of globalization as necessitating new forms of ecological literacy or creative community revitalization have been displaced by the market mantra-often in the name of educational equity. "[T]he discourse of standards, accountability, and excellence has been linked to efforts to close the historic achievement gaps between different racial, cultural, and economic groups," Gruenewald and Smith (2008) write,

> [t]hus, the No Child Left Behind Act of 2001 is invoked at once as legislation aimed at ending inequality of educational opportunity and at strengthening the economic advantage of the entire nation. When the narrative of globalization becomes effectively linked to the narrative of social justice and equity, globalization becomes increasingly difficult to challenge (p. xv).

Akin to many U.S. study abroad programs, U.S. public schools have taken up the globally competitive worker ideology mostly without critique. Schools that reproduce its norms are deemed successful. Alternative metrics of school success such as whether graduates live sustainably upon the Earth or understand the effects of discrete disciplinary knowledge on ecological and social systems are practically nonexistent (Orr 2004).

Educational orientations that *do* consider the ways in which discrete disciplinary knowledge, economic development, local community resilience, and lively commons are interconnected and multi-scaled are ecojustice education (Mueller 2009) and, to a lesser extent, place-based, or place-conscious, education (Sobel 2004). Below, we discuss our use of ecojustice-framed, place-based education as an attempt to mediate the careerist legacy of No Child Left Behind and offer an alternative to traditional study abroad programming. On, metaphorically, to a beautiful place: the cloudforest region of Costa Rica.

"Language and Culture Service Learning in Costa Rica": Enlightened Localism, Diversity in Community, International Service-Learning, and the Global/Local Dialectic

Study Abroad as "Enlightened Localism"

As we discuss in this chapter's introduction, our 5-week course, "Language and Culture Service Learning in Costa Rica" (LCSL) does not run along the ideological lines of most contemporary U.S. study abroad programs. Eschewing the "the world is flat" thesis, our program instead follows the tenets of ecojustice theory and employs place-based education as its primary pedagogy. In lieu of viewing study abroad as a temporal moment in which U.S. students become "global" through immersion in a distant country, we see short-term study abroad in Costa Rica as a way to introduce students to ecojustice principles: ideas of the commons, the instability of the local/global binary, and how language and social practice produce particular views of the Earth and our relation to it.

LCSL encourages students to examine how their lives, language, and thought processes intersect socially, economically, and politically with the lives (and livelihoods) of the people, plants, animals, land, and commons of Costa Rica. Following ecojustice theory, LCSL aims to have students consider how these intersections affect broader ecosystems. According to Mueller (2009),

> The central focus of ecojustice is developing an understanding of the tensions between cultures (i.e., intergenerational knowledges and skills, beliefs and values, expectations and narratives) and the needs of the Earth's ecosystems. Ecojustice philosophy is based on the notion that language carries forward particular cultural metaphors and deemphasizes or ignores others, which influence attitudes towards nature. (1033)

We see traditional U.S. study abroad programming and its attendant focus on the global as a cultural and linguistic metaphor that ignores specificities of place, the health of interconnected ecosystems, and wider questions of social and environmental justice. As a corrective to this metaphor, LCSL follows the tenets of ecojustice theory and utilizes place-based education, "the educational counterpart of a broader movement toward reclaiming the significance of the local in the global age" (Gruenewald and Smith 2008, p. xiii). Place-based, or place-conscious, education is not "tuned to nostalgic or homogenous images of the local, but to local diversity, the diversity within places and the diversity between places" (Gruenewald and Smith 2008, p. xxi). Thus, an overarching goal of our program is to have students understand that the Costa Rican community they visit is not only unique among places in Costa Rica, but also in many ways *more* cosmopolitan than the U.S. Southeast communities from which they come. Some forms of Costa Rican cosmopolitanism, moreover, come with steep social and environmental costs, such as the long and tenuous history of Latin America's involvement in multinational agribusiness (Galeano 1973). In examining some of these costs, it is our hope that students come to see that U.S. cosmopolitanism, too, is fraught with complexity and tensions.

Through intensive field experiences, class discussions, daily readings, and on-line reflective journaling, we aim to have our students understand that the local and the global exist in relation to one another. Both scales construct and are constructed by the another. As one LCSL student observes here in her on-line journal, the people in our Costa Rican host site are connected to others worldwide because of the commons, the cloudforest. She writes:

> (1 August, 2011) I have been very intrigued by the focus on nature and wildlife during our stay. It's interesting that men and women from all over the globe with different professional backgrounds (e.g., education, medicine, conservation, landscape architecture) come here to learn more about the nature practices here. The men and women in this community discuss these topics because it's their life; yet, it connects them to individuals around the world.

Zucker (cited in Sobel 2004), asserts that place-based education is "'enlightened localism': a local/global dialectic that is sensitive to broader ecological and social relationships at the same time as it strengthens and deepens people's sense of community and land" (p. ii). Knowledge, in ecojustice-informed place-based education, is knowledge-in-use for ethical ends. This is another primary goal of our program: we want our students to engage with the idea that that one does not truly "know" something if one does not understand the effects of this knowledge on real communities and the Earth (Orr 2004). One cannot say they possess global knowledge, for example, if one lacks an understanding of how a particular global process affects the environment, local community relationships, and economic activities at multiple scales.

Our program's approach to the study of exports, for example, illustrates a way in which we teach about the global/local dialectic, or "enlightened localism." Rather than simply naming Costa Rica's exports (as students learn to do in U.S. K-12 schools), the LCSL group discusses exports as points of *friction* (Tsing 2005): nodes where the global and the local connect and chafe. A pineapple, for example, that is consumed in the U.S. is likely to have been produced in a small Costa Rican village where chemical input regulation is minimal. This intensive input use not only creates immediate health problems for community residents, but also alters the community's future economic stability, as transitioning to organic farming may be difficult. The political significance of imbibing a piña colada at a U.S. Applebee's, then, is clearer when one connects the act to Costa Rican public health, economic resiliency, and questionable labor practices (McMillan 2012). Through a place-based educational approach informed by ecojustice ethics, however, such global/local connections become more legible and relevant.

Guided by ecojustice theory and using place-based educational pedagogy then, the overarching aim of our short-term study abroad program is to teach students to engage with the limits and possibilities of the *global* by focusing on the *local*—or even the *glocal*, a creolization of the two (Hannerz 2003). With these ends in mind, we arrange for the LCSL students to participate in the following activities over their 5-week stay: work as English language teaching assistants in two Costa Rican elementary schools; participate in homestays and community events with resident families; talk with elders, adults, and students to learn about community challenges and resources; visit local businesses, nature preserves, and a women's cooperative; tour two organic produce farms; visit an organic coffee plantation; tour an international grant-funded tilapia farm; and take daily classes on the university satellite campus alongside (and often in tension with) other U.S. study abroad groups. Through these various engagements, LCSL students learn that one, small Costa Rican village is itself both cosmopolitan and parochial—comprised of the global, the local, and the glocal.

Our host site illustrates the inherent tensions between ideas of the global and local extremely well. Being the site of a U.S. university satellite campus and located in the ecologically rich cloud forest, our focal Costa Rican village hosts an ongoing stream of scientists, tourists, and visitors from around the world. Many of the village's permanent residents augment their incomes by serving as homestay families. Consequently, LCSL students (many of whom are abroad for the very first time) are humbled to learn that many of the village's families—despite never having left Costa Rica—hold more cosmopolitan perspectives than they do. One of us, for example, is shocked to be served pure maple syrup on pancakes (something she denies herself at home!) while staying with a local host couple. As it turns out, the syrup is a gift to the family from a former international visitor from Canada. This is just one example of how, throughout the trip, students encounter the global/local dialectic in surprising ways.

Over the course of their 5 weeks in Costa Rica, LCSL students come to attend to, invest in, and make sense of the social realities and lived experiences of the people in our host community by exploring their own, albeit temporal, places in it. Sutton (2011) writes that, "Local does not mean isolated. It does not mean unchanging. Furthermore, local systems are not always geographically based, and even when they are, they refer to all who inhabit an area, not just those who have been there a long time" (p. 127). Consequently, a place-based educational approach to study abroad—one informed by ecojustice ethics—insists that no place is "remote." The local and the global are in constant dialogue, especially when embodied in the commons: the cloudforest, the nearby ocean, and through cultural practices such as dance and song. Our small, focal Costa Rican village and its commons are impacted and changed by multiple glocal forces: Canadian visitors, the sweetness of maple syrup, and present-day LCSL students alike. Per an ecojustice perspective, some of these glocalities further enclose the commons, such as how use of the university satellite campus is restricted to fee-paying visitors. Yet, ecojustice theory and place-based pedagogy open up such topics for study in our 5-week program.

Diversity in Community

Sobel (2004) writes that, "[p]lace-based education is about connecting people to people, as well as connecting people to nature" (p. 62). Thus, one of LCSL's primary foci is to have our students connect to the local community: one another, other U.S. study abroad groups on the university satellite campus, workers at the campus facility, and long-term Costa Rican residents. The LCSL group itself is comprised of 14 people: 2 co-instructors, 6 traditionally-aged undergraduate students, 5 masters-level students (4 in their 20s and 1 in her early 30s), and the teenaged daughter of one of the instructors. Even among our own group, there is considerable diversity. Eleven of us identify as white, two as African-American, and one as Latina. Twelve of us identify as women, two as men. One participant holds dual Costa Rican and U.S. citizenship; the rest of the group holds U.S. citizenship alone. Of the two males in our group, one, an undergraduate, is participating in LCSL for a second time; the other male, a graduate-level student, is planning to continue on at the university satellite campus facility for 6 months as an English language teaching volunteer. Two of our students have previously studied abroad in Spain and one has traveled extensively; most of the other student group members have never before left the U.S.

The LCSL group's leadership is diverse as well. Paula, the primary LCSL instructor, has lived and worked in Costa Rica for over a decade, is fluent in Spanish, and is married to a Costa Rican national. The 2011 trip marks her fourth time leading the LCSL group, and she is well-respected and known throughout the community. Cori, a long-term English as a Second Language teacher, is visiting the host site for the first time and speaks only limited Spanish. A central part of LCSL is learning about, negotiating, and accommodating difference between and among LCSL group members, instructors included. Simply being from the U.S. does not result in our being a homogenous unit.

Calling our students' attention to the weakness of the "U.S." side of the oft-presumed U.S./global binary is central to the larger purpose of LCSL. Part of our 5-week trip includes engaging in international service-learning (ISL), a main component of which is understanding diversity in community. While multiple theoretical approaches to international service-learning exist (cf. Bringle and Hatcher 2011), LCSL takes a "justice-oriented" approach to service-learning (following Westheimer and Kahne 2004). This conceptual framework sees the main goal of community service engagement as learning about the underlying causes of social and economic disparity. LCSL is also mindful of critical studies of volunteer tourism (e.g., Butcher and Smith 2010), which suggest that short-term, international voluntary service work often attends to the symptoms of problems rather than their causes.

With these theoretical constructs in mind, we approach the ISL component of LCSL cautiously. Before students even begin ISL, it is essential for them to understand the heterogeneity of the community with whom they have come to work. Kahn (2011), taking up this point, writes that

> [i]t is naïve of ISL practitioners to think that they can help or develop a community, since communities and cultures spill out across borders and are composed of various individuals who do not necessarily think like their neighbor. Do you think like your neighbor? Do we assume community members in developing countries inherently do? Is this another form of imperialist thinking that must be dismantled, and that encourages us to listen to only a few voices or organizations as representative of the greater community? (p. 120)

Difference and even dissent among LCSL group members, then, help to illustrate the complexity and conceptual limits of the term, *community*. This is a key issue in both an ecojustice-informed place-based education and ISL.

In order to learn about the composition of the local community, the LCSL group participates in many activities. For example, while staying at the university satellite campus (weeks 1 and 4 of the program), LCSL students take turns mopping and clearing tables in the dining hall after communal meals. This allows them to mingle with the maintenance crew, chat with kitchen staff, and talk casually with members of other U.S. study abroad groups, up to four of which overlap with ours at any given time. For evening fun, LCSL students recruit a facility maintenance worker to give salsa dance lessons, and they invite campus kitchen staff, their family members, and other U.S. study abroad groups to join in. These lessons lead to many informal conversations on and off the dance floor. Additionally, during the first week of our stay, the LCSL group attends a community-wide fundraiser at one of the village elementary schools. While there, we place bets on local horse races, try our hands at bingo, and dance late into the night to salsa and *reggaeton* music in circles of multi-aged people.

The community-wide fundraising event provides LCSL students with a key chance to understand diversity in community and disrupt the U.S./global binary. During the evening bingo game, LSCL students each sit with their assigned host families. These are the Costa Rican community residents with whom LCSL students will live for weeks 2 and 3 of the program. By dispersing and sitting among local residents, LCSL students feel that they minimize their outsider presence and "fit in" better with the *mise en scène*.

Another U.S. study abroad group, however, cuts quite a different figure. In contrast to the LCSL students, this other group stays in a tight-knit huddle throughout the evening, speaking in English quite loudly and barely mingling with resident Costa Ricans. The LCSL group notices how this other U.S. study abroad group stands apart rather than within the community. As a result, they want to disassociate themselves from them. In a post to her on-line reflective journal, an LSCL student summarizes the group's sentiments as follows:

> (20 July, 2011) I think that it's easy when we're in a country where a different language is spoken to say that we are different and separate from others because we speak different languages. But what I am finding more interesting here is how we separate ourselves from people who speak the same language. There's a [U.S.] group staying here [at the university satellite campus] that we are all trying to distance ourselves from in the community, because we don't want to be associated with them simply because we all speak English and are from [the same university]. And I'm thinking that even though we all speak English, I think that maybe our group speaks a different language from them socially.

Here, we see an emergent understanding of the varying ways in which community is constructed. Language use alone need not indicate affiliation or common interest. "To deeply learn through ISL, students must become aware of [the] heterogeneity within communities," Kahn writes (2011, p. 120). This idea comes opportunistically to the LCSL group.

Related to the issue of diversity in community, Sobel (2004) writes that place-based education "teaches about both the natural and built environments. The history, folk culture, social problems, economics, and aesthetics of the community and its environment are all on the agenda" (p. 9). Thus, an additional and related learning goal of LCSL is to have students understand that the built environment in this Costa Rican village is comprised of (rather than just host to) a U.S. university satellite campus. To ease this awareness along, we begin our program's next step: going into the local schools and participating in ISL through English language teaching.

International Service-Learning Through English Language Teaching: Limits and Possibilities

A central component of ecojustice-informed place-based education is community engagement, which can often take place in school contexts. Schools, in an ecojustice-informed place-based educational framework, are not walled-off testing sites or buildings of child-care provision. Rather, schools are commons, community centers—places where students, teachers, and community residents come together for non-commodified conviviality as well as to solve real-world problems. "Community vitality and environmental quality are improved through the active engagement of local citizens, community organizations, and environmental resources in the life of the school," Sobel (2004) writes. Accordingly, the two elementary schools in our Costa Rican host village are pivotal to our study abroad program. We see them not only as places in which to experience local community life, but also as sites for learning about collaborative, real-world problem solving among community members. Ecojustice theory, moreover, teaches us to see schools as vital commons—places that are publicly held, shared, and rich in non-market based activity.

Paula, LCSL's main instructor, draws upon previously established relationships with the local school board and the village English language teacher to facilitate our group's entry into the schools. Our role there is to serve as English language teaching assistants under the tutelage of the main, locally-based English language teacher—an itinerant educator who travels between two buildings. The LCSL students work in two schools, helping small groups in multi-grade English language classes and hosting an English language day camp on the university satellite campus.

As aforementioned, LCSL takes a "justice-oriented" approach (Westheimer and Kahne 2004) to community engagement. Thus, even while engaging in short-term, international voluntary service work, we have our students read and discuss relevant critiques of the practice. These critiques include: congruence with neoliberal principles (Conran 2011), exaggerated volunteer expertise in international settings (Simpson 2005), and a reduction of communal political action to personal "life politics" (Butcher and Smith 2010). Unlike short-term, international volunteering, however, in which service work is extra-curricular and often detached from community life (e.g., Gray and Campbell 2007), ISL is embedded in coursework and relies on guided, active reflection to help participants engage with the structural issues that undergird social problems. According to Bringle and Hatcher (2011), ISL is

> a *structured academic experience in another country* in which students (a) participate in an organized service activity that addresses identified community needs; (b) learn from *direct interaction and cross-cultural dialogue* with others; and (c) reflect on the experience in such a way as to gain further understanding of course content, a deeper understanding of *global and intercultural* issues, a broader appreciation of the *host country* and the discipline, and an enhanced sense of their own responsibilities as citizens, locally and *globally* (p. 19, emphases in original).

Akin to ecojustice-informed place-based education, ISL stresses deep understanding of a local context prior to and during service work. As Sutton (2011) asserts, successful ISL requires "understanding local modes of civic engagement, local political and economic relations, and local concepts of what constitutes community in the first place" (p. 130). One does not simply "do service" in ISL—or, in our case, drop into a new community and "teach English." Rather, a justice-oriented ISL approach promotes "inquiry into the social groupings and divisions that are present; the environmental, political, demographic, and economic forces shaping (and reshaping) lives and communities … the playing out of global forces in this particular local arena" (Sutton 2011, p. 137).

Yet, ecojustice theory allows us to go even further. Discourses around English language teaching and learning carry linguistic and cultural root metaphors, many of which negatively impact the Earth and community vitality (Bowers 2006). Thus, before we even enter the local schools, we ask our students to consider why and how English language study is occurring there. In whose interests is English teaching operating? For what or whose purposes is English being learned? Research indicates that English language study in Latin America generally reaffirms rather than challenges peoples' current social positions (Niño-Murcia 2003). Why, then, is English language study taking up precious curricular time and scarce resources in a small Costa Rican village? What are the effects of English language study on cultural and land-use practices? In order to answer these questions, we read, discuss, and debate while walking home from the local schools, during class meetings, and through on-line reflective journaling. Guided by ISL and ecojustice principles, we want LCSL students to understand the local/global forces that contribute to English language teaching/learning in Costa Rica and in the Global South more generally.

Indeed, the reasons for global English language spread are complex and many. Under conditions associated with late capitalism, language not only serves as a marker of authenticity but also operates as a powerful form of cultural capital (Niño-Murcia 2003). The *de facto* language of the Global North, English is symbolically associated with technology, modernization, and development—whatever is new (Block and Cameron 2002). Consequently, many Global South nation-states (Costa Rica included) have adopted English language study as part of a national educational curriculum. English's symbolic power moves parents, political leaders, and other stakeholders to demand access to English language study in the face of reduced job prospects (Niño-Murcia 2003).

As in other Global South contexts, English in Costa Rica is linked to ideas of cosmopolitanism, travel, and increased employment opportunities (e.g., Block and Cameron 2002). Jobs near the university satellite campus in transportation, canopy zip-line operating, or cloudforest guiding are perceived as more accessible to those with English language skills. Indeed, it is this supplementary work in tourism that often allows local families to keep their land rather than sell it to development interests. Thus, LCSL students are encouraged to place their community-based service work in a larger, often contested, political context.

To be sure, another affinity between ISL and ecojustice-informed place-based education is a cautious—even skeptical—approach to service. Similar to how large-scale, "one-size-fits-all" solutions to community-based problems are antithetical to place-based education, ISL also opposes externally conceived, non-collaborative service work. Elaborating upon this issue, Plater (2011) cautions that

> [k]nowledge and experience acquired in the United States may not transfer to other nations in any but superficial forms. The unintended consequences of poorly conceived, implemented, or supervised ISL can be harmful to the communities where the failures occur, and occasionally disastrous since the innocence or good intentions of the American foreigners

> can quickly become insults and incidents in unfamiliar settings that magnify similar domestic shortcomings (p. 41).

While many might argue that the work of a volunteer English language teacher would not cause disaster in a Costa Rican village, the concept of English language teaching as "service" merits increased scrutiny. Within the tenets of ecojustice theory, the relations among English language use and ecological stewardship are many and complex. Too often, international development organizations frame any kind of English language teaching—even that conducted by well-meaning but untrained volunteers—as a solution to poverty and job scarcity (e.g., Global Volunteers 2002). This framing of English as a panacea unhinges English's role in disrupting linguistic ecologies (Skutnabb-Kangass 2000) and obscures the fact that primary language literacy remains far more important for vulnerable people than simple phrases or greetings in a foreign language (Bruthiaux 2002). Further, displacing local languages with English ignores the ways in which root metaphors operate on and through local languages and how these root metaphors may be shaping peoples' sustainable interactions with and understandings of the Earth (Bowers 2006).

Weaving together ISL, ecojustice theory, and place-based educational pedagogy, then, we have LCSL students read extensively about English language politics, the anthropology of language, and ecojustice while working in our host site's schools. We want LCSL students to understand the various purposes to which English is being put in Costa Rica while recognizing that English language spread may be disrupting local community practices and livelihoods (Bowers 2006).

LCSL students' on-line reflective journal entries demonstrate their growing understanding of the politics and limits of volunteer English language teaching, particularly in a small Costa Rican village. Following our discussions, readings, and reflections after working in the schools, our students come to realize that their teaching curriculum should reflect local priorities rather than abstract "global" ones. In the words of one LCSL student,

> (15 July, 2011) It's not service-learning for us to just run into a classroom and say, 'Hey, we're gonna teach y'all English' and start teaching the ABC's and 123's. It is imperative to find out the needs of the group and really get to know the group in order to truly create service-learning.

Relatedly, the LCSL group has been struck by the fact that a Costa Rican fourth grader includes a mango tree while drawing an English-labeled map of her community. Akin to the local church and health center, the tree assumes a prominent place in the student's drawing and she wants to label it in English accordingly. After an initial chuckle about the improbability of this occurring in a U.S. classroom (*"What U.S. fourth grader would view an apple tree as the orientation point of a town?"* our students laugh), the LCSL group realizes that the Costa Rican student's drawing reflects her community's priorities. The LCSL group has recently visited a local organic farm, and they are aware that some of its fruit trees and edible plants are treated as community commons. This information then guides LCSL students to question their language instruction; a debate ensues about the relations between words, representation, and reality. The phrase "to throw away" is brought up; as a popular bumper sticker asks, “Where is *away*?” and how does this root metaphor shape our understanding of “waste”? Such are the questions our ISL provokes.

Like U.S. schools, many international English language teaching programs are undergirded by the globally competitive worker ideology. These programs frame English as a tool for accessing an abstract “global arena” rather than having local purposes (Jakubiak 2012). In contrast to this rhetoric, the LCSL group comes to see English language teaching in Costa Rica cautiously: they see English as useful in some contexts, but also disruptive in its potential to carry particular root metaphors forward. Commenting on this new awareness, one LCSL student posts the following to her on-line journal:

> (14 July, 2011) Since we have been here, I have been struck by the importance of incorporating what students [already] know into our teaching. When we visited Finca La Bella [a local organic farm], I learned so much about the plants that we saw. I thought about how I could apply some of that knowledge into different lessons. I, however, had to learn about what was in the community before I could apply that to my work.

Here, we see an LCSL student positioning local community members as knowledgeable: they understand farming, local produce, and ecology in a way that our group does not. Consequently, the LCSL group’s English language teaching curriculum becomes focused on community-based knowledge: K-5 students draw maps of the local community and label them in English and Spanish (to be used as maps for visitors from the university satellite campus); they practice giving English language directions (for the interactions they may have with visitors); and they talk, in small groups, about local community life using simple English language expressions.

Our ISL is useful for LCSL students in other ways, too. All pre- or in-service teacher education students, LCSL students use their ISL experience to work toward becoming better teachers in the U.S. Despite increased linguistic and cultural diversity in U.S. schools, in 2006, only 1 % of all teacher education students in the U.S. studied abroad (Cushner 2009). Not surprisingly, then, U.S. teachers often misunderstand or misinterpret immigrant students’ work, prior knowledge, or interests due to language or cultural barriers (Moll and Luis 2005). The time we spend in Costa Rican schools helps LCSL students to better understand the students they will someday teach. One LCSL student writes explicitly to this point in her on-line journal, saying:

> (14 July, 2011) I think that teachers oftentimes forget that they have lots of things to learn from their students, as well. I had a good reminder of that yesterday when the students were doing the word scramble at camp. When we asked them to draw pictures that represent the words they had unscrambled, I would have thought that they would draw north with an arrow facing the top of the page (and some of them did). But a couple students drew the arrow on the page facing true north based on where the page was facing at that time. It was interesting, because if a teacher took that up to grade at his/her desk, the teacher would probably misunderstand and think that the student didn’t understand the concept. On the contrary, the student had learned the realistic and practical use of cardinal directions.

It is critical for U.S. pre-service teachers to understand non-U.S. schooling practices. Visiting schools that the parents of immigrant children may have attended, for example, "allow[s] pre-service teachers to learn more about the educational assumptions, perspectives and experiences of some of their [future] students" (Cushner 2009, p. 164). Spending time in Costa Rican schools thus helps our pre-service teachers become more informed about how the global/local dialectic influences classrooms worldwide.

In sum, the LCSL group does not engage in short-term, volunteer English language teaching as a way to spread the globally competitive worker ideology. Rather, English language teaching becomes a way for LCSL students to enter the schools and learn firsthand about community-based knowledge, local people, and various commons.

Power Relations and Community Change: The Global/Local Dialectic Revisited

A final, key piece of the LCSL program is having students understand the unintended effects of their presence in a small, Costa Rican village. Although short-term, volunteer English language teaching may not produce substantive results, an ongoing stream of international visitors to a small, Costa Rican village undoubtedly has long-term effects. Although our students may teach Costa Rican elementary students no more than a few new English words, the LCSL group's presence shapes the community in profound ways. "Students participating in international partnerships should be prepared not to have expectations for meaningfully contributing to community change," Longo and Saltmarsh (2011) note, and continue,

> but they can be prepared to participate in reflective inquiry on the origins and intent of the projects in which they participate, the relationships of the projects to the social and power structures of the host community and country, and the degree to which their projects and activities might either perpetuate or liberate political, social, and economic structures (p. 77).

Through their work as short-term, English language teaching assistants, LCSL students engage in more than simple language teaching. The continual presence of short-term, study abroad students at the university satellite campus (and in the community) changes the very "locality" of that community and its schools. English language study may receive greater traction there because of the continual presence of "teaching assistants"; how and in what ways, we want the LCSL students to ask, does our presence alter the thought practices and priorities of this community?

Luckily, our efforts are fruitful. In about week 3 of our stay, many of the LCSL students begin to sit less comfortably with how a U.S. university satellite campus alters power dynamics and influences what is "local" in a small Costa Rican community. By bringing in hundreds of international visitors every year, the university satellite campus contributes to community change, social relations in the village, and local culture. LCSL students begin to recognize this—and often with a new sense of humility. In her on-line journal, for example, one LCSL student posts the following:

> (26 July, 2011) From my homestay experience, I feel like I have gained a peek into the community and [have seen] the results of the families having close relationships with the university. I noticed that the families who have taken advantage of activities like ecotourism and coffee touring seem to have more "things." Not just material items but say in the community. I feel like the families who are not involved in activities with the university are not able to have those "things/privileges" the other families do have.

Here, the LCSL student expresses an understanding of how the global/local dialectic shapes and changes communities. Despite its seemingly parochial location, one small, Costa Rican village is very much affected by global processes.

Relatedly, LCSL students are also intrigued by how inequitable access to the university satellite campus and its international visitors creates new problems for the local community. Students worry that material gain is being wrought at the expense of social cohesion. Speaking to this point, one LCSL student posts this to her on-line journal:

> (26 July, 2011) I also wondered about differences in the community that we cannot see. I wondered if there were any class differences, particularly between families who have been able to take advantage of some of the ecotourism such as waterfall visits, organic coffee, crafting, farm tours, etc. and families who have not. It was nice to hear men and women talk about using those opportunities to help their extended family, but I wondered if they have gained any new influence in the community because of their businesses.

Again, we see a student coming to a new understanding of the global/local dialectic: communities both produce and are produced by processes near and far. The presence of a U.S. satellite campus in a small, Costa Rican village not only "cosmopolitanizes" certain people, but also renders others more parochial.

Balancing the Situated Tensions of a Study Abroad Experience

As we discuss in this chapter, we do not take a study abroad group to Costa Rica with the intent to create globally competitive workers. Instead, we seek to teach our students about one very specific place—a village in the cloud forest of Costa Rica, which temporarily includes ourselves. In doing this work, we attempt to give to our students a sense of the uniqueness of *place* as well as a clearer understanding of the ways in which local knowledge and practices are *not* transferrable, not able to be "scaled up" or standardized. In contrast to the "global" rhetoric that circulates endlessly in study abroad circles, our short-term study abroad program aims to have students generate a keen and appreciative sense of the *local* and the ways in which the global and local intersect. By having our students study the complexities of one, small Costa Rican village through a cautious ISL, we hope that they will come to understand that their own local, the Southeast U.S., is complex and multi-scaled, too.

Are we successful? The jury is still out. Orr (2004) suggests that if and when U.S. colleges and universities replace global rhetoric with a "homecoming" major, a more ecologically and socially just world will follow. In the meantime, we urge other educators, as we did, to reframe study abroad. To the extent that study abroad can become learning about someone else's local (rather than an abstract global), we're all for it. Research demonstrates that U.S. schools will only become increasingly diverse in the twenty-first century (e.g., Noddings 2005). It is time we begin seeing place-by-place uniqueness as good and important—indeed, our ecological future may depend on it.

References

Berlant, L. (1997). *The queen of America goes to Washington city: Essays on sex and citizenship*. Durham: Duke University Press.

Berry, W. (1990). *What are people for?* New York: North Point Press.

Block, D., & Cameron, D. (Eds.). (2002). *Globalization and language teaching*. New York: Routledge.

Bowers, C. (2006). *Transforming environmental education: Making renewal of the cultural and environmental commons the focus of educational reform (revised ed.)*. Retrieved June 12, 2013, at https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/3070/?sequence=6

Bringle, R. G., & Hatcher, J. A. (2011). International service learning. In R. G. Bringle, J. A. Hatcher, & S. G. Jones (Eds.), *International service learning: Conceptual frameworks and research* (pp. 3–28). Sterling: Stylus Publishing.

Bringle, J. A., Hatcher, J. A., & Jones, S. G. (Eds.). (2011). *International service learning: Conceptual frameworks and research*. Sterling: Stylus Publishing.

Brosius, J. P. (1999). Green dots, pink hearts: Displacing politics from the Malaysian rain forest. *American Anthropologist, 101*, 36–57.

Bruthiaux, P. (2002). Hold your courses: Language education, language choice, and economic development. *TESOL Quarterly, 36*, 275–296.

Butcher, J., & Smith, P. (2010). Making a difference: Volunteer tourism and development. *Tourism Recreation Research, 35*(1), 27–36.

Conran, M. (2011). They really love me! Intimacy in the volunteer tourism encounter. *Annals of Tourism Research, 38*(4), 1454–1473.

Cushner, K. (2009). The role of study abroad in preparing globally responsible teachers. In R. Lewin (Ed.), *The handbook of practice and research in study abroad: Higher education and the quest for global citizenship* (pp. 151–169). New York: Routledge.

Darling-Hammond, L. (2012, January 30). Why is Congress redlining our schools? *The Nation*. Retrieved March 17, 2012, from http://www.thenation.com/article/165575/why-congress-redlining-our-schools

Doerr, N. M. (2012a). *Do 'global citizens' need the parochial cultural other? Discourse of immersion in study abroad and learning-by-doing* (pp. 1–20). Compare: A Journal of Comparative and International Education.

Doerr, N. M. (2012b). Study abroad as 'adventure': Globalist construction of host–home hierarchy and governed adventurer subjects. *Critical Discourse Studies, 1*(1), 1–12.

Fisher, W. (1997). Doing good? The politics and antipolitics of NGO practices. *Annual Review of Anthropology, 26*, 469–464.

Friedman, T. L. (2005). *The world is flat: A brief history of the twenty-first century*. New York: Farrar, Straus & Giroux.

Galeano, E. (1973). *Open veins of Latin America: Five centuries of the pillage of a continent*. (Cedric Belfrage, Trans.). New York: Monthly Review Press.

Global Volunteers. (2002). *Global volunteers: Leave your mark on the world*. St. Paul: Author. Retrieved March 17, 2013, from http://www.globalvolunteers.org/

Graeber, D. (2010). Neoliberalism, or the bureaucratization of the world. In H. Gusterson & C. Besteman (Eds.), *The insecure American: How we got here and what we should do about it* (pp. 79–96). Berkeley: University of California Press.

Gray, N. J., & Campbell, L. M. (2007). A decommodified experience? Exploring aesthetic, economic, and ethical values for volunteer ecotourism in Costa Rica. *Journal of Sustainable Tourism, 15*, 463–482.

Gruenewald, D. A., & Smith, G. A. (Eds.). (2008). *Place-based education in the global age: Local diversity*. New York: Routledge.

Hannerz, U. (2003). Being there… and there… and there! Reflections on multi-sited ethnography. *Ethnography, 4*(2), 201–216.

Harvey, D. (1989). *The condition of postmodernity: An enquiry into the origins of cultural change*. Oxford: Blackwell.

Herod, A. (2008). *Geographies of globalization: A critical introduction*. Malden: Wiley-Blackwell.

Jakubiak, C. (2012). "English for the global": Discourses in/of English language voluntourism. *International Journal of Qualitative Studies in Education, 25*, 435–351.

Jakubiak, C., & Mueller, M. P. (2011). The allure of corporate deception and greenwashing: Why every rose has its thorn. In J. L. DeVitis (Ed.), *Critical civic literacy: A reader* (pp. 351–366). New York: Peter Lang.

Kahn, H. E. (2011). Overcoming the challenges of international service learning: A visual approach to sharing authority, community development, and global learning. In R. G. Bringle, J. A. Hatcher, & S. G. Jones (Eds.), *International service learning: Conceptual frameworks and research* (pp. 113–124). Sterling: Stylus Publishing.

Kang, M. (2010). *The managed hand: Race, gender and the body in beauty service work*. Berkeley: University of California Press.

Kearney, M. (1995). The local and the global: The anthropology of globalization and transnationalism. *Annual Review of Anthropology, 24*, 547–565.

Kiely, R. (2011). What international service learning research can learn from research on international service learning. In R. G. Bringle, J. A. Hatcher, & S. G. Jones (Eds.), *International service learning: Conceptual frameworks and research* (pp. 243–273). Sterling: Stylus Publishing.

Lewin, R. (2009). *The handbook of practice and research in study abroad: Higher education and the quest for global citizenship*. New York: Routledge.

Longo, N. V., & Saltmarsh, J. (2011). New lines of inquiry in reframing international service learning into global service learning. In R. G. Bringle, J. A. Hatcher, & S. G. Jones (Eds.), *International service learning: Conceptual frameworks and research* (pp. 69–85). Sterling: Stylus Publishing.

McMillan, T. (2012). *The American way of eating: Undercover at Walmart, Applebee's, farm fields, and the dinner table*. New York: Scribner.

Moll, L., & Ruiz, R. (2005). The schooling of Latino children. In M. M. Suárez-Orozco & M. M. Páez (Eds.), *Latinos: Remaking America* (pp. 362–374). Berkeley: University of California Press.

Mowforth, M., & Munt, I. (2009). *Development globalisation and new tourism in the third world* (3rd ed.). New York: Routledge.

Mueller, M. P. (2009). Educational reflections on the "ecological crisis": Ecojustice, environmentalism, and sustainability. *Science & Education, 18*(8), 1031–1056.

Mueller, M. P., & Bentley, M. L. (2009). Environmental and science education in developing nations: A Ghanaian approach to renewing and revitalizing the local community and ecosystems. *The Journal of Environmental Education, 40*(4), 53–63.

Mueller, M. P., & Tippins, D. J. (2010). Nurturing morally defensible environmentalism. In D. J. Tippins et al. (Eds.), *Cultural studies and environmentalism* (pp. 7–10). New York: Springer.

Niño-Murcia, M. (2003). "English is like the dollar": Hard currency ideology and the status of English in Peru. *World Englishes, 22*(2), 121–144.

Noddings, N. (Ed.). (2005). *Educating citizens for global awareness*. New York: Teachers College Press.

Nolan, R. W. (2009). Turning our back on the world: Study abroad and the purpose of U.S. higher education. In R. Lewin (Ed.), *The handbook of practice and research in study abroad: Higher education and the quest for global citizenship* (pp. 266–281). New York: Routledge.

Orr, D. (2004). *Earth in mind: On education, environment, and the human prospect*. Washington, DC: Island Press.

Phillipson, R. (2003). *English-only Europe? Challenging language policy*. New York: Routledge.
Plater, W. M. (2011). The context for international service learning: An invisible revolution is underway. In R. G. Bringle, J. A. Hatcher, & S. G. Jones (Eds.), *International service learning: Conceptual frameworks and research* (pp. 29–56). Sterling: Stylus Publishing.
Pyle, R. M. (2008). No child left inside: Nature study as a radical act. In D. A. Gruenewald & G. A. Smith (Eds.), *Place-based education in the global age: Local diversity* (pp. 155–172). New York: Routledge.
Salazar, N. (2006). Touristifying Tanzania: Local guides, global discourse. *Annals of Tourism Research, 33*, 833–852.
Simpson, K. (2005). Dropping out or signing up? The professionalization of youth travel. *Antipode, 37*(3), 447–469.
Skutnabb-Kangass, T. (2000). *Linguistic genocide in education—Or worldwide diversity and human rights?* New York: Routledge.
Sobel, D. (2004). *Place-based education: Connecting classrooms and communities*. Great Barrington: The Orion Society.
Spring, J. (2004). *How educational ideologies are shaping global society: Intergovernmental organizations, NGOs, and the decline of the nation-state*. New York: Taylor and Francis.
Sutton, S. B. (2011). Service learning as local learning: The importance of context. In R. G. Bringle, J. A. Hatcher, & S. G. Jones (Eds.), *International service learning: Conceptual frameworks and research* (pp. 125–144). Sterling: Stylus Publishing.
Tomkins, R. (2008). Overlooked opportunity: Students, educators, and education advocates contributing to community and economic development. In D. A. Gruenewald & G. A. Smith (Eds.), *Place-based education in the global age: Local diversity* (pp. 173–195). New York: Routledge.
Tonkin, H. (2011). A research agenda for international service learning. In R. G. Bringle, J. A. Hatcher, & S. G. Jones (Eds.), *International service learning: Conceptual frameworks and research* (pp. 191–244). Sterling: Stylus Publishing.
Tsing, A. (2000). The global situation. *Cultural Anthropology, 15*, 327–360.
Tsing, A. L. (2005). *Friction: An ethnography of global connection*. Princeton: Princeton University Press.
Westheimer, J., & Kahne, J. E. (2004). What kind of citizen?: The politics of educating for democracy. *American Educational Research Journal, 41*(2), 237–269.
Woolf, M. (2006). Come and see the poor people: The pursuit of exotica. *Frontiers: The Interdisciplinary Journal of Study Abroad, 13*, 135–146.
Wright, M. W. (2006). *Disposable women and other myths of global capitalism*. New York: Routledge.
Zemach-Bersin, T. (2009). Selling the world: Study abroad marketing and the privatization of global citizenship. In R. Lewin (Ed.), *The handbook of practice and research in study abroad: Higher education and the quest for global citizenship* (pp. 303–320). New York: Routledge.
Zúñiga, V., & Hamann, E. T. (2009). Sojourners in Mexico with U.S. school experience: A new taxonomy for transnational students. *Comparative Education Review, 53*, 329–353.

Cori Jakubiak is an assistant professor of education at Grinnell College. A former K-12 language arts and English as a second language (ESL) teacher, Cori's research interests include short-term, volunteer English language teaching (*English language voluntourism*), environmental justice, and K-12 schooling in the context of English language learners.

Paula J. Mellom is assistant research scientist with the Center for Latino Achievement and Success in Education at the University of Georgia. Her scholarship focuses on second language acquisition, globalization, and issues of identity and culture. Paula also teaches the course, Language and Culture Service-Learning, at the University of Georgia's Costa Rica campus in San Luis, Costa Rica every summer.

Chapter 8
Drawing on Place and Culture for Climate Change Education in Native Communities

Anne L. Kern, Gillian H. Roehrig, Devarati Bhattacharya, Jeremy Y. Wang, Frank A. Finley, Bree J. Reynolds, and Younkyeong Nam

Connection to place is a critical cornerstone of a Native sense of identity, and a necessity for preservation and restoration of land and Tribal sovereignty. The land and environment hold particular significance for Native peoples and communities. Changes in the environment due to a rapidly changing climate have a profound impact on the livelihood of Native people (Davis 2010). Daniel Wildcat (2009) suggests climate change can be thought of as the "fourth removal" for Native communities. For example, effects of climate change are a cause for the movement or

A.L. Kern (✉)
Associate Professor in Science Education, University of Idaho,
1031 N. Academic Way, Coeur d'Alene, ID 83814, USA
e-mail: akern@uidaho.edu

G.H. Roehrig
STEM Education Center, University of Minnesota,
320 Learning and Environmental Sciences, 1954 Buford Ave, St. Paul, MN 55108, USA
e-mail: roehr013@umn.edu

D. Bhattacharya
Department of Curriculum and Instruction, STEM Education Center, University of Minnesota,
320 Learning and Environmental Sciences, 1954 Buford Avenue, St. Paul, MN 55108, USA
e-mail: devarati@umn.edu

J.Y. Wang
250 Education Sciences Building, 56 East River Road, Minneapolis, MN 55455-0364, USA
e-mail: wang0501@umn.edu

F.A. Finley
Department Head for Native American Studies, Salish Kootenai Tribal College,
58138 US Hwy 93, Pablo, MT 59855, USA
e-mail: salishsilver@gmail.com

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_8

elimination of local food sources, such as buffalo and fish resulting in the relocation of a local community to search for other sources of food. With this fourth removal, unlike the others where the focus was to "civilize" the American Indian through "geographical, social, and psycho-cultural" (p. 3), the impacts of climate change reach far beyond Native communities, impacting all life on the planet.

Science Education and Native American Culture

The United States education system has failed American Indian youth (Baker 2003; McKinley 2007). Western models of education fail to incorporate knowledge fundamental to American Indian being and understanding (Cajete 1994, 1999). These models are particularly problematic when considering the science and mathematics taught in public schools where there is a often conflict between Native cultures and values and national goals and standards, thereby creating a science curriculum that is generally irrelevant to students' lives (Allen 1997; Matthews and Smith 1994; Ogbu 1992). In some instances the Indigenous Knowledge passed down through elders' stories are in direct conflict with western scientific knowledge. For example, some Native cultures understand there is a systematic relationship between everything in the natural world. By contrast, in much of western science, particularly as represented in the school curriculum, the tendency is to treat the natural world as isolated units and interactions between single variables (Szasz 1999). Deloria and Wildcat (2001) suggest the goal is for Native students to be *bicultural*, constructing knowledge in both the dominant and their home cultures, so that they are both academically prepared and actively connected to their tribal communities. In other words, it is critical to connect science directly to Native students' lives empowering them to pursue careers as scientists and engineers that allow them to become leaders in their own communities, with a purpose to maintain community sovereignty such that American Indian people as scientists and informed citizens are actively involved in policy-making in their communities related to climate change and other environmental issues. In this chapter, we present a theoretical framework for engaging teachers and students in Native communities in the critical issue of climate change education, including specific applications of the framework illustrated through two teacher professional development programs working with Native communities in Minnesota and Idaho. While our examples are from two specific locations, the framework is applicable within any Native community.

B.J. Reynolds
Black Hills State University, 1200 University St. Unit 9005, Spearfish, SD 57799-9502, USA
e-mail: bree.reynolds@bhsu.edu

Y. Nam
The College at Brockport, State University of New York,
350 New Campus Drive, Brockport, NY 14420, USA

Climate Change Education Teacher Professional Development

Our work through two separate NASA Innovations in Climate Education teacher professional development programs is designed to promote the teaching and learning of climate change education in American Indian communities: Teachers Discovering Climate Change from a Native Perspective (CYCLES) and the Intermountain Climate Education Network (ICE-Net). CYCLES and ICE-Net are three-year professional development programs that integrate Native and western scientific explanations of the natural world, specifically climate change, as interconnected, cyclical processes. CYCLES provides professional development in Northern Minnesota in collaboration with the following Ojibwe reservation communities, Fond du Lac, Leech Lake, Red Lake, and White Earth ICE-Net provides professional development in several tribal communities across a 600-mile stretch of the Intermountain west (Idaho and Northeast Washington), including the Shoshone-Bannock, Nez Perce, Coeur d'Alene, and Spokane reservations.

The CYCLES and ICE-Net professional development programs was developed specifically for teachers in our partner communities. Teachers working in schools on or in close proximity to the reservation were invited to participate. Our participants were primarily non-Native, which reflected the teacher demographics at our school sites. The professional development included a series of multiday summer workshops and school year follow-up activities. Both programs offer 4–8 day resident summer workshops engaging teachers in understanding climate concepts as articulated by the *Climate Literacy: The Essential Principles of Climate Science* (National Oceanic and Atmospheric Administration [NOAA] 2009). During, the workshops teachers explore climate change science within the local environment, using culturally relevant teaching and pedagogies. Follow-up activities are carried out differently by the two programs: CYCLES implements 5 day-long Saturday experiences throughout the school year and ICE-Net offers monthly 90-min "check-in" meetings for program teachers to touch base, ask for ideas from fellow teachers, and assistance from program scientists and experts. Both programs purpose is to engage teachers in learning and reflecting on ways to provide their American Indian students culturally relevant ways to learn about climate change, encouraging them to draw on the local community and environment around them.

In developing and implementing our professional development curriculum, we draw on our framework for climate change education in Native Communities. As stated in our opening paragraph, the effects of climate change will impact everyone, however in American Indian communities these have deep implications for both societal and environmental concerns. The framework draws on the elements of Ecojustice where culture, community, and environment are considered as both content and context. In the following section, we describe the framework and provide examples of activities and lessons that highlight the various features.

A Climate Change Education Framework in Native Communities

The culturally-relevant framework for Climate Change Education in Native communities (Roehrig et al. 2012) used to inform our professional development programs integrates three approaches to science teaching and learning that are aligned to native epistemologies: (1) Place-based approaches to link learning with local understanding and motivation (2) Interdisciplinary approaches to learning science, and (3) Inquiry-based approaches (Fig. 8.1). We recognize that there many Native epistemologies and the approaches and examples used within this chapter are specific to our partner communities.

It is important to recognize that *place* holds a significant and holistic meaning for American Indians. For example among the Coeur d'Alene people *place* provides rich meaning in terms of history, culture, and environment; historically, as the location for being, culturally, as a sense of identity, and environmentally as a place of stewardship and guardianship (Woodworth-Ney 2004). As a result *place* has the potential to offer a familiar context in which to learn about and understand the effects of climate change.

The goal is to design climate change curricular activities for cultural relevance that integrate all three approaches from the framework. In the following section, we describe the three approaches embedded in the framework and examples of activities and lessons from our professional development programs. Each example activity incorporates multiple approaches from the framework; however, for each example we highlight a specific aspect of the framework.

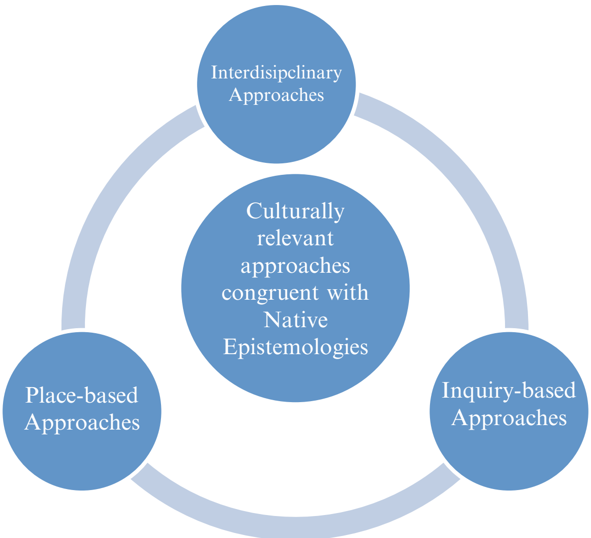


Fig. 8.1 Framework for climate change education in native communities

Place-Based Approaches

Place-based approaches to education are grounded in the notion that the students' local environment and community are a primary resource for learning, which is rooted in the unique history, culture, and environment of a particular place. Gruenewald (2003) suggests, that placed-based approaches to teaching are grounded in the notion that geographical places are rich in social, cultural, and historical significance, yet become devoid of life "when we fail to consider places as products of human decisions" (Gruenewald 2003, p. 627). Semken and Freeman (2008) note, "in the natural sciences, place-based pedagogy is advocated as a way to improve engagement and retention of students, particularly members of indigenous or historically inhabited communities" (p. 1044). Davidson-Hunt and O'Flaherty (2007) add "the goals of a place-based learning community are to support people in responding to their own needs, developing a capacity to generate their own research projects, creating supportive relationships with other actors through the building of dynamic processes for the coproduction of locally relevant knowledge" (p. 295).

While the purpose of a place-based approach to climate change education for American Indian students helps to maintain a sense of identity and cultural connections to the land, it is also important for students to be able to make connections between local and global climate concerns as climate change effects the entire planet With the anchor of their own local issues, students are encouraged to investigate how climate change issues in their community are similar or dissimilar to other places and how the local can contribute to an understanding of *global* climate change and the development of the big ideas in climate science (NOAA 2009; NSF 2009).

Program Highlight: Place-Based Approaches

Place-based approaches provide a context and opportunity to elicit prior knowledge. It is essential to become familiar with the community and community resources. Thus, one of the first activities that ICE-Net teachers complete is a *Community Resources Inventory* of their local community. The Community Resources Inventory allows teachers to identify local climate change resources and environmental agencies. These resources include agencies such as local departments of natural resources, non-profit environmental groups, and Tribal committees. These organizations can provide a wealth of resources that teachers can draw on to engage the community. The use of local resources provides an opportunity for community communication and relationship building. The building of community membership is instrumental in engaging American Indian teachers, and by extension their students, in more than developing STEM knowledge; it provides opportunities for civic engagement where students give back to their tribal communities or other places in the region. Civic engagement, in various forms, can familiarize teachers with local needs and builds skills in interacting with members of the community.

The CYCLES program focuses on unique and local research projects that bring together place-based climate issues, culture and climate change science throughout the summer and follow-up workshops. Many local plant or animal species are used for exploring impacts of climate on ecology and agriculture but the wild rice provides a context for enacting culturally-relevant, place-based education. Wild rice grows abundantly in shallow lake and marshy habitats of northern Minnesota. This sacred plant plays a crucial role in the economic and ceremonial life of many tribes, including the Ojibwe. Wild rice is extremely sensitive to environmental factors and cannot withstand extreme changes in water levels. Flooding and deep water in early spring lead to delayed seed germination on the bottoms of lakes and rivers, while low water levels in the late summer causes the wild rice stalks to break under the weight of the fruit head. Over time, extended drought conditions could encourage greater natural competition from more shallow water species (Hoene 2010).

CYCLES use of the context of wild rice also illustrates interdisciplinary and inquiry-based approaches to learning that draws on multiple forms of data to understand the effects of climate and other human impacts on wild rice harvests. Wild rice lakes are interacting systems of chemistry, biology, physics, and geology, and sediment cores integrate the records of these systems over time. Sediment core transects from shallow to deep water (i.e., from the edge to the center of the lake) provide tangible evidence of differences in sedimentation (coarse to fine grained) and biota. Three follow-up workshops focus on cultural and place-based issues surrounding the growth of wild rice. In September, teachers learn the traditional processes for harvesting wild rice, working side by side with elders to harvest at a local lake (see Fig. 8.2). Elders stress the differences between paddy rice (produced by farming)

Fig. 8.2 CYCLES teachers using traditional techniques to harvest wild rice

Fig. 8.3 Teachers collecting lake core samples at Lake Itasca

and naturally grown wild rice and changes in yields over time related to climate change. Personal recollections of elders and community members and the oral histories passed down through generations provide important data depicting variability in wild rice population abundance and distribution.

During January and February, CYCLES teachers collect and analyze lake sediment cores from Lake Itasca in northern Minnesota. At the January workshop, teachers work with research scientists from the University of Minnesota Limnology Research Center, LacCore, to complete a transect of the east arm of the lake, collecting five core samples (see Fig. 8.3). The five different locations are chosen because of the lake's unique topology to understand geological and biological interactions and events that have happened during the last 10,000 years. In February, CYCLES teachers analyze their core samples at the LaCore research facility, exploring the long ecological history of the lake and human impacts on water chemistry and plant life (including wild rice) over time. Through the application of the framework, teachers (and students from teachers classes that complete follow-up activities at their school sites) are provided with an opportunity to connect historical information shared by elders to scientific findings from the lakes on their reservation.

During the first ICE-Net summer workshop, teachers are introduced to the tradition of storytelling in the local community (see Fig. 8.4). Western society references the past using specific chronological dates with years, months etc. Many American Indian communities more often relate stories and references to past events. Tribal Elders and community leaders use stories, not only as entertainment, but also to document their history. Elders may talk about weather in terms of seasons or harvests comparing the present to the past, such as "remember the past buffalo hunts, when the buffalo were trapped in the valley due to heavy snowfall on the prairie" (Finley, personal communication). Time is marked by natural phenomena such as moon phases, rather than western calendar months. For example, in some regions, Native stories tell of the "full wolf moon" during the cold and deep snows when wolf packs could be heard to howl hungrily outside the village. The "full worm moon" denotes spring as the ground thaws causing earthworms to appear out of the ground.

Fig. 8.4 Community leader sharing oral histories of place through stories

An understanding that some stories are very old and may contain vestiges of historic weather patterns when decoded can help teachers and their Native students make a connection to the enduring effects of climate change. Famed Blackfeet poet and songwriter, Jack Gladstone has taken some older stories and turned them into songs. For example, "The Bear That Stole the Chinook" (Gladstone 1992), a popular story among the Blackfeet, Montana community, tells of a time when there was no warming wind in the wintertime, when the wind blew cold and bitter and remained that way for a very long time. While these oral stories are typically unfamiliar to our non-Native teachers, they are usually highly regarded by Tribal youth, and have the potential to provide a bridge to the data and knowledge of climate change science (i.e. *Climate Change Standards/Principles"#4.A-Climate is determined by the long-term pattern of temperature and precipitation averages and extremes at a location. Climate descriptions can refer to areas that are local, regional, or global in extent. Climate can be described for different time intervals, such as decades, years, seasons, months, or specific dates of the year*) to the celebration and history of Native lore.

The snow came early and lay on deep
The cold blown bitter made the women weep
Our men tracked hard but could find no game
In our children's bellies were cryin' pains
Our elders gathered in the eve and dawn
They prayed and waited and looked
But, little did they know that way up high
The Bear Had Stole the Chinook.

A ragged orphan boy living alone
Called to the animals in his home
Owl and Magpie flew on in
With Coyote and Weasel, there were four of them

As their council met, the Magpie "cawed"
As our heroes shivered and shook
He said, "my relatives told me so",
He said, "The Bear Has Stole the Chinook."

Our heroes' journey to release the wind
Turned west to the mountain bear's den
Four days they teamed and traveled along
Together they did ascend…
Up to the den that held the Chinook.

The Grizzly snored and snarled in his sleep
Owl crept close, into his lodge peeped
Bear punched Owl's eyes with a stick
So they sent in a brother who was lightning quick.
The weasel slithered easy through the hole,
And found the elk skin bag of the crook
The bear, enraged roared, "Go Away!" (and said)
"I'm the Bear Who Stole the Chinook!"

Then our friends made medicine smoke appear
And blew it in the Grizzly Bear's den
The big ol' Griz fell fast asleep
As Coyote crept on in.

He found the bag where the wind was kept
And pulled it to the light of day
There a Prairie Chicken picked the stitches out
Then the Chinook blew on its way
The Chinook blew on its way.

The Bear burst suddenly from his sleep **Grrrrr!**
Our friends all fled, their job complete
The Bear, in vain, pursued the wind
But, the warm wind never was again his friend.
Now Bear sleeps underground the winter long
In his lodge he grumbles and looks
Back to the days of the winter warmth
To the Bear Who Stole the Chinook
To the Bear Who Stole the Chinook
I'm the Bear Who Stole the Chinook!

I'm the Bear Who Stole the Chinook!
Grrrrr! Grrrrr! (Gladstone 1992)

Interdisciplinary Approaches

Interdisciplinary curricular approaches to science teaching are an important consideration when working with teachers of Native students, as an integrated approach is aligned with Indigenous worldviews. An Indigenous worldview is interconnected and holistic (Deloria 1992), taking into account the myriad of interconnections between living and natural entities (Brayboy and Castagno 2008). Unfortunately, schools have traditionally taught the subjects, including the sub-disciplines of science, in isolation without drawing upon the organic connections between them (Czerniak et al. 1999; Katehi et al. 2009; Sanders 2009). This compartmentalization of school subjects can be an impediment to American Indian students' ability to learn and engage with science (Barnhardt and Kawagley 2004).

Climate change represents one of the most pressing global and multidisciplinary problems facing humans and is identified as one of the big ideas in Earth Science essential to developing K-12 scientific literacy in the new *Next Generation Science Standards* (NRC 2012). Understanding the evidence for climate change and proposed solutions requires a significant understanding of geologic time, hydrology, geomorphology, ecology, and atmospheric processes. However, both educators and scientists stress the necessity of studying the earth as an integrated system in order to explain complex phenomena (Johnson et al. 1997). Students need to develop understandings of the interactions between the atmosphere, hydrosphere, lithosphere, biosphere, and heliosphere. For example, the Earth Science Literacy Initiative (ESLI) (National Science Foundation [NSF] 2009) states that Earth is a complex system of interacting rock, water, air, and life, which requires an integrated approach to science teaching. Climate literacy cannot be achieved if Earth science continues to be taught as independent and isolated sub-disciplines (Libarkin et al. 2005). National initiatives in the Earth sciences, such as the ESLI (NSF 2009), focus on the fundamental concepts (big ideas) in Earth science through an Earth System approach and provide a framework for teaching climate change that aligns both with the ways in which scientists conceptualize their work and the holistic view of the earth embodied in many Native cultures.

Program Highlight: Interdisciplinary Approaches

To provide greater relevance and immediacy for climate change education CYCLES builds upon cutting-edge research being conducted in northern Minnesota relevant to the teacher participants in the program. While impacts commonly associated with climate change, such as sea-level rise, are unfamiliar phenomena for Minnesotans, their landscape is experiencing many climate related changes, such as earlier "ice-out" dates on lakes and shifting biomes. Thus, the first 5-day summer workshop is held at Cedar Creek Ecosystem Science Reserve (http://www.cedarcreek.umn.edu/). The Cedar Creek Ecosystem Science Reserve is a 5,400-acre ecological research site in central Minnesota with natural habitats that represent the entire state. This allows access for teachers to explore the three prevalent Minnesota biomes: prairie, deciduous and boreal forests.

Cedar Creek is home to many large-scale interdisciplinary, scientific experiments; David Tilman and Peter Reich, two eminent ecologists, conduct their primary research at Cedar Creek. BioCON (Biodiversity, CO2, and Nitrogen) is a long-term experiment that explores the ways in which plant communities will

Fig. 8.5 Three sisters garden

respond to three environmental changes that are known to be occurring on a global scale: increasing nitrogen deposition, increasing atmospheric CO_2, and decreasing biodiversity. Projects such as BioCON provide clear examples for teachers that are both place-based and reflect the interdisciplinary nature of understanding climate change. Data from BioCON shows that elevated CO_2 levels do not have the hoped-for effect of greatly increasing plant growth and thus to decrease atmospheric levels of CO_2. This research also demonstrates that nitrogen limitation constrains ecosystem responses to elevated CO_2, illustrating the fact that climate is regulated by complex interactions among the components of Earth System (Essential Climate Literacy Principle 2 [NOAA] 2009).

Principles of biodiversity are not new to Native cultures; for centuries, tribes including the Ojibwa, plant Three Sisters gardens to supplement traditional hunting and gathering. The Three Sisters are corn, beans and squash planted close together in a mound. The corn is planted in the center of the mound and the cornstalk then serves as a pole for the beans (see Fig. 8.5). The beans provide nitrogen to the soil, while the squash provides coverage and shade both preventing weeds and creating a microclimate to retain moisture in the soil. Teachers learn about the Three Sisters gardening approach and how this native knowledge relates to the biodiversity lessons of BigBio and BioCON and the interactions of biodiversity and nitrogen levels under a climate change scenario.

Inquiry-Based Approaches

Research on how Native American students learn supports the use of hands-on learning (Freeman and Fox 2005). The Bureau of Indian Affairs (BIA) developed education standards to assist educators in integrating Native content and perspectives into the K-12 curriculum (Bureau of Indian Affairs [BIA] 2000). The Science as Inquiry standards state that students should "develop an understanding about science inquiry as a specific process/framework for investigating natural phenomena" and how inquiry is "used by different American Indian peoples in the past to investigate and explain natural phenomena" (BIA 2000). Thus, when considering climate change, it is critical that both teachers and students understand how scientists work and the forms of evidence used by both scientists and Native peoples. For example, ESLI's Big Idea #1 is that Earth scientists use repeatable observations and testable ideas to understand and explain our planet suggesting that students should be engaged in scientific explorations related to climate change.

Care must be taken however that an exclusive approach that privileges western science (repeatable, testable observations) is not assumed. In fact, the American Association for the Advancement of Science has begun to recognize the potential contributions of Indigenous people to our understanding of the world (Lambert 2003), leading to an increasing realization that typically marginalized groups are a valuable source of climate change information (Salick and Byg 2007). Indigenous people have traditionally engaged in science. *Traditional Ecological Knowledge* (TEK) includes narratives and observations that provide data and explanations for various kinds of natural resource phenomena (Alexander et al. 2011). TEK is "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes 1999, p. 8) and provides important evidence for changing climate.

Program Highlight: Inquiry Approaches

To demonstrate ways to embed common science inquiry activities within a cultural context, ICE-Net teachers engage in the *Climate Change-Greenhouse Gases* activity. The core scientific understanding developed in this lesson is that some greenhouse gases retain heat longer than others, with the implication being that as heat retention increases over time overall warming becomes significant on a global scale. This activity is a small-scale chemistry investigation that involves measuring the heat retention of various greenhouse gases, such as CO_2, CH_4, and water vapor.

In this activity, a "simulated ecosystem" is created in a petri dish where teachers can observe the heat retention rates of CO_2, CH_4, and water vapor that are pumped into the individual simulated ecosystems (see Fig. 8.6). Additional equipment includes heat lamps-to raise the initial temperature of the ecosystems, and microencapsulated liquid crystal thermal paper (thermo-strips)-used to observe the rate of heat retention in the separate "simulated ecosystems" (petri dishes). The thermostrips change color as the ambient temperature varies in the "ecosystem;" thus the rate of heat retention can be measure by observing the rate of temperature decrease over time. The petri dish with the carbon dioxide holds heat longer, and thus decreases in temperature slower than the one without the added CO_2.

Fig. 8.6 Teachers compare the heat retention of different greenhouse gases

The Tribal leader working with the ICE-Net project shares stories about historical "weather" patterns and the length of drought during a hunting season. The CC-Greenhouse Gases activity provides an observable model of how greenhouse gases can increase the overall temperature of the environment by retaining heat due to an increase in greenhouse gasses, CO_2 in particular. The relationship of an increasing climate temperature can be related to the cultural rituals of Tribes of Western Montana and Northern Idaho who have adjusted harvesting times and celebrations to welcome the blooming season of traditional plants such as bitterroot and camas to accommodate the earlier (about 3 weeks) budding and blooms. Records of spring budding celebrations can be compared to the increasing spring temperature records.

Another example of a culturally relevant inquiry activity is the *Tree Rings and Climate Change* activity used in the CYCLES program. The *Tree Ring* activity includes two sets of inquiry activities: examining the relationship between local tree ring growth and local weather data for a short-term analysis (30–50 years) and for a long-term analysis (150–200 years) (see Fig. 8.7). During the first activity teachers collect local oak tree cores from the Cedar Creek site and analyze tree rings using skeleton plots and microscopes. Prior to collecting the tree cores, a tribal elder gives a traditional tobacco blessing. Teachers explore the relationship between the observed tree ring growth patterns and local weather data, such as precipitation records. The second activity involves finding patterns between long-term dendrochronology data (tree ring growth data) and historic weather data, specifically precipitation data. Through the inquiry activity, teachers have opportunities to examine a b

Fig. 8.7 (**a**) Tribal elder performs a tobacco blessing before tree cores are taken and (**b**) teachers analyze and collate their tree core samples comparing with ground and satellite data records

local proxy data and develop understandings of how it is used to reconstruct climate throughout earth history.

Phenological events, such as the flowering, migration, and breeding of specific species are becoming known as a 'globally coherent fingerprint' of climate change impacts on plants and animals (Parmesan 2007). Currently, phenology holds one of the most sensitive biological responses to environmental variation. The *ICE-Net* teachers are introduced to the network of citizen science phenology recorders though *USA National Phenology Network* (www.usanpn.org). The *Lilac Bloom Activity* links climate to growth patterns of the lilac (*red rothomagensis)*, a cloned, perennial, deciduous shrub that is grown as an ornamental shrub that produces reddish-purple flowers, growing 12–16 feet tall (see Fig. 8.8). Cloned lilac plants are readily available and a low cost species to purchase as a climate indicator species in a school garden. While the lilac is not a traditional or native plant, the connections to growth behavior and tracking of first bloom have been occurring in Native communities for centuries. As described above, harvest patterns and budding ceremonies of native plants have been a recognized part of culture and place in these communities. Tribal records and archives can reveal the recording of these "phenological" records through celebration and harvest accounts and chronicles.

In the *Lilac Bloom* activity, teachers and their students track the variability of bud growth in the spring and loss leaf growth in the fall. Through recording the timing of those "plant life" events, the impact of climate variability and climate change becomes apparent over time. Students can monitor these events and the change in plants over a growing season with a 'Plant Cam', an automated camera, and post their recordings to a national network of lilac bloom observers across the country.

Fig. 8.8 Full bloom lilac (red rothermagenesis)

These "online" resources where students record their data are part of an authentic database of lilac bloom data provided by citizen scientists across the country (see *USA National Phenology Network*).

Relationships With and Within Native Communities

The reverence and significance of *place* provides an opportunity for teachers to build connections to the everyday life of American Indian youth. Our framework provides an innovative and promising approach for teaching not only climate change, but other scientific topics, with American Indian students. The blending of integrated, place-based and inquiry-based approaches allows us to address the needs of students and teachers in American Indian communities in a manner that is respectful of Native ways of knowing and cultural values and knowledge held sacred within the community (Cleary and Peacock 1998; Deloria and Wildcat 2001). It is critical to note that application of the framework requires developing relationships and collaborations with and within Native communities.

As we move forward, it is essential to acknowledge Tribal communities as distinct sovereign governments that are engaged in protecting and exercising their sovereignty to assure the basic welfare of their community and need to shape a future of hope and prosperity for their generations yet to be born. As such, building leadership and protecting tribal sovereignty are central endeavors for tribes. A key charge for educators of American Indians students is to support and assist them in learning how to maintain the place in which they live.

Acknowledgments This material is based in part upon work supported by the NASA Innovations in Climate Education program under Grant Number NNXlOAT53A and NNY10AT77A.

We would like to acknowledge the support and expertize of Jeff Corney and Mary Spivey at Cedar Creek Ecosystem Reserve and Amy Myrbo and her staff at the LacCore Center in planning and implementing professional development and scientific activities with the teachers.

References

Alexander, C., Bynum, N., Johnson, E., King, U., Mustonen, T., Neofotis, P., Oettlé, N., Rosenzweig, C., Sakakibara, C., Shadrin, V., Vicarelli, M., Waterhouse, J., & Weeks, B. (2011). Linking indigenous and scientific knowledge of CC. *BioScience, 61*, 477–484.

Allen, N. J. (1997). *Indigenous models for science-and-culture curriculum development*. Paper presented at the annual meeting of the national association for research in science teaching, Oak Brook, IL, 21–24 March 1997. Retrieved on January 7, 2013, from http://www.eric.ed.gov/PDFS/ED407222.pdf

Baker, D. R. (2003). Equity issues in science education. In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education* (pp. 869–895). Dordrecht: Kluwer Academic Publishers.

Barnhardt, R., & Kawagley, A. O. (2004). Culture, chaos and complexity: Catalysts for change in indigenous education. *Cultural Survival Quarterly, 27*, 59–64.

Berkes, F. (1999). *Sacred ecology: Traditional ecological knowledge and resource management*. Philadelphia: Taylor and Francis.

Brayboy, B. M. J., & Castagno, A. E. (2008). How might Native science inform "informal science learning?". *Cultural Studies of Science Education, 3*, 731–750.

Bureau of Indian Affairs. (2000). *American Indian content standards by subject* (Center for Educational Technology in Indian America). Retrieved on January 7, 2013, from http://web.archive.org/web/20030502224845/http://www.ldoe.org/cetia/science.htm#912

Cajete, G. A. (1994). *Look to the mountain: An ecology of indigenous education*. Skyland: Kivaki Press.

Cajete, G. A. (1999). *Igniting the sparkle: An indigenous science education model*. Skyland: Kivaki Press.

Cleary, L. M., & Peacock, T. D. (1998). *Collected wisdom: American Indian education*. Needham Heights: Allyn & Bacon.

Czerniak, C. M., Weber, W. B., Sandmann, A., Jr., & Ahern, J. (1999). Literature review of science and mathematics integration. *School Science and Mathematics, 99*, 421–430.

Davidson-Hunt, I., & O'Flaherty, M. (2007). Researchers, indigenous peoples, and place-based learning communities. *Society & Natural Resources, 20*, 291–301.

Davis, S. H. (2010). Indigenous peoples and climate change. *The International Indigenous Policy Journal, 1*, 1–17.

Deloria, V., Jr. (1992, Autumn). Relativity, relatedness, and reality. *Winds of Change, 7*(4), 34–40.

Deloria, V., Jr., & Wildcat, D. R. (2001). *Power and place: Indian education in America*. Golden: Fulcrum Resources.

Freeman, C., & Fox, M. (2005). *Status and trends in the education of American Indians and Alaska Natives* (NCES 2005–108). Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Gladstone, J. (1992). The bear that stole the Chinook. *Buckskin Poets Society.* Retrieved on November 1, 2012, from http://www.jackgladstone.com/Lyrics__Buckskin_Poet_Society.html

Gruenewald, D. A. (2003). A multidisciplinary framework for place-conscious education. *American Educational Research Journal, 40*, 619–654.

Hoene, N. (2010, March). Climate change, an Ojibwe prespective. Minnesota Sea Grant Newsletter. Retrieved from http://www.seagrant.umn.edu/newsletter/2010/03/climate_change_an_ojibwe_perspective.html

Johnson, D. R., Ruzek, M., & Kalb, M. (1997). What is earth system science? Paper presented at *Remote Sensing-A Scientific Vision for Sustainable Development. 1997 IEEE International, 2,* 688–691.
Katehi, L., Pearson, G., & Feder, M. (Eds.). (2009). *Engineering in K-12 education: Understanding the status and improving the prospects*. Washington, DC: National Academies Press.
Lambert, L. (2003). From "savages" to scientists: Mainstream science moves toward recognizing traditional knowledge. *Tribal College Journal, 15*, 11–12.
Libarkin, J. C., Anderson, S. W., & Dahl, J. (2005). Qualitative analysis of college students' ideas about the earth: Interviews and open-ended questionnaires. *Journal of Geoscience Education, 53*, 17–26.
Matthews, C. E., & Smith, W. S. (1994). Native American related materials in elementary science instruction. *Journal of Research in Science Teaching, 31*, 363–380.
McKinley, E. (2007). Postcolonialism, indigenous students, and science education. In S. Abell & N. Lederman (Eds.), *Handbook of research on science education* (pp. 199–226). Mahwah: Lawrence Erlbaum.
National Oceanic and Atmospheric Administration. (2009). *Climate literacy: The essential principles of climate science.* http://www.climate.noaa.gov/education/pdfs/ClimateLiteracy-8.5x11-March09FinalHR.pdf
National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academy Press.
National Science Foundation. (2009). *The earth science literacy initiative*. Retrieved on January 7, 2013, from http://www.earthscienceliteracy.org
Ogbu, J. U. (1992). Understanding cultural diversity and learning. *Educational Researcher, 21*, 5–14.
Parmesan, C. (2007). Influences of species, latitudes and methodologies on estimates of phonological response to global warming. *Global Change Biology, 13*, 1860–1872.
Roehrig, G. H., Campbell, K. M., Dalbotten, D., & Varma, K. (2012). CYCLES: A culturally-relevant approach to climate change education in native communities. *Journal of Curriculum and Instruction, 6*, 73–89.
Salick, J., & Byg, A. (2007). *Indigenous peoples and CC*. Oxford: Tyndall Centre for CC Research.
Sanders, M. (2009, January). STEM education, STEMmania. *The Technology Teacher, 68*, 20–26.
Semken, S., & Freeman, C. (2008). Sense of place in the practice and assessment of place-based science teaching. *Science Education, 92*, 1042–1057.
Szasz, M. C. (1999). *Education and the American Indian: The road to self-determination science 1928*. Albuquerque: University of New Mexico Press.
USA National Phenology Network. (2011, April). *Phenology as an indicator of environmental variation and climate change impacts.* www.usanpn.org
Wildcat, D. (2009). *Red alert! Saving the planet with indigenous knowledge*. Golden: Fulcrum.
Woodworth-Ney, L. (2004). *Mapping identity: The creation of the Coeur d'Alene Indian Reservation, 1805–1902*. Boulder: The University Press of Colorado.

Anne L. Kern is an associate professor in science education at the University of Idaho. Her research focuses on using place-based pedagogies in teaching science, technology, engineering, and mathematics (STEM) content, particularly with American Indian students. She is the Principle Investigator for the NSF funded project, *Back to the Earth.*

Gillian H. Roehrig is Associate Director of the STEM Education Center, University of Minnesota. Her research focuses on teacher professional development and induction, STEM integration and climate change education. She is PI on the NASA Innovations in Climate Education, CYCLES, grant and co-PI on a new NSF-funded Water, Sustainability, and Climate grant.

Devarati Bhattacharya is a doctoral student in Science Education at the University of Minnesota. Her background in environmental science steered her towards education where her current research focuses on how science teachers conceptualize, create and disseminate understanding about complex ecological issues like global climate change.

Jeremy Y. Wang is a PhD student in Educational Psychology at the University of Minnesota. He has 8 years of education experience as a middle school science teacher, curriculum developer, and researcher. His research interests revolve around cognitive aspects of scientific reasoning and learning, climate change education, and teacher professional development.

Frank A. Finley is the Department Head for Native American studies at Salish Kootenai College in Pablo, MT, and a graduate student at the University of Idaho in Moscow. He is a member of the Confederated Salish and Kootenai Tribes. He is interested in the intersection of Western and indigenous science, and applications of those outcomes.

Bree J. Reynolds is a National Board Certificated science educator with over 8 years of experience teaching K-12 science. She is a graduate student at the University of Idaho and an instructor in the Center for Teaching and learning at Ross University School of Medicine in the Commonwealth of Dominica.

Younkyeong Nam is an assistant professor at The College at Brockport, State University of New York. Dr. Nam completed her PhD at the University of Minnesota where she focused on secondary earth science teacher's conceptual understandings of water in earth system and its impact on lesson design.

Chapter 9
Art to Capture Learning About the Longleaf Pine Ecosystem – Why a Picture Is Worth a Thousand Words

Michael W. Dentzau and Alejandro José Gallard Martínez

> the sustainable ecological knowledge that youth gain from experiences goes beyond comparison with those gained by mere expressions and written words – (Mitchell and Mueller 2011, p. 219)

Nestled within 48,000 acres of privately owned conservation lands in the Florida Panhandle is an oasis for environmental learning – The E.O. Wilson Biophilia Center at Nokuse Plantation. The Center is the capstone to an ambitious environmental stewardship project, Nokuse Plantation, conceived and implemented by M.C. Davis, with the mission to create a model that connects the large-scale preservation of lands with experiential learning. The center serves as a catalyst for the preservation of nature's biodiversity. Davis believes that the future of biodiversity lies in the combined resources of multiple actors and is best accomplished "by joining the passion of individuals with the resources of the entrepreneur and the power of government, all guided by science" (http://www.nokuse.org/).

Nokuse Plantation (pronounced "no go zee") is the Creek Indian word for black bear. It was during a public presentation on the Florida black bear that Davis began to understand the need for its protection and restoration of bear habitat. He decided to direct his attention and skills as a private businessman to build on existing conservation projects in an effort to provide a large-scale network of conservation lands. The black bear is considered an "umbrella species" because of its wide ranging habitat needs, and by addressing the needs of such a species, protection will be afforded to many other less widely ranging species that comprise the ecosystem (Noss 1991).

M.W. Dentzau (✉)
College of Education and Health Professions, Columbus State University,
3535 South Lumpkin Road, Columbus, GA, USA
e-mail: dentzau_michael@columbusstate.edu

A.J. Gallard Martínez
College of Education, Georgia Southern University, Statesboro, P.O. Box 8013, GA, USA
e-mail: agallard@georgiasouthern.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_9

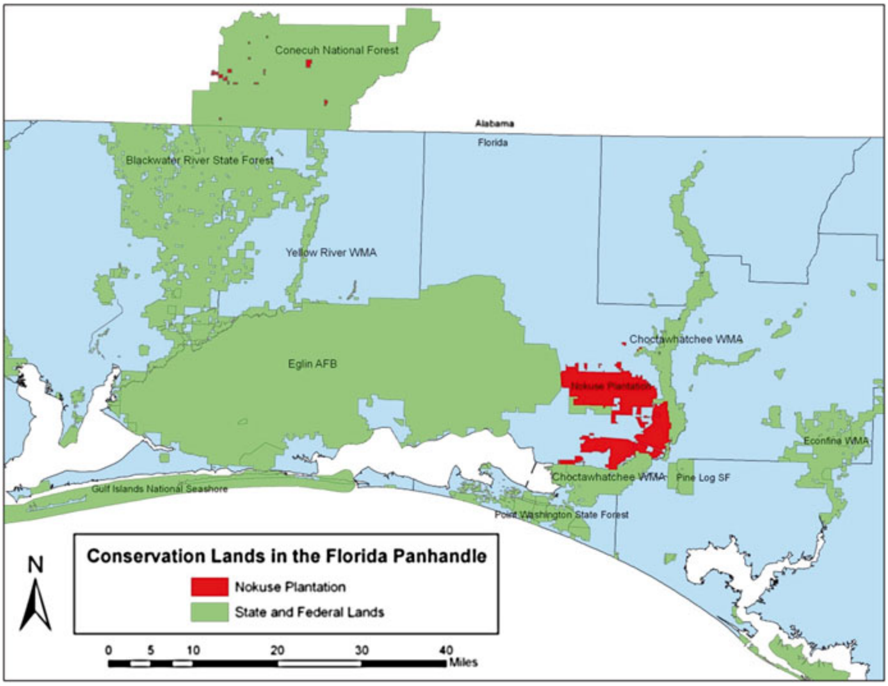


Fig. 9.1 Landscape location of Nokuse Plantation and the greater Panhandle conservation lands

Securing the necessary lands for Nokuse Plantation occurred over many years and was driven by the favorable conditions that allow private interests to work in ways that are not permissible by public entities. Lands could be held in trust out of the public gaze which allowed the piecing together of the essential parcels without unsubstantiated price inflation. It also provided the flexibility to purchase lands, if deemed essential to the project, at prices that sometimes exceeded market value – an option that is generally not available in public acquisitions. This process resulted in the accumulation of those core lands managed and preserved as the Plantation. The Plantation, however, is a cog in a larger conservation project that joins state and federally lands in a virtually contiguous 1,000,000 acres that reaches into Alabama (Fig. 9.1).

The Longleaf Pine Ecosystem

Much of the uplands, and portions of the wetlands, within the larger landscape covered in Fig. 9.1, and specifically within the Plantation, were historically dominated by longleaf pine (*Pinus palustris*). It is estimated that longleaf pine has been eliminated as the dominant tree from 97 % of the lands it once covered prior to European settlement in the area between Virginian and Texas (Frost 1995). The precipitous decline of this community type is attributed to the land use changes that have occurred since early presettlement years, including conversion for agriculture, grazing by livestock and fire suppression (Frost 1995). The single most devastating impact was from logging for the production of ship masts and dwellings throughout the continent and Europe (Whitney et al. 2004). Once logged from its historic range, early foresters documented the inability of this pine species to replace itself. They determined that the destruction of seedlings by free ranging hogs and fire were the primary causes (Ashe 1894a as cited in Frost 1993). While hogs indeed impact longleaf seedling survival, fire is not the enemy as once thought, and in fact, is a required disturbance for the maintenance of longleaf ecosystems and species. The necessary conditions for survival and perpetuation of the greater longleaf pine ecosystem and its integrated micro-communities is the focus for the curriculum, facilities and exhibits of the E.O. Wilson Biophilia Center.

Goals of the Center

The mission of the Center "is to educate visitors on the importance of biodiversity, to promote sustainable balanced ecosystems, and to encourage conservation, preservation and restoration" (http://www.nokuse.org/). The Center involves the local public school system in an active partnership to engage students with ecological issues. Multiple grades are afforded the opportunity to come to the Center, however we focus on the experience of grade 4 students for this chapter.

The exhibit hall combines both free exploration and some guided learning. Stations include longleaf pine ecosystem dioramas, frog biome, bird window, gopher tortoise burrow replica suitable for students to crawl through, snake and aquatic turtle exhibits, photosynthesis model, animal sounds "piano", and multiple taxidermies of typical and iconic inhabitants of the ecosystem (Fig. 9.2). Trails through remnant and recovering longleaf pine forest, embedded wetland communities, and upland bluffs that transition into hardwood wetlands, provide direct contact with the ecosystem. Students have guided learning opportunities with gopher tortoises, animal tracks, embedded microcommunities, specific plants, predator-prey relationships, and various vertebrate and invertebrate species collected by stationary pre-set traps nearby.

How important are such experiences with the natural world? Consider the notion of ecological literacy that has been that has been proffered by David Orr (1989, p. 334):

> To become ecologically literate one must certainly be able to read, and I think even like to read. Ecological literacy also presumes the ability to use numbers, and the ability to know what's countable and what's not, that is, to know the limits of numbers. But these are indoor skills. Ecological literacy requires the more demanding capacity to distinguish between health and disease in natural systems and to understand their relation to health and disease in human ones; knowledge of this sort is best acquired out-of-doors.

Fig. 9.2 View of the exhibit hall of the E.O. Wilson Biophilia Center showing the gopher tortoise burrow and dioramas

In order to engender ecological literacy we must immerse students in the study of nature and provide a sense of ownership to the issues and the power to make a difference (Mitchell and Mueller 2011). This supports the core goal of the American Association for the Advancement of Science (Rutherford and Ahlgren 1989, p. xiii), which states that science education "should help students to develop the understandings and habits of mind they need to become compassionate human beings able to think for themselves and to face life head on". Ecological literacy supports the holistic development of a well-rounded citizen.

The Outdoors as a Classroom

Varied research suggests that field-based lessons and curriculum generate greater cognitive understanding than when those same concepts are imparted in the classroom exclusively. Nigerian students that have first hand experiences with organisms in their natural habitats have increased performance on ecological assessments when compared to those exposed to the content only in the classroom setting (Hamilton-Ekeke 2007). Focusing on potential gender differences, the gains for

4th and 5th grade boys are especially high for an environmental education curriculum that incorporates lessons out of doors when compared to only traditional classroom instruction (Carrier 2009). Experienced-based strategies in the natural environment are more effective than complimentary traditional strategies in encouraging student learning for sustainability in Queensland (Ballantyne and Packer 2009), and residential programs are shown to be "influential in forming long-term memories and knowledge" among 5th grade participants in Idaho (Knapp and Benton 2006). Isabel Ruiz-Mallen et al. (2009) note that school students who participated in a local outdoor environmental education program have greater ecological knowledge based upon a combination of qualitative and quantitative assessments than those who do not participate, even when the control group has compulsory ecological classes. Justin Dillion et al. (2006, p. 107) find "substantial evidence to indicate that fieldwork, properly conceived, adequately planned, well taught and effectively followed up, offers learners opportunities to develop their knowledge and skills in ways that add value to their everyday experiences in the classroom". In a program that focuses on increasing children's everyday perception of local plants and animals on their way to and from schools in Switzerland, participation is shown to increase the identification of common species when compared to a control group (Lindemann-Matthies 2002). Adrienne Cachelin et al. (2009, p. 13) contend that the "rich peripheral signals generated in outdoor contexts actually allow the brain to store the information differently: in spatial memory", ultimately leading to lasting learning. This is consistent with the understanding that memory is enhanced when concepts are stored in "natural, spatial memory" (Knapp 1992, p. 6).

Environmental Education and Broader Educational Goals

One of the earliest definitions provides that "environmental education is aimed at producing a citizenry that is *knowledgeable* concerning the biophysical environment and it associated problems, *aware* of how to help solve these problems, and *motivated* to work toward their solution" (Stapp et al. 1969, p. 54). The literature also suggests that the benefits of environmental education extend beyond the potential to develop environmental responsible behavior and impacts broader educational goals. Wolff-Michael Roth et al. (1996) argue "that traditional science teaching leads to (a) singular and mythical views about science and scientists, (b) scientifically nonliterate citizens, and (c) knowledge that is of little use outside schools" (p. 460). The ability for environmental education to provide a range of perspectives on topics through its multi-disciplinary roots and inclusion of situated learning "offers a conceptual richness that challenges current thinking in science education" (Dillon and Scott 2002, p. 1112). In sum, environmental education has the potential to engage students with issues that extend beyond nature and reach to the fundamental "character of education as a whole" (Bonnett 1997, p. 249).

Contextualizing the Assessment of the Impact

Although strongly linked to the local school districts, the Biophilia center is best characterized as an informal learning environment because of its setting remote from the formal classroom, although it may not truly be considered a "free-choice learning environment" because of the structured activities underlying curriculum. One-way to assess the benefits of learning outside of schools is to consider the impact of the occurrence on the individual. "Impacts depend on personal, physical, social and cultural contexts and may not be evident until sometime after the experience" (Friedman 2008, p. 12). Impact categories that can be used to consider the merits of informal learning include: awareness/knowledge/understanding, engagement/interest, attitude, behavior and skills (Dierking 2008).

The Assessment of Drawings

Since assessment of the impacts of any outreach program is valuable, the authors in consultation with the leadership of the Center sought a metric that would provide information without detracting from the experience for the student. The option to consider the use of student drawings rose from the literature as a potentially rich source of information since art and learning have been considered to be closely linked (Vygotsky 1971). Drawings can be an "efficient and effective method" in assessing children's learning, often providing an understanding that may be hidden in other assessment types (White and Gunstone 1992, p. 105). Drawings are very open assessments with few limitations placed on responses, and as a result, they may be complimentary to more generally accepted closed assessments and may "tap different aspects of understanding" (p. 105). Some scholars suggest that drawing analysis as a means of assessing children's understanding is reliable and "among the most accurate obtained through any means of assessment" (Lewis and Greene 1983, p. 23), and that the act of drawing to be significant because it is "a cognitively complex activity which many children find absorbing and practise extensively" (Thomas and Silk 1990, p. 159). Marilys Guillemin (2004) argues, "that drawings offer a means of gaining further insight into the ways in which participants interpret and understand their world" (p. 287). When used a research tool, drawings "focus a person's response" and lead to "honesty and parsimony" (Nossiter and Biberman 1990, p. 15).

The linkage between drawings and learning has been explored in literacy strategies. Suzanne McConnell (1992; 1993) developed an approach called "talking drawings" whereby "translating mental images into simple drawings helps students at all levels bridge the gap to better comprehension and learning" (p. 260). Susan Fello et al. (2006) extend this to science education finding the process "enables children to combine their prior knowledge about a topic with new information derived from expository text" (p. 80).

Drawings have been used to visualize and characterize children's perceptions of the environment and scientific concepts (e.g., Shepardson et al. 2011). Rob Bowker

(2007) establishes that the pre and post drawings of 9–11 year olds after a visit to a tropical rainforest exhibit provide insight to the understanding and learning of the experience. Drawings are used as representations of student understanding of the concept of the environment (Shepardson et al. 2007), and as 4th and 7th grade students' mental models of the desert environment (Judson 2011)

Demographics of the Fourth Graders

The participants for this study included 406, 4th grade students from nine schools in two school districts in the region. Classes attending the Biophilia Center did so for either 2 days or 5 days depending upon the interest and resources of the individual school. For evaluation purposes, the experience was separated into two groups – 2 days over 2 weeks and 5 days over 5 weeks. A total of 201 students comprise the sample for the 5-day experience while 205 individuals represent the 2-day experience.

Of course, students attending the center for 5 days had more time to interact with more activities than those students attending for only 2 days. Table 9.1 provides a list of the activities and learning modules provided at the Center and the frequency that each was taught for the nine schools. As evident from the table the following activities were consistently offered to all 2-day and 5-day participants: Exhibit Hall Exploration,

Table 9.1 Specific activities completed at center by each individual school referenced to the duration of their experience

	5-Day Schools						2-Day Schools		
	A	B	C	D	E	F	G	H	I
Exhibit Hall	√	√	√	√	√	√	√	√	√
Longleaf Pine Hike	√	√	√	√	√	√	√	√	√
Harvest Ant Activity	√	√	√	√	√	√			
Video Introducing Dr. Wilson/Center Intro	√	√	√	√	√	√	√	√	√
Estimating the Height of a Tree	√	√	√	√	√	√			
Wetland Fauna Collecting	√	√	√	√	√	√			
Tortoise Exploration	√	√	√	√	√	√	√	√	√
Measuring Students Pace	√	√	√	√	√	√			
Tortoise Home Range	√	√	√	√	√	√			
Tortoise Carrying Capacity SIM	√	√	√	√	√	√	√		√
Prescribed Fire PowerPoint	√	√	√	√	√	√	√	√	
***Remnants of a Forest* – Video**	√	√	√	√	√	√	√		
Analysis of Burn Plots	√	√	√	√	√	√	√		√
Forest Understory Exploration	√	√	√	√	√	√	√		
Exhibit Hall Diorama and Snakes	√	√	√	√	√	√			
Bird Video	√	√	√	√	√	√			
Turtle Trail Hike	√	√	√	√	√	√	√	√	√
Exhibit Hall Bird Exploration	√	√	√	√	√	√			

Longleaf Pine Hike, Video of the Center, Tortoise Exploration, and the Turtle Trail Hike. A brief description of each activity/module is provided in Appendix I.

Prior to attending the Center, and then again after their last visit, students were asked to draw what they believed a longleaf pine forest from north Florida looked like, and to include the plants, animals and the processes that occur in the ecosystem. All of these activities were completed at the individual schools, under the direction of the classroom teacher, and occasionally as a project for art class. The authors had no contact with the students, nor did we have any control over the explanation of the assessment, or the medium utilized for the drawings (although instructions were provided to the teachers).

How We Evaluated the Drawings

The review of the drawings began with the identification of the presence or absence of 20 key concepts of the longleaf pine ecosystem, and dealt with appropriate fauna, flora, community structure, habitat components, species interactions, abiotic characteristics and dominant processes, such as how fire shapes the community. These concepts formed the basis of a rubric that was developed and validated for the program (Dentzau and Gallard 2014), which has been adopted by the center to evaluate future program effectiveness.

Drawings were reviewed in an iterative manner using a modified content analysis that allowed additional themes not encapsulated by the key concepts to emerge. Content analysis is “a research technique for the objective, systematic, and quantitative descriptions of manifest content of communications (Berelson 1952, p. 74). Robert Bogdan and Sari Biklen (1982) consider the process as “working with data, organizing it, breaking it into manageable units, synthesizing it, searching for patterns, discovering what is important and what is to be learned” (p. 145).

The Sense We Made of the Drawings

During the content analysis of the pre and post drawings themes emerged that in some cases overlapped the items of the rubric and in others that extended beyond the scope of rubric. All themes and patterns emerged without consideration of the length of the respective experiences; however, data is explored both as an aggregate and by length of experience. While several themes emerge, we highlight the students’ focus on animals for this chapter, including:

- Changes in biodiversity representation;
- The propensity of a student to attempt to draw and define specific animals;
- Unique animals highlighted by instruction and activities; and
- Animal alternative conceptions.

Changes in Biodiversity Representations

Biodiversity is classically defined as "[t]he variety of organisms considered at all levels, from genetic variants belonging to the same species through arrays of species to arrays of genera, families and still higher taxonomic levels" (Wilson 1992, p. 393); in other words, the variety of life forms or species. Here, biodiversity represented by the students is determined through changes in number of animal species and in the frequency of representation by animal categories. In the simplest metric biodiversity increased as represented by a reduction in the number of drawings including only plants. Approximately 26.8 % of the pre drawings in this study contained no animals, while this percentage dropped to 14.8 % in the post drawings**.** A representative pre and post example from a single student is provided in Fig. 9.3.

Another way to consider biodiversity is to look at the change in the number of distinct animal species represented by students from the pre to post drawings. To achieve this, each drawing is evaluated to determine the number of distinct species being represented by the student. Obviously this requires some interpretation, and certain assumptions are made. Animals deemed to represent gross alternative conceptions of the forest ecosystem, for example monkeys, are not included in the analysis. Animals with four legs that are otherwise uncharacterizable are assumed to be mammals. Birds of different colors are assumed different species, unless a parental or offspring relationship is suggested.

Fig. 9.3 Example showing drawings from a single student with the pre drawing (*left*) with no animals and post drawing (*right*) with some animal diversity

Table 9.2 Statistics for changes in distinct number of animal species with experiences combined

Drawings	Mean (*M*)	Change in *M*	*N*	*SD*	*t*	*df*	*p*
Pre	2.42	1.01	406	2.26	−7.43	405	<0.001
Post	3.43			2.66			

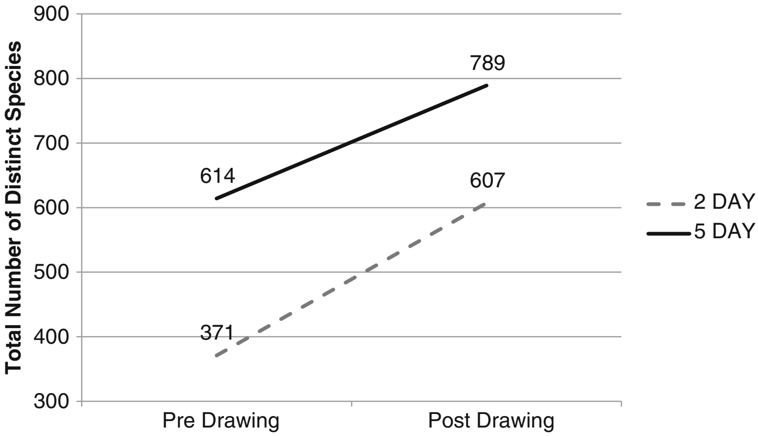


Fig. 9.4 Change in total number of distinct species in the pre and post drawings by duration of experience

Table 9.2 provides the mean number of distinct animal species in all pre and post drawings. When the experiences are combined, these data show a significant increase in the mean number of species being represented from the pre to post drawings. While there is a significant difference in the mean starting points and ending points of the 2-day versus 5-day experiences ($t = -5.81$ (404), $p = <.001$, and $t = -3.65$ (403.58), $p = <.001$, respectively), there is no statistically significant difference in the change of the mean between the 2-day and 5-day experiences ($t = 1.12$ (403.98), $p = .262$). Therefore, as expressed in terms of biodiversity growth, increases are similar for both 2 and 5 day experiences when considering the change in absolute number of distinct species being represented (Fig. 9.4).

Another way to look at biodiversity shifts is to consider the shift in frequency when drawings are assigned to discrete species numbers categories. To facilitate this, categories representing 0 species, 1 species, 2 species, 3 species, 4 species, 5 species, 6 species and >6 species, are established, and each drawing is assigned to a single category. Figure 9.5 shows the pre and post data for both treatments combined, and demonstrates a significant pre-post shift in the distribution of species ($X^2 = 143.64$, df = 7, $p < 0.001$), with a general trend of the post drawings to reflect more species. Figures 9.6 and 9.7 demonstrate a pre/post example from an individual student.

Examination of these data by length of experience does provide additional information masked by the combined data. Figure 9.8 represents the relative percentages of each of the categories in both the pre drawings and post drawings for the 2-day experience. The pre drawing distribution is strongly, positively skewed

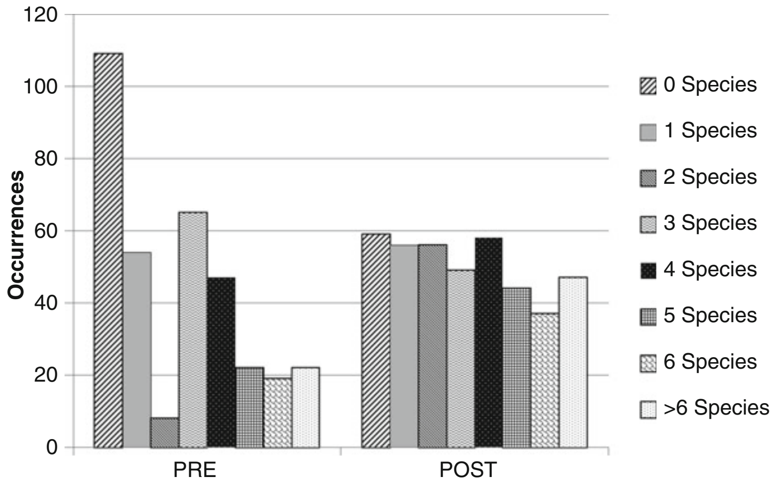


Fig. 9.5 Frequency of drawings for all treatments combined classified into numbers of animal species represented (n students = 406)

Fig. 9.6 Pre drawing of student showing low biodiversity associated with the ecosystem

with over ½ of the drawings including either one or no animals. As evident the distribution changes in the post drawings to approximate a more even distribution across the categories. In the 5-day data (Fig. 9.9), however, there is a more equal distribution among all of the categories in the pre drawings and this trend continues with the post drawings, with shifts towards more species per drawing however clearly evident.

Fig. 9.7 Post drawing from same student showing increased biodiversity

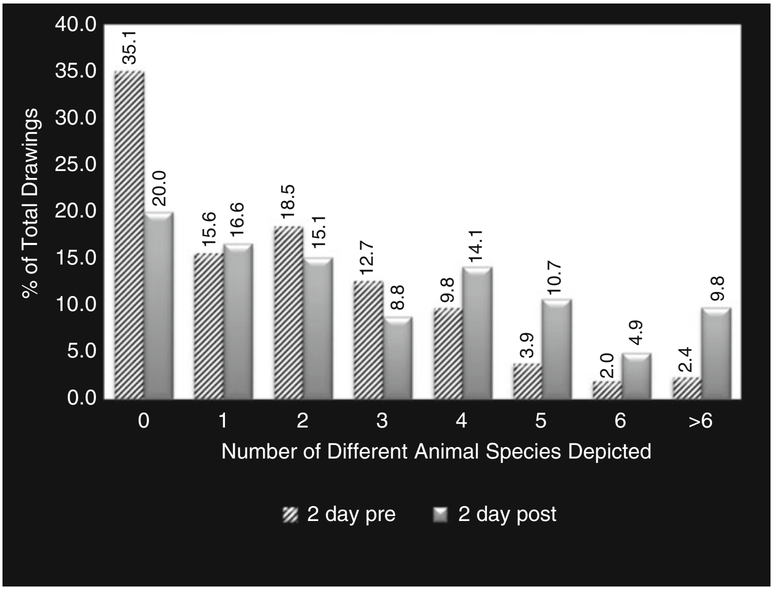


Fig. 9.8 Percentage of drawings in the 2 day experience for the pre and post drawings within each category

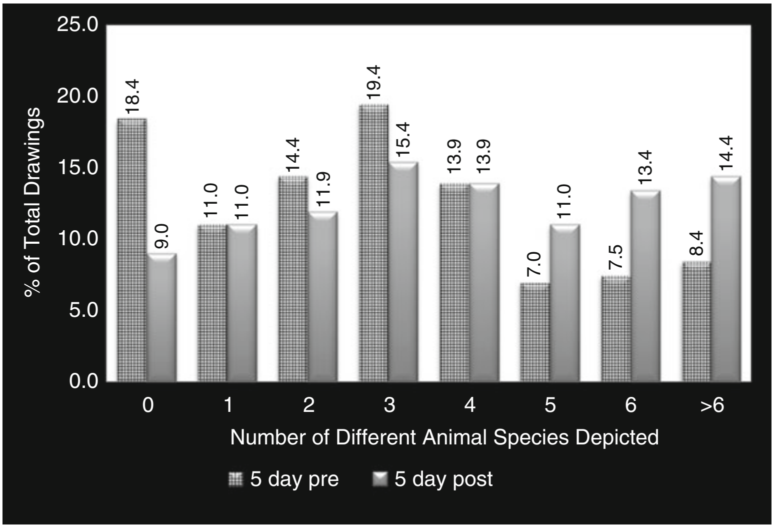


Fig. 9.9 Percentage of drawings in the 5 DI for the pre and post drawings within each numerical species class

Table 9.3 Specific animal categories images to which images are assigned

Mammals	Birds	Reptiles
Amphibians	Fish	Invertebrates
Unknown Class		

Finally, content analysis also indicates a shift in the proportions of categories or groupings of animals between the pre and the post drawings, which may be yet another measure of animal biodiversity. To arrive at these data all images of animals in each drawing are placed into a single category as referenced in Table 9.3. The same subjectivity in accurate classification of images to distinct species also applies for category class, and must be considered in interpreting the results.

Figure 9.10 shows the change in distinct species numbers in each of the 7 categories when the data for both treatments are combined. These data show substantial increases in the number of bird, reptile and insect species represent in the post drawings when compared to the pre drawings for all students combined. Also evident is a decrease in the number of mammal species represented in the post drawings when compared to the pre. Little change is evident for amphibians, fish and images that could not be classified into a category. Figures 9.11 and 9.12 provide an example demonstrating this from an individual student.

These data provide another example where differences in the length of the experience appear insightful; Table 9.4 provides the category data separated by experience length. Although the occurrence of mammal species declined drastically with the experiences combined, it is clear that this result is driven by the changes for the 5-day and not the 2-day experience. When the data are converted to represent the

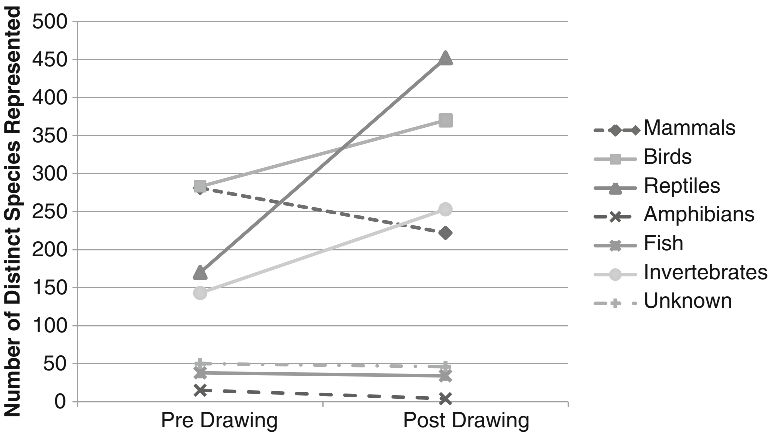


Fig. 9.10 Number of distinct animal species by categories for pre and post drawings of all 406 students

Fig. 9.11 Pre drawing from a student showing dominance by mammals

mean number of mammals depicted pre-post, there is a significant decrease for the 5-day experience ($t = 3.446$ (200), $p = .001$), but not for the 2-day experience ($t = .071$ (204), $p = .944$). The increases in the bird, reptiles and insects noted above, however, are still evident when the data is parsed into different lengths of experience.

Fig. 9.12 Post drawing from the same student as shown in Fig. 9.11 showing increases in reptiles, birds and invertebrates

Table 9.4 Number of occurrences of distinct species by animal category for pre and post drawings for each experience

	5 day experience		2 day experience	
Category	Pre	Post	Pre	Post
Mammals	183	124	99	98
Birds	155	203	128	167
Reptiles	108	250	62	202
Amphibians	11	11	4	3
Fish	25	23	13	11
Invertebrates	93	147	50	106
Non-Descript	38	27	12	19
TOTAL	**613**	**785**	**368**	**606**

Animal Specificity

Animal specificity, or the propensity of a student to attempt to draw and define a specific animal, increases from the pre to post drawings (as demonstrated in Figs. 9.13 and 9.14). With a few notable exceptions (e.g., gopher tortoise, red-cockaded woodpecker) animals in the pre drawings are predominately common or generic representations (e.g. deer, red bird, unidentified snake, butterfly). While these

Fig. 9.13 Pre drawing showing unspecified animals from a student

same species are often referenced in the post drawings, there is also an increase of specific species (e.g. gopher frog instead of simply frog), and species that are otherwise "inconspicuous" (e.g., insects). Table 9.5 provides a listing of those animals that are only found in the post drawings when both of the experiences are combined. A few instances of species specificity, such as red-cockaded woodpecker, eagle, gopher tortoise, harvester ants and red fire ants, are documented in at least some pre-drawings. Another example of increases in animal specificity is observed in a pre and post comparison represented by Figs. 9.15 and 9.16. Often in either the pre or the post drawings, specific species were designated as such with labels or the use of characteristic community references (e.g. burrow associated with a tortoise or bands of round drill holes to represent a yellow-bellied sapsucker).

A review of the frequency of representations of the gopher tortoise, a key component of the Biophilia Center's instruction and a keystone species of the longleaf ecosystem, provides another insightful comparison (Table 9.6). When looking at the experiences combined the gopher tortoise is represented in 3.7 % of the pre drawings (15 students), and 36.0 % of the post drawings (146 students). Many of these post

Fig. 9.14 Post drawing of same student as referenced in Fig. 9.13 showing specificity of animal species

Table 9.5 Animals referenced only in student post drawings for experiences combined

Gray Fox	Fox Squirrel	Coyote
Panther	Bat	Chipmunk
Red-Headed Woodpecker	Blue Jay	Sparrow
Cardinal	Barn Owl	Barred Owl
Bobwhite Quail	Yellow-Bellied Sapsucker	Sparrow
Blue Heron	Soft Shelled Turtle	Box Turtle
Red Tailed Hawk	Pine Snake	Indigo Snake
Red Rat Snake	Pigmy Rattlesnake	Water Moccasin
Corn Snake	King Snake	Wolf Spider
Purse Spider	Ant Lion	Crawfish
Flea	Fly	Gopher Frog

drawings show not only the gopher tortoise but also reference the burrow of the tortoise, which is a valuable habitat component of healthy longleaf pine upland (Fig. 9.17).

Post increases are demonstrated for other specialized or unique species, but not to the degree represented by the gopher tortoise (Table 9.7). These species are considered either unlikely to be known by the student population prior to engagement at the Biophilia Center (e.g. harvester ant) or those that had a prominent position in the instruction at the center (e.g. red-cockaded woodpecker).

Fig. 9.15 Pre drawing showing generic and commonplace animals

Fig. 9.16 Post drawing from same student represented in Fig. 9.15 showing animal specificity

Table 9.6 References to Gopher tortoise and Gopher tortoise burrows in the drawings

	2 Day Pre	2 Day Post	5 Day Pre	5 Day Post	Combined Pre	Combined Post
Number	4	58	14	88	15	146

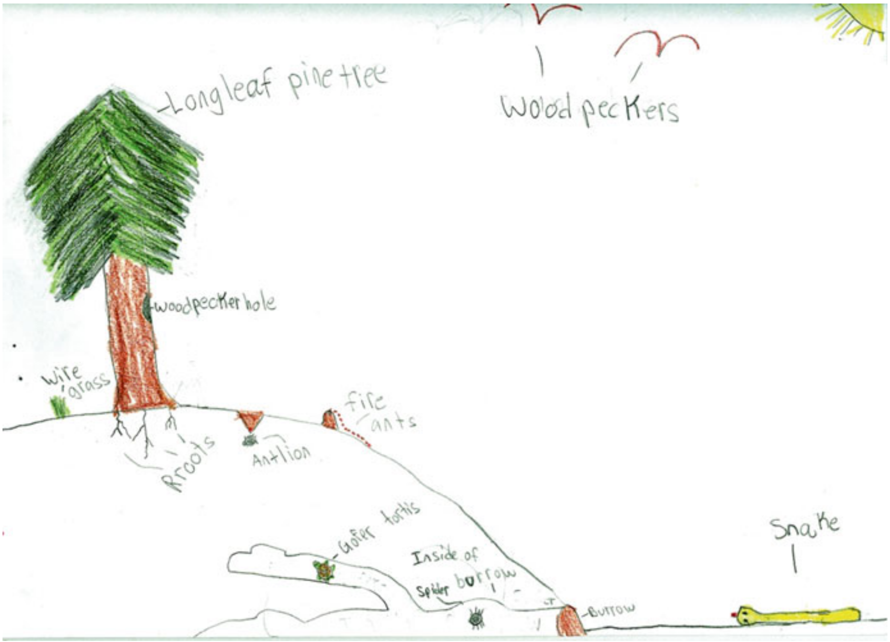


Fig. 9.17 Post drawing showing a gopher tortoise and detailed burrow system

Table 9.7 Frequency of occurrence (n = 406) of specialized or unique animal species

Species	Pre	Post
Harvester Ant	1	14
Fire Ant	2	8
Indigo Snake	0	6
Red-Cockaded Woodpecker and RCW References	2	43
Yellow-Bellied Sapsucker/Foraging Holes	0	17
Beaver and Beaver Dam	1	24
Pine Snake	0	4
Fox squirrel	0	3
Bear	1	4

Animal Alternative Conceptions

The animal alternative conceptions in the drawings are almost exclusively related to the pre drawings and were relatively few in occurrence. A total of 17 obvious animal alternative conceptions are represented by 10 students (2.5 % of sample population), and are evenly distributed between the two experiences (Table 9.8). Figure 9.18 shows an example where both appropriate animals and alternative conceptions (flamingo and koala) are depicted, while in Fig. 9.19 inappropriate species dominate (monkey and reindeer).

Table 9.8 Animal alternative conceptions reflected in the drawings

Student	Animal	Experience
A	Panda Bear	2 Day Pre
B	Flamingo; Koala	2 Day Pre
C	King Cobra; King Anaconda; Grizzly Bear	2 Day Pre
D	Monkey	2 Day Pre
E	Reindeer; Monkey	5 Day Pre
F	Monkey	5 Day Pre
G	Ostrich	5 Day Pre
H	Lion; Anteater	5 Day Pre
I	Ant Lion; Monkey	5 Day Pre
J	Large Cat in Zoo	5 Day Pre
K	Cheetah on Branch	5 Day Post

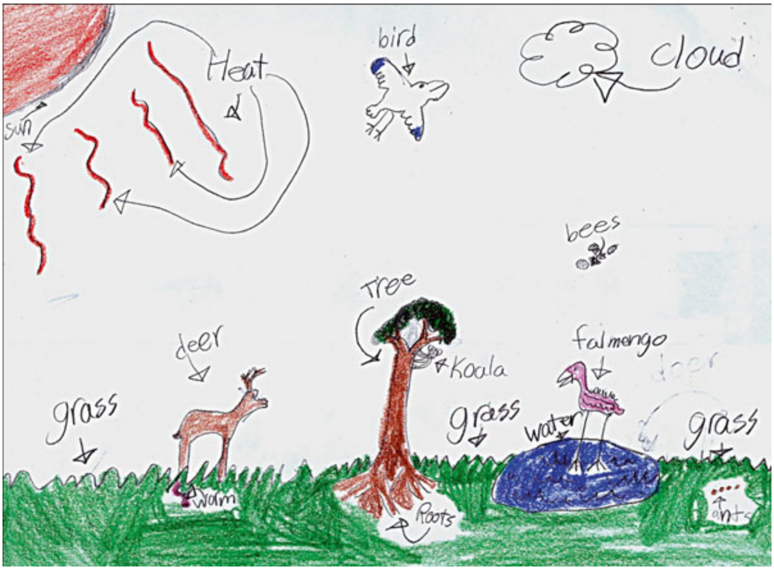


Fig. 9.18 Pre drawing showing animal alternative conceptions – flamingo and koala

Fig. 9.19 Pre drawing dominated by animal alternative conceptions (monkey and "rain" deer)

Students Make Connections to Biodiversity

Experience with the Biophilia Center substantially increases the number of students, that when prompted, associate animals instead of only plants, with the longleaf pine ecosystem. Strommen (1995), when dealing with a sample of 40 1st grade students, finds that 21 % include no animals in their drawings when asked to draw their understanding of a forest ecosystem; this corresponds closely to the 26.8 % of pre drawings in this study that includes only trees and no animals. Our study benefits from the ability to look at these changes over a period of instruction, which shows a substantial decrease to 14.8 % in the number of students failing to connect animal life to the ecosystem. This is an important point to consider if one of the objectives is to help students learn science informally and also to help make sense of their surroundings in a scientific manner. Ron Wagler (2010, p. 372) offers:

> It is essential that students are exposed to a K-4 science curriculum which incorporates reptiles, amphibians and invertebrates; represents all animals in a scientifically accurate way; and conveys the interconnected life-sustaining relationship animals have to one another and to the environment.

Our pre data indicates that students in this study substantially overestimate the contribution of large mammals and underestimate the role of arthropods to ecosystem function and dynamics. This finding agrees with those of Strommen who concludes, "children appeared to overestimate the number and type of large carnivores to be found in forests" (p. 694). More recently, Jake Snaddon et al. (2008) find similar results in a sample of 167 primary aged children in the United Kingdom. These children when asked to express their "ideal rainforest", display an understanding of an ecosystem that they have likely not visited, and at the same time, seem to lack a perception of the importance of social insects and annelids.

Our post data, however, demonstrating a shift from charismatic megafauna towards more inconspicuous animals, offers some encouraging results. A curriculum, therefore, that highlights and celebrates such species, especially in their native context, may be effective in providing alternative conceptions that are more in line with ecological reality. Hopefully this curriculum serves as one component that drives the development of their appropriate mental models of ecosystems. Although shifts in the right direction are evident in the current data, we assume that lasting benefits will come from the continued reinforcement of the proportional contributions of invertebrates and vertebrates in ecosystem functions throughout the learning process.

The post data, while suggesting that an experience such as that offered by the Biophilia Center may be able to assist students in changing their initial perception of biodiversity of the longleaf pine forest, is mixed with respect to the impact of duration on this understanding. While a shift to increased invertebrates (insects) is established in both the 2 and 5-day data, a decrease in mammals is only observed in the 5-day program. It is unclear if this is an anomaly of the data or in some way reflects the impact of the different lengths of the instruction in the two experiences.

Students Make Sense of Animal Specificity

The data show a clear increase in the specificity of animals proceeding from commonplace, undifferentiated animals to keystone, rare, emblematic and specifically referenced or labeled animals. According to Linda Cronin-Jones (2005), "[g]enerally drawings by elementary students include more details and realistic representations for subjects they know more about" (p. 228). Therefore, the increase in specificity implies an increased understanding (learning) about the longleaf ecosystem. While this might seem intuitive and is hopefully expected from any curriculum, it does not diminish the importance of such data when it comes to engendering both an understanding and respect for ecological systems. As an example, one study involving 4,000 Swiss students ages 8–16 finds that the more plants and animals students are cognizant of and familiar with in the local environment "*the more did they appreciate these organisms* (emphasis added)" (Lindemann-Matthies 2005, p. 655). After all, enhanced appreciation of the nature world that surrounds us is considered necessary for long-term environmental sustainability.

While the deficit model of pro-environmental behavior where environmental knowledge leads to environmental attitude and ultimately pro-environmental behavior (Burgess et al. 1998), is arguably over simplistic (Hines et al. 1986), it has be suggested "that nature experience is one central foundation for the development of knowledge and values in relation to the environment" (Bögeholz 2006, p. 65). Numerous researchers have proposed such a knowledge linkage as a precondition of attitude (e.g., Kellert 1996). Monroe (2003), using a summary of the literature concludes that environmental literacy can be promoted through education based on environmental issues and through significant life experiences. Any increase in environmental understanding and hopefully awareness is therefore movement in the right direction.

What Students Did Not Understand or Were Confused About

While only 2.5 % of the students expressed alternative conceptions with fauna, the pre-post design is able to show that in all cases the students corrected the alternative conceptions to eliminate non-native animals. The restructuring of existing knowledge and the concomitant change in students' conceptual frameworks is essential in the progression towards a well-defined conceptual model. This idea is also supported by,

> Children's drawings often reveal misconceptions, which if undetected may otherwise act as barriers to further learning. If stereotypical images are not indentified and challenged, children will fail to recognize other examples in different settings. Failure to acknowledge that children perceive concepts form preferred perspectives may hinder their understanding when these topics are first introduced. (Dove et al. 1999, p. 496)

Our Path to Understanding Today and Tomorrow Through Informal Science Education

The understanding of biodiversity is foundational knowledge for elementary-aged children. The National Research Council (1996) notes that students in grades K-4 should be exposed to a diverse array of animals and that "[m]aking sense of the way organisms live in their environments will develop some understanding of the diversity of life and how all living organisms depend on the living and nonliving environment for survival" (p. 128). Taken in the context of global extinction rates, which have been estimated at 27,000 species/year (Wilson 1992), the influence of human activities is unmistakable (Pimm and Raven 2000), and the need for increased understanding is genuinely significant. But how effective are science educators in conveying this message? In one study involving 109 UK students between four and 11, children that are eight and older are able to identify "Pokémon 'species' substantially better than organisms such as oak trees or badgers" (Balmford et al. 2002, p. 2367). Are we in fact presenting the wonders of nature to students in a way that is less exciting than a role playing game based upon fictional species? This finding may not surprise those who understand and value the necessity of learning through doing and the constraints placed upon learning through the neoliberal model of education. Perhaps in the larger societal scope of things, if UK students had been afforded the opportunities to dedicate as much time to their surroundings as they did to Pokémon, the results of Balmford et al. would have been different. Yet another possibility is that learning Pokémon 'species' is viewed as critical knowledge to have because this knowledge enhances their everyday life by helping them win at this game. In other words, the knowledge is useful and applicable to a game players' life. If so, instead of simply bemoaning this apparent disconnect, maybe we as educators should work within the culture, and with the tools of the culture, to attempt to increase the relevance of biodiversity to our youth.

Mark Rickinson (2001) concludes that "the general message stemming from recent evidence is that the factual environmental knowledge among secondary age students is lower than might be hoped" (p. 227). Further, the understanding of environmental issues of young people "is very focused on the science of global environmental issues" (p. 243). What do we need to do to change this? Martin Braund and Michael Reiss (2006) explain that

> when pupils visit or are taught in places that explain science in often new and exciting ways, they frequently seem to be more enthused. There is, we believe, something about these contexts and places that brings about a change through increasing the desire in people to find out and understand more. (p. 1378).

Connecting children to their local environment in a manner that makes understanding of the natural world useful and applicable to students' lives, as in the example of Pokémon, may be the missing catalyst that is engendering this knowledge deficit. The example of the learning opportunities afforded by a facility such as the E.O. Wilson Biophilia Center may be able to provide the engagement needed to make biodiversity relevant and help our youth develop a connection to their local environment. While clearly an opportunity like the center cannot be reproduced in every community, its model is worthy of replication regionally wherever possible. In the absence of such opportunities, however, simple connections with nature in the immediate surroundings of a child, both in formal and informal settings, may provide some of the same cognitive and affective benefits at a nominal expense. These can include native plant gardens, backyard ponds, bird feeders, community plant and animal identification guides…the list goes on.

It all depends upon what we privilege as a society. Do we want students to understand the natural world and be "compassionate human beings able to think for themselves and to face life head on" (Rutherford and Ahlgrens 1989, p. xiii.)? Until we as a collective group embrace the need to provide opportunities that afford real-life and life-long connections of ecologically accurate information in education, we fail to achieve this greater goal. We believe that, as stated earlier, ecological literacy supports the development of a well-rounded citizen. When exposed to such a transformative experience as we have documented herein, it remains to be seen if these students become knowledge advocates imparting the excitement to their peers and parents. That would be truly rewarding.

Appendix I

Introductory Video on Dr. Wilson and the Biophilia Center

This video is presented in the Center's Theater and introduces students to the namesake of the facility, Dr. E. O. Wilson and the mission and importance behind the development of the Biophilia Center at Nokuse Plantation.

Exhibit Hall Exploration

This activity is a combination of free exploration and guided discovery where staff of the Center introduce students to various stations in the exhibit hall. The hall has the following stations/exhibits for student interaction:

- Large sculptures of animals including, gopher tortoise, harvester ant and indigo bunting.
- A cast/mold of a harvester ant mound showing the intricacies of the tunnel.
- Display of historic and archeological artifacts.
- Frog biome that shows live frogs and plays the call of each.
- Bird window with placards identifying bird species that may be visible.
- Molded gopher tortoise burrow suitable for students to crawl in one end and out the other.
- Longleaf pine diorama that shows the various stages of the longleaf pine from seedling to mature tree with a depiction of prescribed fire.
- Active beehive contained in plexiglass that has a connection to the outside.
- Large interactive schematic of a leaf and photosynthesis.
- Diorama of a transition from an upland ridge into a wetland community showing pitcher plants and other flowering species that are not easily seen during all times of the year.
- Aquatic exhibit with live turtles.
- Snake exhibit with several different species.
- Exhibit demonstrating heat sensing ability of predatory snakes.
- Musical exhibit substituting animal calls for notes.
- Taxidermies of beaver, feral hog, black bear, Florida panther, bobcat, quail, wading birds, woodpeckers and other typical species.

Longleaf Pine Hike

The Longleaf Pine Hike is completed on a blazed trail that loops around some mature remnant longleaf pine uplands and through several embedded wetland drains. Through this excursion students often see the various stages of the longleaf pine (grass stage, bottle-brush and mature), turkey oak, yaupon holly (*Ilex vomitoria*), purse web spiders/spider webs, evidence of yellow-bellied sapsucker foraging, harvester ant mounds, the microcommunity developed when a tree falls and the roots form a vertical substrate, a red bellied woodpecker cavity, a tree that was struck by lightning, different fungi and lichens, a shell from a box turtle and deer antlers. Students are also shown the differences between the slash pine and longleaf pine with respect to cone size, needles, growth forms, etc.

Tortoise Exploration

During this activity one of the staff that is expert with turtles and tortoises introduces students to the gopher tortoise and its life cycle. This is based primarily within the exhibit hall and uses the diorama and tortoise shells and skulls that the students can hold and examine. Occasionally live gopher tortoises are available, but not all classes have the opportunity to interact with live animals. Staff explains the gopher tortoise relocation plan that is being conducted on other parts of Nokuse Plantation and how biologist mark and number the tortoises for later identification.

Turtle Trail Hike

This hike takes students along a wetland finger adjacent to a high upland where they can see the elevation change from uplands to wetlands and the change in vegetation that occurs. Students also often see the characteristics indications of yellow-bellied sapsucker foraging and the microcommunity that develops when a tree falls and the roots form a vertical substrate. The students are also introduced to beavers and their role in the ecosystem as well as a discussion of various aquatic wildlife that is collected in traps pre-set along the trail. Species encountered in the traps include crawfish, spotted sunfish, pirate perch, pickerel, warmouth, lesser siren, two toed amphiuma, loggerhead musk turtle, largemouth bass, tadpole madtom, river frog, bronze frog, and others.

Tortoise Carrying Capacity SIM

This exercise is designed to demonstrate how populations might fluctuate over time through the introduction of the concept of carrying capacity. Carrying capacity is the highest number of organisms that can be supported by an area or habitat without the numbers resulting in damage to the area. The SIM activity estimates how gopher tortoise populations can change from year to year and how many tortoises a simulated habitat can support.

Analysis of Burn Plots

The Center maintains 4 contiguous plots approximately 1/2 acre each which are provided different treatments. One is an unthinned and unburned slash pine plantation – this represents the conditions on site before any environmental restoration was completed by Nokuse Plantation. The other three have been thinned of slash pine and have been burned during different seasons and frequencies. The students are asked to compare burned plots from unburned plots and to collect observations in their field journals.

Prescribed Fire PowerPoint

This brief powerpoint is shown in the theater at the center and provides information about the value of prescribed fire for the longleaf pine ecosystem and the natural fire regime of the system.

"Remnants of a Forest" – Video

This multimedia presentation discusses the longleaf pine ecosystem and its decline in the southeastern United States. Students are provided with a brief history of the longleaf pine ecosystem, the role of fire in maintaining the community and its diverse groundcover, and some of the prototypical species of the ecosystem, including red-cockcaded woodpecker, pitcher plants, gopher tortoise, quail, indigo snake, burrows, flatwoods salamander, gopher frog, pine snake and rattlesnake. The value of the gopher tortoise as a keystone species of longleaf pine is introduced.

Understory Exploration

During this activity the students return to the forest burn plots to look specifically at the understory of the longleaf pine ecosystem. The students are asked to write down the plants (using general descriptive terms or drawings) they see at ground level, one foot above ground level, and then those even taller but still within the understory. This is designed to emphasize the vertical structure of the longleaf pine forest and forests that are managed/shaped by fire. Depending upon the effort expended on looking at the plants some groups also engaged in a food web game. Students sit in a circle with a ball of string and one individual names an animal and extends the string ball to another student who needed to either name an animal that would be either a prey or predator to the first animal. This engagement continued until a "food web" was created.

Jeopardy

Fashioned after the popular game show, this version uses a similar format of providing the answer with the students needing to provide the response in a form of a question. Topics focus on the experiences the students have both in the exhibit hall and on the trails at the center.

Harvester Any Activity

In this activity the students investigate the foraging behavior of the Florida harvester ant, which is common to the longleaf pine forest upland communities. As the name implies, these insects gather food and store it in chambers underground. Food sources consist of seeds, which are collected from the ground or off of plants, with the chaff from husked seeds deposited around the main entrance to the chamber. Students working in teams examine harvester ant mounds in the field, and conduct guided inquiry on preferred food types through several simple experiments.

Estimating the Height of a Tree

This activity involves the students in the application of simple measurements that are used as one technique to solve a real world problem, in this case, the height of a large pine tree. Although foresters and ecologists often have sophisticated equipment to estimate tree height, a simple technique involving pairs of students, a 1-foot ruler, and a 100-foot tape measure are used to provide a very good estimate of height.

Field Measurement Techniques

In this activity, students learn a technique to measure their own pace, or the distance covered by one normal step, to be able to measure distance and calculate area. This technique is often used by field biologists as a simple and fairly reliable measure.

Wetland Fauna Collecting and Identification

This activity takes place in the artificially created wetlands and pond that straddles the entrance boardwalk to the center. The students follow the instructors as they use dip nets to collect predominately aquatic invertebrates and occasionally small fish or amphibians for transfer to small containers for observation as they use identification cards to attempt to determine the different kinds of animals collected.

Tortoise Home Range

The students are introduced to the concept of home range, defined as the area in which an animal lives, using the gopher tortoise. While the ecologists at Nokuse Plantation use transmitters attached to tortoises and incorporate data over many months, the students are given representative locations and a simulated burrow and use their field measurement skills to estimate the maximum distance the tortoise travels from the burrow and the approximate area it covers based upon a minimum of 5 measurements.

Exhibit Hall Diorama and Snakes

For some students this represents a second visit to the Exhibit Hall and this focuses on the live snakes and characteristics of snakes.

Bird Video

This video is narrated by a young girl and provides video of birds in different habitats, including the beach, marshes, ponds, fields and forests. Individual species are discussed with identification features and some specializations provided.

Exhibit Hall Bird Exploration

During this activity the students are provided with a scavenger hunt list of birds that they are to locate in the Exhibit Hall. Students are to identify several species of birds and fill out characteristics such as size, color, beak size, etc.

References

Ballantyne, R., & Packer, J. (2009). Introducing a fifth pedagogy: Experience-based strategies for facilitating learning in natural environments. *Environmental Education Research, 15*, 243–262.

Balmford, A., Clegg, L., Coulson, T., & Taylor, J. (2002). Why conservationists should heed Pokémon. *Science, 295*, 2367.

Berelson, B. (1952). *Content analysis in communication research*. New York: Free Press.

Bogdan, R. C., & Biklen, S. K. (1982). *Qualitative research for education: An introduction to theory and methods*. Boston: Allyn and Bacon, Inc.

Bögeholz, S. (2006). Nature experience and its importance for environmental knowledge, values and action: Recent German empirical contributions. *Environmental Education Research, 12*(1), 65–84.

Bonnett, M. (1997). Environmental education and beyond. *Journal of Philosophy of Education, 31*(2), 249–266.

Bowker, R. (2007). Children's perceptions and learning about tropical rainforests: An analysis of their drawings. *Environmental Education Research, 13*(1), 75–96.

Braund, M., & Reiss, M. (2006). Towards a more authentic science curriculum: The contribution of out-of-school learning. *International Journal of Science Education, 28*(12), 1373–1388.

Burgess, J., Harrison, C. M., & Filius, P. (1998). Environmental communication and the cultural politics of environmental citizenship. *Environment and Planning A, 30*(8), 1445–1460.

Cachelin, A., Paisley, K., & Blanchard, A. (2009). Using the significant life experience framework to inform program evaluation: The nature conservancy's wings & water wetlands education program. *The Journal of Environmental Education, 40*(2), 2–14.

Carrier, S. J. (2009). Environmental education in the schoolyard: Learning styles and gender. *The Journal of Environmental Education, 40*(3), 2–12.

Cronin-Jones, L. (2005). Using drawings to assess student perceptions of schoolyard habitats: A case study of reform-based research. *Canadian Journal of Environmental Education, 10*(1), 224–240.

Dentzau, M. W., & Gallard, A. J. (2014). The development and validation of an alternative assessment to measure changes in understanding of the longleaf pine ecosystem. *Environmental Education Research*. doi:10.1080/13504622.2014.930728

Dierking, L. (2008). Evidence and categories of ISE impact. In A. Friedman (Ed.), *Framework for evaluating impacts of informal science education projects.* Retrieved from http://insci.org/resources/Eval_Framework.pdf

Dillion, J., Rickinson, M., Teamy, K., Morris, M., Choi, M. Y., Sanders, D., & Benefield, P. (2006). The value of outdoor learning: Evidence from research in the UK and elsewhere. *School Science Review, 87*(320), 107–111.

Dillon, J., & Scott, W. (2002). Editorial: Perspectives on environmental education-related research in science education. *International Journal of Science Education, 24*(11), 1111–1117.

Dove, J. E., Everett, L. A., & Preece, P. F. W. (1999). Exploring a hydrological concept through children's drawings. *International Journal of Science Education, 21*(5), 485–497.

Fello, S. E., Paquette, K. R., & Jalongo, M. R. (2006). Talking drawings: Improving intermediate students' comprehension of expository science text. *Childhood Education, 83*(2), 80–86.

Friedman, A. (2008, March 12). *Framework for evaluating impacts of informal science education projects.* Retrieved from http://insci.org/resources/Eval_Framework.pdf

Frost, C. (1995). Four centuries of changing landscape patterns in the longleaf pine ecosystem. In S. I. Cerulean & R. T. Engstrom (Eds.), *Proceedings of the 18th tall timbers fire ecology conference*, May 30-June 2, 1991 (pp. 17–43). Tallahassee: Tall Timbers Research, Inc.

Guillemin, M. (2004). Understanding illness: Using drawings as a research method. *Qualitative Health Research, 14*(2), 272–289.

Hamilton-Ekeke, J. T. (2007). Relative effectiveness of expository and field trip methods of teaching on students' achievement in ecology. *International Journal of Science Education, 29*(15), 1869–1889.

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1986). Analysis and synthesis of research on responsible pro-environmental behavior: A meta-analysis. *The Journal of Environmental Education, 18*(2), 1–8.

Judson, E. (2011). The impact of field trips and family involvement on mental models of the desert environment. *International Journal of Science Education, 33*(11), 1455–1472.

Kellert, S. R. (1996). *The value of life: Biological diversity and human society*. Washington, DC: Island Press.

Knapp, C. E. (1992). *Lasting lessons: A teacher's guide to reflecting on experience*. Charleston: ERIC.

Knapp, D., & Benton, G. M. (2006). Episodic and semantic memories of a residential environmental education program. *Environmental Education Research, 12*(2), 165–177.

Lewis, D., & Greene, J. (1983). *Your child's drawings: Their hidden meaning*. London: Hutchinson & Co. Ltd.

Lindemann-Matthies, P. (2002). The influence of an educational program on children's perception of biodiversity. *The Journal of Environmental Education, 33*(2), 22–31.

Lindemann-Matthies, P. (2005). 'Loveable' mammals and 'lifeless' plants: How children's interest in common local organisms can be enhanced through observation of nature. *International Journal of Science Education, 27*(6), 655–677.

McConnell, S. (1992). Talking drawings: A strategy for assisting learners. *Journal of Reading, 36*(4), 260–269.

Mitchell, D. B., & Mueller, M. P. (2011). A philosophical analysis of David Orr's theory of ecological literacy: Biophilia, ecojustice and moral education in school learning communities. *Cultural Studies of Science Education, 6*, 193–221.

Monroe, M. C. (2003). Two avenues for encouraging conservation behaviors. *Human Ecology Review, 10*(2), 113–125.

National Research Council (NRC). (1996). *National science education standards*. Washington, DC: National Academy Press.

Noss, R. F. (1991). From endangered species to biodiversity. In K. A. Kohm (Ed.), *Balancing on the brink of extinction: The Endangered Species Act and lessons for the future* (pp. 227–246). Washington, DC: Island Press.

Nossiter, V., & Biberman, G. (1990). Projective drawings and metaphor: Analysis of organisational culture. *Journal of Managerial Psychology, 5*(3), 13–16.

Orr, D. W. (1989). Ecological literacy. *Conservation Biology, 3*(4), 334–335.

Pimm, S. L., & Raven, P. (2000). Biodiversity: Extinction by numbers. *Nature, 403*, 843–845.

Rickinson, M. (2001). Learners and learning in environmental education: A critical review of the evidence. *Environmental Education Research, 7*(3), 207–320.

Roth, W., McGinn, M. K., & Bowen, G. M. (1996). Applications of science and technology studies: Effecting change in science education. *Science, Technology & Human Values, 21*, 454–484.

Ruiz-Mallen, I., Barraza, L., Bodenhorn, B., & Reyes-Garcia, V. (2009). Evaluating the impact of an environmental education programme: An empirical study in Mexico. *Environmental Education Research, 15*(3), 371–387.

Rutherford, F. J., & Ahlgren, A. (1989). *Science for all Americans: A project 2061 report on literacy goals in science, mathematics, and technology*. Washington, DC: American Association for the Advancement of Science.

Shepardson, D. P., Wee, B., Priddy, M., & Harbor, J. (2007). Students' mental models of the environment. *Journal of Research in Science Teaching, 44*, 327–348.

Shepardson, D. P., Choi, S., Niyogi, D., & Charusombat, U. (2011). Seventh grade students' mental models of the greenhouse effect. *Environmental Education Research, 17*(1), 1–17.

Snaddon, J. L., Turner, E. C., & Foster, W. A. (2008). Children's perceptions of rainforest biodiversity: Which animals have the lion's share of environmental awareness? *PLoS ONE, 3*(7), e2579. doi:10.1371/journal.pone.0002579.

Stapp, W. B., Bennett, D., Bryan, W., Fulton, J., McGregor, J., Novak, P., Wan, J., Wall, R., & Havlick, S. (1969). The concept of environmental education. *Journal of Environmental Education, 1*, 30–31.

Strommen, E. (1995). Lions and tigers and bears, oh my! Children's conceptions of forests and their inhabitants. *Journal of Research in Science Teaching, 32*, 683–698.

Thomas, G. V., & Silk, A. M. J. (1990). *An introduction to the psychology of children's drawings*. London: Harvester Wheatsheaf.

Vygotsky, L. S. (1971). *The psychology of art*. Cambridge, MA: The MIT Press.

Wagler, R. (2010). The association between preservice elementary teacher animal attitude and likelihood of animal incorporation in future science curriculum. *International Journal of Environmental & Science Education, 5*(3), 353–375.

White, R. T., & Gunstone, R. F. (1992). *Probing understanding*. London: Falmer.

Whitney, E., Means, D. B., & Rudloe, A. (2004). *Priceless Florida: Natural ecosystems and native species*. Sarasota: Pineapple Press, Inc.

Wilson, E. O. (1992). *The diversity of life*. New York: W. W. Norton & Company.

Michael W. Dentzau is an assistant professor at Columbus State University and the executive director of the Oxbow Meadows Environmental Learning Center, which is a cooperative venture between the university and Columbus Water Works. His research centers on understanding the impact of out-of-school environmental education programs and the importance of context in the teaching and learning of environmental science.

Alejandro José Gallard Martínez is a professor and Goizueta Distinguished Chair at Georgia Southern University in the Teaching and Learning Department. The platform for his research is to explore equity and social justice in education in general and in science education specifically. Through the lens of complexity his foci are to understand teaching and learning science and education policy in relation to differences associated with ethnicity, gender, race and SES. His frameworks include global perspectives on differences, otherness, polyphony of voices and meaning making that reflects categories used to situate people in social life.

Chapter 10
Section Editorial – Ponder This: Can Ecojustice Education Go Mainstream?

George E. Glasson

Several years ago I visited Lampang, a province in northern Thailand to observe a teacher professional development program that focused on place-based science education (Klechaya 2014). In the local community, the students' families were predominately from the hill tribe people, a minority group that is largely marginalized from the mainstream Thai culture, both economically and through the lack of educational opportunities. The students' parents made a living mostly through rice farming or selling vegetables in the local markets. One day during this project, I observed elementary children collecting water samples to learn about the health of a local river (see Fig. 10.1). Using water test kits, students measured dissolved oxygen, pH, nitrates and phosphates, coliform bacteria, and other indicators of water pollution. As I observed the children eagerly testing and comparing water samples, I couldn't help but notice livestock grazing close-by in the muddy banks along the river. Later, I learned that the children discovered that the water, even though it appeared to be clear, was unhealthy to drink and was a polluted habitat for critters to live in. The children shared and discussed their findings with the local farmers and later presented their results to the community at the school science symposium. As a result, the students and community members learned about the impact of animal wastes on the health of the river and how insecticides could harm fish populations.

Before this place-based project, the teachers were originally unprepared to teach science and the students were disengaged from the mainstream science curriculum. However, with support from Rojjana Klechaya, the place-based science educator coordinating the professional development program, the teachers learned how to engage children in authentic problem solving and inquiry learning that related to local environmental issues. I was intrigued by other place-based science

G.E. Glasson (✉)
School of Education, Virginia Tech, 203 War Memorial Hall, Blacksburg, VA 24061, USA
e-mail: glassong@vt.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_10

Fig. 10.1 Students collecting water samples in a rural Thai community

projects in this rural community that situated learning in the local Thai culture, such as: raising frogs and selling in the local market, growing local vegetables and herbs in the school garden, and studying dengue fever and mosquito life cycles. In each case, parents, experts in the community, and even Buddhist monks served as mentors in the children's projects. These projects involved students as youth scientists as they were engaged in making ethical choices that might impact the local ecosystems and economy. Throughout the investigations, children were learning science in the context of place-based ecojustice education that was embedded in their own community.

STEM Education Conference

More recently in 2013, I again visited Thailand to attend a conference in Bangkok on STEM (Science-Technology-Engineering-Mathematics) Education. The conference was designed to address the need to develop the science and technological workforce in the Association of Southeast Asian Nations (ASEAN) countries through world-class, quality STEM education. STEM education is a predominant framework for globalized education that is increasingly embraced by the governments and the corporate world. The goal of STEM education is to prepare students for the workforce in the global marketplace. STEM education is standards-based and is driven by neoliberal economic policies associated with globalization. Assessment in STEM education focuses on school accountability and how individual students perform on standardized international science and mathematics tests, such as the Program for International Student Assessment (PISA). During the conference, I was struck by how the vision of STEM education proponents contrasted to the place-based science education project that I visited a few years earlier in rural Thailand. The neoliberal, corporate vision of STEM education was seemingly incompatible with ecojustice education, where education is community-based and the goal is for students to be active citizens critically engaged in learning about eco-socio-scientific issues. In marginalized communities found in both rural and urban areas, students and families seldom benefit from the material wealth generated by corporations. Standardized STEM education models that are driven by high stakes tests are largely irrelevant to the needs of these students.

Later at the conference, I had the opportunity to observe presentations at a day-long roundtable meeting from educators from 11 countries (including both ASEAN and Asian countries from the north): Republic of Indonesia, Lao People's Democratic Republic, Republic of Singapore, Thailand, Malaysia, Sri Lanka, Republic of the Philippines, Republic of China [Taiwan], South Korea, China, and Japan. A STEM educator from each country was asked to report on the current status of STEM education in their respective countries. In most all of these countries, STEM subjects were taught separately rather than as an integrated curriculum that connects and transcends traditional subject boundaries. Rather than promoting inquiry and problem-based learning, teacher-centered pedagogies were most predominant in STEM education. Although preparing future scientists, engineers, and a scientifically literate workforce were considered important; several presenters reported that many students, particularly in rural areas, do not have access to the scientific and technological infrastructure and resources thought to be necessary for a world class STEM education. Other presenters reported that STEM education does not address the many ecological sustainability issues that are important to local communities, such as pollution of rivers and agricultural land, flooding, poverty, and smog in the cities. STEM education also neglects connections to local cultures and funds of knowledge in the local communities. Although there are exceptions in more industrialized ASEAN countries or in urban centers, teachers were not prepared in content or pedagogy to teach STEM subjects.

Ponder This: Can Ecojustice Education Go Mainstream?

As I ponder this apparent mismatch between STEM education and ecojustice education, I propose the following question: Can ecojustice education go mainstream? This question is especially relevant in considering students from marginalized populations like the rural Thai children investigating the health of the local river. This question is also relevant for students from any place throughout the globe who are involved in ecojustice education but may be subjected to high stakes testing in schools. Considering that STEM education is increasingly becoming mainstream, I would like to consider the Next Generation Science Standards (NGSS). As discussed by Teresa Shume in Chap. 2, the goal of these standards are linked to economic development and preparing students to compete in the global economy. These standards are considered mainstream as they were developed by a national consortium of scientists, engineers and educators from professional organizations including the National Research Council, National Association of Science Teachers, and the Association for the Advancement of Science (NGSS 2013). Many countries throughout the world in support of STEM Education (including educators in the ASEAN countries) are paying close attention to the NGSS that are designed for students to learn about common processes between science and engineering, core science concepts, and cross-cutting concepts that transcend scientific disciplines.

In reviewing the NGSS, it is quite evident that the standards do not saliently address place-based ecojustice education. Nevertheless, a closer look reveals important pedagogical and core concepts related to "earth and human activity" that may be very useful in providing a rationale that supports ecojustice education (NGSS 2013, p. 125). First, the standards emphasize that science and engineering practices are based on students being engaged in argumentation based on evidence. Consider the following NGSS standard related to earth and human activity:

Constructing Explanations and Designing Solutions

- Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4) (NGSS 2013, p. 127)

This standard clearly addresses what we want our students to do in ecojustice education, especially if they are involved in youth activism and citizen science. The children in the Lampang province in Thailand were engaged in citizen science as they analyzed and shared the importance of the data they collected from the water samples with farmers in the local community. Second, the NGSS reveals important core concepts relating to the human impact on global climate change. Consider this core NGSS standard relating to global climate change:

Global Climate Change

- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding human behavior and applying that knowledge wisely in decisions and activities. (MS-ES53-5) (NGSS 2013, p. 84)

Although global climate change remains politically controversial, the core concepts relating to human impact on global climate change are now considered mainstream and legitimized by the scientific community. Third, the NGSS standards make it clear that science and technology raises ethical issues and that the issues are not resolved by science, but within the context of societies and culture. For example, consider this NGSS crosscutting standard that addresses ethical issues, decision-making and human values:

Science Addresses Questions About the Natural and Material World

- Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2)
- Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2)
- Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2) (NGSS 2013, p. 127)

In effect, by studying the eco-socio-scientific and ethical issues that are associated with human activity and climate change, it can be easily inferred that ecojustice education is becoming mainstream in the NGSS standards.

Nevertheless, when considering the ethics of human impact on the environment, it is important to understand that these issues have origins within the local community and culture. For example, as discussed by Anne Kern and her colleagues in Chap. 7, global climate change is having a huge impact in local Native American communities growing wild rice in the shallow lakes and marshes of Minnesota. Recently in West Virginia, a chemical used in the processing of coal recently leaked out of unregulated storage tanks into the Elk River. Local residents smell a strong licorice odor and reported to the authorities. The result was that 300,000 residents were out of clean drinking water for weeks. The chemical that leaked was used in the coal industry, which as we know, has created catastrophic environmental catastrophes through mountaintop removal and pollution of rivers and streams. Pollution from the coal industry has also been in the headlines of the neighboring state of North Carolina as coal ash generated by the power company has leaked from holding ponds into multiple rivers and streams. The impact on the local environment from the burning fossil fuels is an ecojustice issue with global climate change implications.

Authentic Assessment of Student Learning

Even though high stakes standardized testing is a hallmark for STEM education, it is clear that assessment of students engaged in ecojustice education and citizen science will not be accomplished through raising the bar. Like in the stream investigation conducted by Thai children, authentic assessment is necessary to connect to the goals of preparing youth scientists to investigate environmental issues that impact the local community. Ecojustice educators must ask these questions related to assessment: How do students investigate the impact of human activity on their local environment? How do students engage in the local community? How do children's actions contribute to the sustainability of local ecosystems and culture? What are the representations of student learning about ecojustice issues? As the children in rural Thailand collected and analyzed data relating to water pollution and shared their results with the community, they were clearly involved in authentic assessment. Standardized assessments do not align with the goals of ecojustice education and are therefore inappropriate for assessing youth engaged as citizen scientists.

One final question emerged from my experiences in Thailand: Can STEM education be place-based while focusing on ecojustice issues? The answer is emphatically yes! It was very clear to me that the educators in the ASEAN countries were considering the need for STEM education to address eco-socio-scientific issues that were relevant in local communities. This can be accomplished by embracing the NGSS standards of learning that engage students as citizen scientists in problem solving, analyzing and discussing evidence, ethical decision-making, and connecting local environmental problems with global issues. Rather than relying on decontextualized standardized tests, the assessments should be aligned with the vision for encouraging students to be active citizen scientists who contribute to the well being of their communities. Assessments can be aligned with the NGSS but they must also be authentically aligned with the issues and the values of the local community. As the survival and sustainability of humans and the earth systems of our planet are dependent on preparing our youth scientists, ecojustice education will become mainstream for the next generation of students.

References

Klechaya, R. (2014). Place-based education for Five Elementary Schools in Rural Thailand. In *Proceedings from the 12th Hawaii international conference on education*, Honolulu.

National Research Council. (2013). *Next generation science standards*. Washington, DC: National Academy Press. Retrieved April 3, 2014, from http://www.nextgenscience.org/next-generation-science-standards

George E. Glasson is a professor of science education at Virginia Tech in Blacksburg, VA. He coordinates and teaches in the secondary science licensure program and has published research on place-based education, sustainability science, and ecojustice issues.

Part II
Citizen Science Section

Chapter 11
The Commonplaces of Schooling and Citizen Science

Xavier Fazio and Douglas Doug Karrow

I remember waking up with my Dad in our camper van parked within a conservation area. It is a beautiful sunny day in mid-June around 6:00 AM, and the year is 1982. I walk outside and the forest echoes with a variety of bird songs. In this natural area, a lake, wetlands, forests and meadows play an important ecological role in protecting the headwaters of the Credit and Nottawasaga Rivers. Within its boundaries, varied landscapes provide recreational and educational experiences for many people. The lake is rich in life with fish and underwater plants. On shore, mammals such as deer, red fox, porcupines and even flying squirrels can be found here. Ospreys, great blue herons, mallard ducks and many other breeding bird species are also seen, as are painted turtles and leopard frogs. In spring and fall, migratory birds take advantage of the diverse habitats along their journey north and south. We are here for one particular goal this morning: to assist the Federation of Ontario Naturalists and Long Point Bird Observatory in collecting breeding bird data in order to compile a breeding atlas for the birds of Ontario (Bird Studies Canada). We are conducting a survey of breeding birds in the rolling hills and lakes near Orangeville, Ontario, Canada. For the first time ever, in cooperation with hundreds of volunteers and coordinated by ornithologists, a 5-year survey of breeding bird distribution for all of Ontario is being conducted using valid scientific protocols. We are doing citizen science that beautiful Saturday morning.

X. Fazio (✉)
Department of Teacher Education, Brock University,
500 Glendale Avenue, St. Catharines, ON L2S 3A1, Canada
e-mail: xavier.fazio@brocku.ca

D.D. Karrow
Science/Environmental Education, Brock University,
Hamilton Campus, 1842 King St., E, Hamilton, ON L8K 1 V7, Canada
e-mail: doug.karrow@brocku.ca

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_11

It is June 2007 on a warm, slightly overcast day over Woodfield Public School located on the Niagara Escarpment, a UNESCO Biosphere Reserve conserving Ontario's natural and social capital by protecting prime agricultural lands, forests, water, wetlands, heritage and recreational spaces. More specifically, the school resides in a semi-rural area, with a few residences, a small woodlot, and farmers' fields adjacent to the school property. Other than American robins, house sparrows, and the occasional swallows and squirrels, not much animal life abounds the boundaries of Woodfield P.S. At around 2:00 pm, a mixture of 25 grade 4–8 students and two teachers exit the back of the school and head toward the soccer field carrying hula-hoops, shovels, laminated worm ID charts, trays, water bottles, thermometers, observation sheets and clipboards. This is part of a regular routine for this group. Each Friday a group of approximately 25 students and teachers take ownership for one monitoring site on the school premises while student groups rotate each week from one site to the next collecting, identifying and recording the abundance and variety of worm species in various habitats on and adjacent to the school site. Worm abundance and diversity data collected from the school are compiled and later entered onto the Ministry of Environment's environmental monitoring database. As one of the participating teachers tells us at the end of the monitoring process: Students would pester her every week asking, "When are we going out again to watch worms?" Who would have believed that observing worms and contributing to science is so much fun!

We introduce this section through the above vignettes. They illustrate citizen science experiences that we as authors have observed and participated in both school and out-of-school settings. These vignettes signal our intentions for this editorial based on an adage coined by Gregory Bateson, namely, *it is a difference which makes a difference*.

For this section introduction, we provide a brief overview of citizen science and our personal experiences implementing citizen science with elementary and secondary schools. Next, we problematize citizen science and schools using visual representations in order to highlight and juxtapose the 'commonplaces' of schooling as articulated by Joseph J. Schwab, a prominent curriculum theorist. We use visuals and text to introduce the reader to a variety of settings and how these representations illustrate both similarities and differences, and highlight the conceptual tension or dialectic between schools and citizen science. Finally, we offer some prompts for interpreting reports and essays about citizen science.

Overview of Citizen Science

Citizen science is a term that has been around for decades. It is used to describe the participation of the general public in authentic scientific studies. In its simplest terms, it involves everyday citizens cooperating with scientists to conduct scientific-based research. Scientists in universities and government agencies around the world are engaged in a variety of citizen science programs (Cornell Lab 2014). Although citizens have been involved in a plethora of science projects in recent years (e.g., *Discover Life, 2014; Environment for the Americas, 2012; Monarch Watch, 2012; Project BudBurst, 2014; Project FeederWatch, 2014*), members of the public have been independently recording observations of natural phenomena for centuries (Miller-Rushing et al. 2012). Citizen science has gained greater attention in the field of ecology primarily due to the history of amateur scientists (i.e., naturalists) collecting long term and diverse ecological data.

Over the last decade, the term "citizen science" has come to mean different things to academics and laypersons alike. Other phrases such as "public participation in science" and "volunteer-based monitoring" are used interchangeably, causing some confusion for educators and scientists new to citizen science. Bonney et al. (2009) attempt to reduce this confusion in a report for the Center for Advancement of Informal Science. In this report, they categorize models for public participation in scientific research including: contributory, collaborative, and co-created descriptive models. While these models provide a general heuristic for analyzing past and current citizen science projects, of interest to readers, these categorizations may assist in future theorizing and formalizing of citizen science within schools. Ultimately, the broad aim of any citizen science program is to promote learners' scientific and ecological literacy in formal and extended school settings.

Past Experience with Citizen Science and Schools

To support the teaching of environmental and science curriculum learning goals, from 2006 to 2009 we coordinated a collaborative research partnership with elementary and secondary schools in southern Ontario, Canada involving a government ecological monitoring agency called the Environmental Monitoring and Assessment Network (EMAN). This program is a partnership between Environment Canada and Nature Canada, coordinating a variety of ecological monitoring programs (Environment Canada 2008). EMAN is made up of organizations and individuals across Canada involved in ecological monitoring to better detect and report upon ecosystem change.

In order to facilitate the participation of interested individuals with limited scientific expertise (i.e., citizen scientists) a specific program called *NatureWatch* was created. *NatureWatch* is a suite of accessible ecological monitoring and assessment programs called: FrogWatch, PlantWatch, WormWatch, and IceWatch. Participants follow the program's specific ecological science protocol for collecting certain environmental monitoring data, whether identifying frog species by their species-specific call, collecting and identifying earthworms and their abundance, observing ice-on/ice-off dates on bodies of water, or identifying the flowering dates of various plants (NatureWatch 2012). Collected data sets are recorded and organized by the citizen scientists and then entered onto Environment Canada's EMAN database for environmental researchers to interpret and for government policymakers to utilize (Karrow and Fazio 2010). Participants are provided feedback on their data, which is uploaded onto a centralized database—accessible by both environmental scientists and the public. Prior to this, research partnerships involving education practitioners and ecologists was mostly nonexistent in Canada, partly because *NatureWatch* had never been implemented within schools, and education research into the relationship between this form of citizen science and schools had never been considered. Our research into school-based ecological monitoring served as a catalyst to initiate and secure this research partnership (Fazio and Karrow 2009). The viability of these programs became the basis of this research with elementary and secondary schools, specifically, how citizen science educates and nurtures ecological literacy within students and teachers.

Given the context of elementary and secondary schools, our findings from these studies reveal confusions and deficiencies in the rhetoric and practice surrounding ecological literacy in schools, and in particular, confusion with respect to ecological curriculum, teaching and learning. Further, designing quadripartite collaborations amongst external providers, schools, environmental scientists, and educational researchers is challenging when existing resources are limited or unavailable to support such unique collaborations. While we envisaged school participants' enhanced capacity to contribute to community-based ecological monitoring, and students and teachers alike becoming more ecologically knowledgeable, regrettably, our research has discovered more challenges to school-based practices and aims of citizen science.

Environmental education shares many elements with citizen science in schools—especially linking schools, communities and the environments that they occupy (Barratt-Hacking et al. 2007). Environmental education and citizen science in schools necessarily involves teachers and students engaging with nature in local community contexts. As we discover, however, citizen science is a demanding endeavor often in conflict with the dominant purposes, structures, and practices of schooling. Indeed, it has been known for a long while that the constraining regularities of schooling conflict with many goals of environmental education in schools (Stevenson 2007)—this is also true of citizen science. Therefore, to address school's normative constraints, citizen science practices must be coherent with many of the practitioner and student activities occurring in these schools in the shorter term.

We have argued elsewhere that laudable citizen science programs applicable for schools (e.g., *NatureWatch*) are challenging to implement given the general aims of school (Fazio and Karrow 2013; Karrow and Fazio 2010). While citizen science programs can be adapted to the operating contexts of schools, doing this limits the potential of citizen science to address the concerns of school environments and communities (Mueller et al. 2012). It is the challenge of how to reorient practices in schools for our youth that will be required for the future. Reconceptualising outcomes and finding synchrony between schools and citizen science is the next important task for researchers and practitioners in science and environmental education.

Visual Representations

Citizen Science and Schools

Schwab's (1973, 1983) commonplaces—*learner, teacher, content, and milieu*—provide a conceptual framework for thinking about curriculum in schools and its relationship to citizen science. Commonplaces are interrelated components that help frame curriculum. In essence, they are the fundamental processes and products of schooling. They are useful as a schema to juxtapose schools and citizen science. As influenced by their social and familiar environments, the *learner* represents knowledge of students in terms of their abilities, aspirations, and qualities. The *teacher* represents educators' knowledge and pragmatic pedagogical and subject matter experiences—including their beliefs and attitudes towards schooling. The c*ontent* represents the underlying systems of thinking and products stemming from the subject disciplines, and associated curricular materials. Finally, *milieu* or context brackets the educational context (classroom, school, local environment) where learner, teacher, and community are physically and culturally interrelated.

In this section, we capitalize on the idea that integration of multiple modes of communication can enhance or transform the meaning of ideas (Mitchell 1994; National Council for Teachers of English (NCTE) 2005). Specifically, by integrating visual and textual modes, organized by the commonplaces, we hope to illustrate and prompt critical thinking about the similarities and differences representing schools and citizen science. By working in tandem, the texts presented in the chapters of this section of the book on citizen science combined with these visual representations further prompt possibilities for much needed dialogue to conceptualize and reconceptualize citizen science and schools.

Learner

According to Schwab's (1973, 1983) commonplaces, the *learner* is broadly conceived as representing the knowledge of a "student." A learner is an individual who is attending an elementary, secondary, or post-secondary institution, or may be beyond the school context, such as a member of the community at large—a mature citizen for instance. The knowledge is viewed in terms of what students know, what they aspire to know, and the unique qualities the learner possesses to mediate the learning itself. These facets of knowledge are co-constructed through social interactions. In the school, for example, social interactions may be facilitated through other students, teachers, and perhaps ancillary school staff and scientists. Beyond school contexts, social facilitations of knowledge occur through adult citizens, naturalists, and scientists (Figs. 11.1 and 11.2).

Consider the following questions:

Do students and adults learn citizen science in the same manner? Are all learners given equitable opportunities to learn? What curricular resources do learners have available to support their learning? How will learners collaborate with scientists?

Fig. 11.1 Secondary students conducting a Wormwatch survey

Fig. 11.2 Adult citizen science participants (From: https://blogs.dal.ca/sustainabilitynews/files/2012/09/citizenscience.jpg)

Teacher

The *teacher* is the locus of the educator's knowledge, embodying certain teaching and subject matter experiences, each shaped by their personal beliefs and attitudes toward schooling. Within schools, teachers must assume responsibility for the

Fig. 11.3 Teachers learning about citizen science (NatureWatch)

explicit acts of teaching and their intended and unintended consequences upon/of the learner (or students). Within educational sites in the larger community, citizen science "guides" interact in distinctly difference ways with citizen science participants (Figs. 11.3 and 11.4).

Consider the following questions:

Are science teachers capable of leading citizen science programs? What professional learning is required for science teachers to support learners doing citizen science? Should science teachers be participants in citizen science alongside students?

Content

Wordle is an online tool for generating "word clouds" from text provided (Wordle 2012). The clouds give greater prominence to words that appear more frequently in the source text. Thus, the program presents a visual content analysis of texts. Figure 11.5 represents abstracts from this section's chapters (pp. xx-xx), where clear links between citizen science and schools are being presented. In Fig. 11.6, abstracts are presented from plenary speakers at a recent public participation in scientific research (PPSR) conference held August 2012 (Citizen Science Community Forum 2012).

Consider the following questions:

What is similar/different between the vocabularies in these images? What are the emphases for doing citizen science in school? How do the content emphases affect the experience of citizen science? Why should students in school learn citizen science?

Fig. 11.4 Citizen science participants being guided

Context

The last of Schwab's four commonplaces, *context* or *milieu*, situates and coalesces the previous three commonplaces into a functioning whole. Of course, within school settings these usually involve the classroom or activities situated on or within the school property, that is namely the playground, sports field, naturalized area, or a small patch of grass. Compared with contexts for conducting citizen science beyond schools, these more "natural" settings shape experience in profoundly different ways. Of course the way citizen scientists participate, interact, mobilize, and enact, are enabled differently within these contexts (Figs. 11.7 and 11.8).

Consider the following questions:

Does learning about citizen science in schools differ from learning it in a more complex natural environment? Should the environmental context of schools determine the citizen science programs made available to students?

Fig. 11.5 Wordle image from abstracts for this section of the book

Where Do We Go from Here?

In this introductory chapter for the citizen science section, we provide an overview of citizen science and schools based on our experiences. Using vignettes, descriptive texts and images with queries organized around Schwab's curriculum commonplaces, we present citizen science in schools juxtaposed with more natural settings. Our intention using this multimodal representation method is to evoke a deeper analysis of the similarities and differences between schools and citizen science. Consider some themes based on our analyses of these texts and images:

- Incentives for schools to participate in citizen science.
- Scientific and ecological identity of learners.
- Learning outcomes of students participating in science.
- Professional learning required to mediate citizen science programs.

Fig. 11.6 Wordle image from abstracts of plenary speakers from the 2012 PPSR conference

- Practitioner understandings of the outcomes from citizen science.
- Science education, citizen science, and interdisciplinary curricular emphases.
- Social and ecological outcomes and school-community collaboration.
- Natural versus human-designed environments and citizen science.
- Curriculum re-conceptualized beyond Schwab's four commonplaces.

As you read the chapters focused on citizen science and schools, keep in mind the commonplaces of schooling. Accordingly, consider some of the above themes when problematizing and generating ideas for future collaborative work between citizen science and schools.

Fig. 11.7 School yard as a site for doing citizen science

Fig. 11.8 A natural space for doing citizen science

References

Barratt-Hacking, E., Scott, W., & Barratt, R. (2007). Children's research into their local environment: Stevenson's gap, and possibilities for the curriculum. *Environmental Education Research, 13*, 225–244.

Bonney, R., Ballard, H., & Jordan, R. (2009). *Public participation in scientific research: Defining the field and assessing its potential for science education*. Washington, DC: CAISE.

Citizen Science Community Forum. (2012). *Public participation in scientific research conference plenary presentations.* Retrieved October 15, 2012, from http://www.citizenscience.org/community/plenary-presentations/

Cornell Lab of Ornithology. (2014). *Citizen science toolkit: Projects.* Retrieved August 30, 2014, from http://www.birds.cornell.edu/citscitoolkit/projects

Discover Life. (2014). Retrieved October 14, 2014, from http://www.discoverlife.org/

Environment Canada. (2008). *Environmental monitoring and assessment Network*. Retrieved September 24, 2010, from http://www.ec.gc.ca/faunescience-wildlifescience/default.asp?lang=En&n=B0D89DF1-1

Environment for the Americas. (2012). *Conserving birds by connecting people home page*. Retrieved August 6, 2012, from http://www.birdday.org/

Fazio, X., & Karrow, D. (2009, October). *Collaborative communities: Exploring a school-university-government ecological monitoring partnership*. Paper presentation for the North American Association for Environmental Education (NAAEE) 38th annual conference, Portland, OR.

Fazio, X., & Karrow, D. (2013). From local observations to global relationships. In Michael P. Mueller, Deborah J. Tippins, & Arthur J. Stewart (Eds.), *Assessing schools for generation R (Responsibility): A guide to legislation and school policy in science education* (pp. 333–346). Dordrecht: Springer Publications.

Karrow, D., & Fazio, X. (2010). Viewpoint: 'NatureWatch', schools and environmental education practice. *Canadian Journal for Science, Mathematics, and Technology Education, 10*, 1–13.

Miller-Rushing, A., Primack, R., & Bonney, R. (2012). The history of public participation in ecological research. *Frontiers in Ecology and the Environment, 10*, 285–290.

Mitchell, W. J. T. (1994). *Picture theory: Essays on verbal and visual representation*. Chicago: The University of Chicago Press.

Monarch Watch. (2012). *Monarch watch*. Retrieved October 9, 2012, from http://www.monarchwatch.org/

Mueller, M. P., Tippins, D., & Bryan, L. A. (2012). The future of citizen science. *Democracy and Education, 20*, 1–12.

National Council for Teachers of English (NCTE). (2005). *Position statement on multimodal literacies*: NCTE position statement on education issues. Retrieved March 17, 2012, from http://www.ncte.org/positions/statements/multimodalliteracies

NatureWatch. (2012). *NatureWatch home page.* Retrieved September 25, 2010, from http://www.naturewatch.ca/english/

Project BudBurst. (2014). *Project budburst*. Retrieved October 9, 2014, from http://budburst.org/

Project Feederwatch. (2014). Retrieved October 14, from http://feederwatch

Schwab, J. J. (1973). The practical 3: Translation into curriculum. *School Review, 79*, 501–522.

Schwab, J. J. (1983). The practical 4: Something for curriculum professors to do. *Curriculum Inquiry, 13*, 240–265.

Stevenson, R. (2007). Schooling and environmental education: Contradictions in purpose and practice. *Environmental Education Research, 13*, 139–153.

Wordle ™. (2012). *Wordle.* Retrieved October 5, 2012. http://www.wordle.net/

Xavier Fazio is an associate professor at Brock University in St. Catharines, Ontario, Canada in the Department of Teacher Education. He teaches within the Teacher Education and Graduate/Undergraduate Departments. Current research interests include science and environmental education, citizen science, teacher education and development, and complexity theory as it applies to educational contexts.

Douglas Doug Karrow is an associate professor of environmental and science education in the Department of Teacher Education, Brock University, Hamilton, Ontario, Canada. Teaching responsibilities include teacher and graduate education. Empirical and philosophical inquiries structure research into environmental education and school contexts.

Chapter 12
Living History—Challenging Citizen Science and Youth Activism Through Historical Re-enacting

Kimberly Haverkos

In sixth grade, I told my teacher, Mr. Miller, that he was wrong. As a "good" student, this was unusual behavior for me. I normally remained very quiet and compliant in the classroom, following directions, accepting the daily dose of knowledge provided by the teacher. Mr. Miller's lecture on the beginnings of the American Revolution, however, based on the traditional, clean narratives in our school history books, left out a number of what I felt were important details and information. Particularly of interest (to me anyway) was the story of George Washington's rise to fame as a General and then President of this new country. Mr. Miller's story told of Washington's bravery in the French and Indian War, which then led to his role as a leader in our American history. As a child re-enactor of the French and Indian War and the American Revolution, I rejected that story because I had experienced a different one. I had "re-lived" the events of the French and Indian War. I had learned of Washington's blunders that drove the colonies into the French and Indian War by re-enacting those events. As far as I was concerned Washington, although a revered leader, was also a flawed person who had made mistakes and the history books, and my teacher, were wrong.

My experiences as a historical re-enactor of the eighteenth century have stayed with me into adulthood. I continue to re-enact today and have introduced my children and my partner into the re-enacting world. And I continue to use my experiences as a re-enactor to question the common sense stories of history.

No one lives a perfectly clean and sterile life—there is messiness and contradiction in much of what we do. Re-enacting is not my profession; it is my hobby. Professionally, I am a science and teacher educator trained in critical pedagogy.

K. Haverkos (✉)
Education Department, Thomas More College,
333 Thomas More Parkway, Crestview Hills, KY 41017, USA

12083 Four Way Acres, Moores Hill, IN 47032, USA
e-mail: Kimberly.Haverkos@Thomasmore.edu; haverkk@thomasmore.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_12

(Re)Living history is not unproblematic. Science education is not unproblematic. Teacher education is not unproblematic. It is in this messiness and in the contradictions of each of these large and complicated ideas that I find spaces of possibility for critical pedagogy and activism, science education, and historical re-enacting.

As a teacher educator, part of what I attempt to do is educate my pre-service teachers in living out the habits of democracy. Educating students for the habits of democracy includes an engaged discussion with what it means to be a responsible citizen socially, civically, and politically. In a world where science legitimates (or de-legitimates) many social, civic, and political decisions, educating teachers and students about democracy necessarily includes an education engaged with science. Citizen science or active participation in scientific endeavors is considered one way to educate citizens, teachers, and students *about* science. But as Mueller et al. (2012) suggest, this removes science and scientific issues from their historical, cultural, and political contexts and does little to engage the learner with the issues at hand. They call for diverse geographic knowledge through community immersion as a remedy. Historical re-enacting provides an immersion community where traditional knowledges are legitimated, encouraged, and esteemed. Through engagement with both the natural environment and history of a place, historical re-enacting provides a platform to democratize citizen science by critically examining what is legitimated by both citizen and science. Historical re-enacting, this living of history, provides historical, cultural, and political meaning

Fig. 12.1 The author's family excited to be learning about the past

to scientific issues that are being addressed today. This chapter will seek to analyze how historical re-enacting can provide critical spaces for first raising questions around issues of citizenship; second, by raising questions about relationships with nature and science; and finally developing an understanding of citizen science rooted in youth activism through the traditional knowledges and experiences with nature that re-enacting history allow (Fig. 12.1).

What Does It Mean to Be a Citizen? Using the Past to Examine the Citizen in Citizen Science

In my portrayal of a white (occasionally privileged) woman of the eighteenth century, I must necessarily explore what rights I would have been able to exercise under the constraints of the time. I must understand and re-create the lack of rights that I would have had while living in a time where, although still not equal, I have and exercise a number of rights as a citizen of the United States. I must examine the privileges and lack of privileges that occur in both times and spaces and work not towards a resolution, but instead a continuous examination. It is a constant tug of war between what was and what is, between what has changed and what has not. It is an act that requires constant questioning and examining as I live my lives both in the present and the past: who counts as a citizen and what does it mean to be a citizen?

The concept of citizenship is complex and multivoiced with a number of thoughts about how best to prepare all students for their role as citizens. But, again, what does it mean to be a citizen? According to Kathleen Knight Abowitz and Jason Harnish (2006), “Citizenship, at least theoretically, confers membership, identity, values, and rights of participation and assumes a body of common political knowledge” (p. 653). This identity of citizen also confers responsibilities and required actions, but it is these actions, or lack thereof, that are often the center of current discussions around citizenship.

> Questions about what constitutes good citizenship and proper civic education have also been fueled by a widely perceived crisis in democratic life and citizenship in America… [evidenced by a]Growing distrust in government and other key institutions, diminished trust in fellow citizens, eroding interest in public affairs, and declining voting rates …Nationalist expressions, ironically combined with a renewed sense of our global ties to other peoples and nations, have further intensified and complicated the interest in citizenship and in the role of schools in shaping democratic citizens (p. 654).

Much like issues of literacy in other subject areas, a number of people have decried the lack of civics education in the American curriculum (Hutchins 2012). Instead of buying into assumptions about apathetic youth who are disengaged with democracy, they point to what is taught *and not taught* about being a citizen through the curriculum as part of the problem (Hutchins 2012; Knight Abowitz and Harnish 2006).

Citizen science, or the explicit linking of individuals' roles as both citizen and collector of scientific knowledge, points to possibilities for activism and participatory democracies through science but under the guise of which form of citizenship? Mueller et al.'s (2012) article on the future of citizen science, as well as the responses to that article, show citizen science itself is a contested and evolving term that questions what it means to be a citizen who does science within today's societal limitations, what a more democratic citizen science might look like, and challenges whose interests are served by the current forms of citizen science (Weinstein 2012; Calabrese Barton 2012; Cooper 2012). In terms of discourses around the words citizen and citizenship, these questions, while specific to science, echo the questions that are being asked by "…a vibrant and complex array of citizenship meanings that have more recently developed out of, and often in opposition to, these dominant discourses…" of citizenship that reproduce class, race, gender, and ethnic divides and hierarchies (Knight et al. 2006, p. 654). Feminist, cultural citizenship, reconstructionist, queer and transnational discourses around citizenship challenge traditional notions of citizenship and agency within citizenship, particularly those found in schools. In light of these critical discourses of citizenship, Knight et al. (2006) are worth quoting at length here:

> The emergence of a strong array of diverse critical discourses of citizenship challenges traditional definitions of membership and pushes against traditional boundaries of agency, identity, and membership. Agency is the idea that individuals and groups act—that citizenship is something that happens when people are engaged in activity for, with, on behalf of, or even against others. The goodness of agency seems to be a key assumption in all understandings of citizenship…but feminist, queer, cultural, and transnational discourses question traditional notions of civic agency. Where do citizens do their work? …Do they engage in discourse or ironic performance, empathetic dialogue or storytelling, conflict or peacemaking? Do they engage their discourse through traditional public forums or through worldwide electronic transmissions? … The question of civic identity… [challenges] us to look at the histories of who has been welcomed into the civic realm and who has not. In light of these histories, critical citizenship discourses challenge the very constructions of some of our most cherished political identities (p. 680).

The citizen science movement when seen through the critical discourses available around these definitions of citizenship allow for the possibilities of contextuality and democracy in and through science and agency through activism. As Mueller et al. (2012) point out, "…we need to find ways to include youths not only in pedagogy that heightens epistemic development but also in schooling where they have opportunities to engage real issues through their activism" (p. 11). As one avenue forward, I believe that a citizen science that is informed by the living history of a place may provide some of these opportunities.

The integration of citizenship and science discourses through citizen science (in its many and contradictory versions) is being challenged, explored, and advanced within social studies classrooms. Social studies also allows for the contextual necessity of understanding the history of a place and how that history informs both the present and fluctuating possibilities of the future. According to Hutchins (2012), increasing interdisciplinary connections by teaching civics across the curriculum allows for students to "…experience increased relevancy in subjects in which they struggle…" by "…leverag[ing] student interest in current events" (p.72). However, this interest must attach the past to the present by linking the historical context of multiple times to a place. The importance of history in traditional discourses of citizenship are well documented as a way to reinforce and reproduce the values of an imagined past in the present, but history also plays an important, if often unrecognized role in critical discourses of citizenship. The history (of time, places, and citizenship) that students are taught in schools is often sterilized—the messiness and contradictions removed in order to provide easy access to an imagined past. But the past, our history, is not the tidy package presented in school textbooks as I reminded my sixth grade teacher. The past is made up of a multitude of voices, stories, actions and reactions that are often contradictory, confused, and misrepresented. Very often we hear the story of Abigail Adams, her historically structured feminism, and her letter writing campaign to her husband, John Adams, with her pleas that while he constructed the new "code of laws" of the land, he "Remember the ladies." What we don't often hear, discuss, or acknowledge, is John's response to Abigail, "As to your extraordinary code of laws, I cannot but laugh (Bober 1998, p. 73)." Although our modern expectations create an equal partnership between these two historical figures, a closer reading of their constant letter exchanges reveals the realities of the eighteenth century and social expectations, which are in stark contrast to our sterilized version of their relationship. By engaging a feminist discourse of citizenship and looking at the relationship between Abigail and John Adams, we can better understand feminist calls today for the dismantling of civics discourses that are attached to citizenship as a performance within the *public* sphere. Abigail Adams' work in the domestic sphere was as engaged with ideas and actions of citizenship and activism as her husband's actions were in the public sphere. In terms of citizen science, we can again look at the feminist discourse around citizenship and ask where does legitimate science occur—in the public sphere? The domestic sphere? Who is able to perform that science? What actions constitute citizenship linked to citizen science? What actions *should* constitute that citizenship?

For students to be engaged as activists within citizen science, the historical context of the place that they are engaged with must provide access to an untidy past, to hidden voices and stories, to the complexities that created the situation that they are now engaged with. Through historical re-enacting, through a re-living of the past, some of those complexities can be (re)experienced. Jon Hunner (2011) discusses the Historic Environment Education (HEE) movement, seeking ways to democratize the past, but also change the future. "With the motto of "think historically, act locally," teachers and museum professionals are linking local and environmental resources to enliven the classroom, challenging students to incorporate themselves, their communities, and their surroundings into complex encounters of place and past" (Hunner 2011, p. 33). While Hunner (2011) discusses the time travel aspect, the living of history to engage with the historical context of local places, the potential to engage with the environment of the place and to engage with citizen science through activism and the history that created that environment is potent. Students working with the quality of the water in a local stream must understand the uses of that stream throughout the past in order to both understand the present predicament and change the future expectations of usage within that stream. To collect water samples may help students learn *about* water quality within that stream, but *engaging* students in a lived experience of how that stream was used from the past to the present brings in the complex political, social, ethical and moral discussions necessary to change the ways in which that stream is used in the future. Mueller and Tippins (2012) call for geographic knowledge to be rediscovered before it becomes extinct, but that rediscovery is necessarily historicized. Re-enacting the past allows a possibility for access to geographic knowledges that were once common place. It also engages the student in the physicality of the place, allowing connections between humans and environment to come to the fore. As Mueller et al. (2012) suggest, without this geographic knowledge, and without an understanding of the history of the people *and* the place, students and other citizen science activists may miss important patterns, possible future actions, or marginalized voices often excluded (historically and presently) from decision making as both citizens and scientists. Historical re-enacting is one point of entry into the messiness required of activism, but it is also a way into necessary discussions that allow for a dual focus on what it means to be a citizen activist and what it means to do science.

Local History and Knowledges of Nature and Science

Katie Davies (2010) laments the fact that "…the thought that a learning society should produce engaged citizens with the capacity to lead social change has all but disappeared from public discourse" (p. 10). Pushing for the development of a worldwide learning society, Davies suggests that "[o]nly by listening to each other and sharing what we know…" throughout the course of our entire lives, focusing on life-long learning, and learning from constant access to educational experiences can humankind hope to become a sustainable society (p. 10). She goes on to suggest, "It is also possible to learn from *the historical, place-based experience* of living sustainably in local communities, which is passed on through the generations" (p. 11, *italics added*). Our connections to the past are constantly competing with our experiences in the present, which drive our evolution of knowledge, our experiences of the world around us, and occasionally disrupt our plans for the future. John Dewey reminds us, "…knowledge of the past is the key to understanding the present" (1944, p. 214). I would add that the past is also necessary to understanding possible futures in a way that lessens the marginalization of both others and nature and democratizes the ways in which decisions are made around issues of citizenship and science.

In discussing ways to engage the prospective teacher in action research, Mueller et al. (2012) state, "In the process [of engaging with the cultural practices of the community] they learn that the teaching and learning of science must move beyond the transmission of facts to acknowledge the diversity of *experiences, voices, traditions, and histories* of people" (p. 9, *italics added*). The same can be said for students who engage with the living history of a place (Hunner 2011; Hutchins 2012;

Ohn and Wade 2009; Weglein Kraus 2008). Living history can be a process of engaging students with science by connecting to students' prior knowledges about local places and environments. Living history is dynamic and moving unlike the stagnant pages of their history books (and often the science classes they experience). Engaging with living history also brings to the fore the importance of lived experiences. While re-living history is not unproblematic, it does provide "…a more human coloring, a wider significance, to [a student's] own study of nature. His knowledge of nature lends point and accuracy to his study of history. This is the natural 'correlation' of history and science" (Dewey 2010, p. 57). Hunner (2011) also suggests this correlation, "In addition to providing living history experiences, HEE [historic environment education] uses oral history, heritage preservation, archeology, and naturalist studies to make history come alive," at the same time engaging the student with their history, their environment and nature (p. 34).

Over the course of 30 years of re-enacting the eighteenth century, this connection between living history and nature and living history and science has become very clear for me. As children we learned about our environment as a way to understand the history we portrayed. We learned about edible plants found in the woods of Western New York, the importance of clean water access to those we portrayed, early science studies and experiments, the loss of scientific information because of disease, famine, and war. My brothers and I compared these events and experiences of the past with our understandings and experiences of the present. For me, this lead to a future in science education that is intricately interwoven with my lived experiences of the – way – past. Teachable moments are everywhere I look in the lived history that I perform. As a way to make explicit and continue to learn about those connections, I still find myself asking questions about the different tasks that I perform as a re-enactor. What process did those living in the eighteenth century use to accomplish this task? How is nature part of that process? What science is involved in this task? How does science and/ or technology affect this process today? These are not yet activist oriented questions, but placed into their historical, social, and political context, they can become starting points for activist inquiry and citizen science.

If, for example, we look at the domestic sphere of the eighteenth century home and the production of medicines, we can begin to see connections between our past and our present. The health care of the family was the responsibility of the woman of the home—What process did those living in the eighteenth century use to accomplish this task? The traditional, gendered knowledges of how to produce and apply plant-based medicines was passed on from mother to daughter, grandmother to granddaughter. Willow bark teas relieved headaches—How was nature part of that process? Today, we know that the chemical properties of that bark contain the base compounds we use for the production of aspirin—What science is involved in this task? Today, a multitude of pain relievers and other drugs are available through chemical production in factory settings—How does science affect this process today? What questions might students develop from this knowledge of the past that will lead to activist tendencies? Through living the history of the past, interest in the more current outbreak of fungal meningitis due to the contamination of steroid

Fig. 12.2 The author's daughter moves kernels of corn into a mortar and pestle to make corn meal. The production of food is a topic where living history provides access to a number of inquiry focused questions and possible activism. What process did those living in the eighteenth century use to produce their food? How was nature part of that process? What science was involved in this task? What is science and/ or technology's role in food production today?

shots may be better understood as part of the evolution of both natural and scientific knowledges. Re-enacting the past and understanding the human to nature/ nature to human connection of the past may also provoke serious questions about pharmaceutical companies and the business of medicine today. What role does nature play in the production of medicine today? This question, driven by a lived and local experiential knowledge of the past, links the student to more global and abstract ideas about how science and society interact today. These explorations may also provide access to activist movements that seek to protect the intellectual property rights of indigenous cultures and the knowledges they possess around a plant-based medicine today. Additionally, experiences of the past may provide students with a more democratic vision of citizen science as they examine what and who is legitimated by science throughout history into the present (Fig. 12.2).

Re-enacting History: Rooting Activism in the Past to Move Forward

Living history is often seen as a way to engage students with the social studies curriculum. Whether students are taken to watch a re-enactment of a past battle or a famous event, or they are invited to participate in a living history experience playing the role of someone out of the past, the interdisciplinary possibilities move way beyond the social studies classroom. Connecting science to the history of a place prior to the curricular industrial revolution is an important endeavor. Exploring the ways in which humans interacted with the world around them provides a unique perspective that is often overlooked in school curricula, particularly curricula that ignore the messiness of living.

Mueller et al. (2012) suggest that we must "…promote youth activism through citizen science as a pedagogy in which teachers and their students gather information to make the most informed decisions about potential consequences…" (p. 11). Without the historical perspective, those decisions remain unformed and un-informed. In particular, youth activism possibilities remain unconnected to a larger frame of reference that allows the influences of the past to become visible and explicit. Hutchins (2012) describes the benefits of the civic oriented experiences his students engage in as they come to realize the relevance of history in their lives. They come to understand that they, themselves, are making history. This pushes them to invest in different forms of activism available to them, to seek out and understand places that require change, and to passionately engage in being agents of that change. Bringing living history into this citizen-oriented perspective creates a broader understanding of one's place in history as well as a better understanding of how the past influences the present and how the present creates the future. As Hunner (2011) points out, "often, participants who relive the past also engage with issues in their own lives" (p. 6). Focusing student educational experiences on (re)living history within specific localities allows for different projects and different forms of activism to develop that meet the specific historical, cultural, and natural needs of the community. This allows for a citizen science that is local and engaged because the issues and activism come from the questions students engage with through their newly gained historical perspective. Because this perspective remains grounded in the local, natural environment and history, students can move to a more global realization of what activism may look like in other places while understanding the importance of local, traditional knowledges, cultures and histories.

This form of activism that uses living history to make sense of the present requires a new way of looking at re-enacting the past. It can no longer be seen as simply a way to make history come alive. Rather, it becomes a way to engage students with the issues that they face in their current lives. Jessica Weglein Kraus (2008) makes a distinction that is important to acknowledge here. "If history is about considering events, their antecedents, and their consequences, heritage…uses history…as a means of affirming…identities. It's about finding roots" (p. 145). Using examples of her experiences re-creating histories from around the world for students in the United States, Weglein Kraus is leery of using re-enactments to "…shock [students] out of their complacency in order to teach them. This coercion seemed an inappropriate weapon in the educator's arsenal" (p. 147). Her examples represent global experiences of history that are not within students' local realities. The unattainable location and history is made available through a dramatic and stylized re-living of an historical event, but one that lacks the context of place-based and local experiences for the students. A citizen science that uses historical re-enacting to explore possible avenues of activism looks to place both the history and the heritage of a localized community. It looks at the roots and identities that are established within that local place, particularly those that have been ignored by traditional histories, and follows them to the issues and challenges faced by the current community. It explores the historical consequences of events in real time—living and re-living a timeline that leads to a specific moment ripe for change. It does not seek to coerce or guilt students into action, but instead looks to students to lead the way through the messiness of the stories of the past into the possibilities of a future history. Weglein Kraus is worth quoting at length:

> To my mind *stories are essential*. They are the means through which we organize and communicate our experiences, interpret the world around us, and come to terms with who we are and where we've been. But for those of us charged with the responsibility of transmitting history, in order for narrative to be more than personal revelation, a wrenching tale, or a dishy bit of gossip, *it needs to be tied to analysis and inquiry*. (2008, p. 149, *italics added*)

What stories are told in our students' history books? What stories can our students tell about their past, local history, and role in the environment? It is in the ability to tie these stories of the past to the present through analysis and inquiry that makes historical re-enacting such a valuable tool for a citizen science that seeks to democratize both the acts of citizenship and the practices of science (Fig. 12.3).

Where might historical re-enacting find a place in current school experiences? Where might the activist tendencies best be brought to focus? Currently, there is a move to integrate service learning in schools as an act of citizenship and democratic participation. Ohn and Wade (2009) share that 64 % of public schools and 83 % of public high schools require students to participate in service learning projects where they are to: meet community needs, build collaborations between school and community, learn curricula, reflect on their experiences, use their new knowledges, learn beyond the classroom, and develop and foster a sense of caring. As addressed earlier,

Fig. 12.3 Learning traditional knowledges: starting a fire with flint and steel

normative views of students imply that students' participation as citizens is weak, at best, suggesting students are consumers of resources, passive victims in need of help, and recipients of others' efforts (Kielsmeier 2011). Service learning challenges these assumptions and instead sees students as resources, active producers of help, and leaders willing to give of their time and knowledges because it legitimates their own experiences and knowledges, recognizing that students, too, are producers of knowledge. "Fundamentally, service-learning challenges the traditional identities and roles of students and calls on them not only to consume knowledge but also to produce it" (Felten and Clayton 2011, p. 82). Through historical re-enacting and service learning projects, students' knowledges and skills interact with their re-enacted and present experiences to generate both learning and possibilities for activism within a community where the interactions, connections, and relationships are recognized as a way toward social change. Service learning, when linked to a democratized and contextual citizen science through historical re-enacting, can normalize critical thinking, connectivity, relationships, and learning, which holds great potential for bringing to the fore the issues that center equity and the environment in the quest for just social change.

While each of these alone is a laudable goal, according to Ohn and Wade's study (2009), the effectiveness of the service learning project depends on the citizenship beliefs being shared in the classroom. The ability to build reflective and critical thought into the process is not as simple as performing acts of service. Similar to Mueller et al.'s (2012) concerns around citizen science as being *about* science rather than *engaging* in science, Ohn and Wade (2009) challenges the service learning project and learning by doing, noting that there is little connection to what they term "doing by thinking." There is a lack of reflection, lack of diverse perspectives presented, and an inability to construct historical narratives. Missing from the service projects is a historical perspective rooted in multiple, lived histories—the stories that come from a lived experience of the past which allows for a critical reflection of diverse points of view. A lived sense of history experienced through re-enacting the past provides access to civic competence and acts of citizenship, including creating and democratizing experiences of citizen science. A program that links service learning and historical re-enacting to a specific environment may provide the impetus for moving from a position of learning *about* to being *engaged in* that is needed for successful projects that link acts of citizenship to practices of science through activism.

Redefining Citizen, Citizen Science and Youth Activism

Through re-enacting the past, it is impossible to participate without asking "What has changed?" This question drives the historical experience, environmental experience, and possibility of future activism if harnessed and facilitated through educational experiences. Growing up as a re-enactor, we often spent time re-enacting the eighteenth century along the banks of the Erie Canal in New York. The Erie Canal was built in the early nineteenth century, but there we sat in the twentieth century, re-creating the eighteenth century alongside a nineteenth century man-made waterway. The question of "what has changed?" was not only a social historical question, it was also a scientific one that explored the waters, the environment, and the nature that we engaged with during these events. We were able to experience the past, the present, and think about the future in ways that acknowledged the connections we had to that specific place, the histories that created and sustained that place, and the environment it had been, the environment it was, and the environment it possibly could become. In the past 10 years, the United States has celebrated a number of historical anniversaries that we as re-enactors have been able to participate in: the 250th anniversary of the French and Indian War, the 200th anniversary of the War of 1812, and the anniversary of the Lewis and Clark Expedition. As re-enactors, we are able to explore, story, and share a number of diverse and often marginalized voices of those historical moments through an understanding of the local historical context and the traditional knowledges of the past that are rooted in scientific knowledges of today. This linking of the past to the present by exploring what has changed allows for inquiry driven activism led by students on any number of fronts. It democratizes the process of citizen science because it challenges students to be citizens of the past, the present, and the future through their own knowledges of the past and the present as they make decisions about the future.

Historical re-enacting, as explored in this chapter, challenges the ways in which we define citizenship. By examining who counted as a citizen through the stories of the past, living history forces an examination of who counts as a citizen in the present. If we are working toward a more democratized vision of citizen science, one that starts from the bottom up and is immersed in place-based education, those activities that challenge the normalized boundaries of citizen and what actions constitute acts of citizenship are important to explore. Additionally, living history necessarily puts students into contact with nature and the sciences of the past. These experiences, when facilitated by questions that compare the past to the present can drive the inquiry required to frame democratized citizen science and youth activism around local, community based issues. Finally, by tapping into students as resources of traditional knowledges, producers of knowledge, and critically and historically aware of the place and environment they experience daily, youth activism begins with an exploration of history. The reliving of local histories can link student driven inquiry to a specific environment in order to move from a position of learning about to being engaged in acts of citizenship and practices of science through activism (Fig. 12.4).

Fig. 12.4 The author's son experiencing his first battle. What questions, stories, and acts of citizenship or science inquiry might arise from this experience?

References

Bober, N. (1998). *Abigail Adams: Witness to a revolution*. New York: Aladdin Paperbacks.

Calabrese Barton, A. (2012). Citizen(s') science. A response to "The Future of Citizen Science." *Democracy and Education, 20,* Article 12. Retrieved October 27, 2012, from http://democracyeducationjournal.org/home/vol20/iss2/12/

Cooper, C. B. (2012). Links and distinctions among citizenship, science, and citizen science. A response to "The Future of Citizen Science." *Democracy and Education, 20*, Article 13. Retrieved October 27, 2012, from http://democracyeducationjournal.org/home/vol20/iss2/13/

Davies, K. (2010). Sustainable minds. *Alternatives Journal, 36*, 8–11.

Dewey, J. (1944). *Democracy and education: An introduction to the philosophy of education*. New York: The Free Press.

Dewey, J. (2010). *The school and society and The child and the curriculum*. Lawrence: Digireads.com Publishing.

Felten, P., & Clayton, P. (2011). Service learning. *New Directions for Teaching and Learning, 128*, 75–84.

Hunner, J. (2011). Historic environment education: Using nearby history in classrooms and museums. *The Public Historian, 33*, 33–43.

Hutchins, W. (2012). Groomed for citizenship. *Educational Leadership, 69*(7), 70–73.

Kielsmeier, J. (2011). Service learning: The time is now. *The Prevention Researcher, 18*, 3–7.

Knight Abowitz, K., & Harnish, J. (2006). Contemporary discourses of citizenship. *Review of Educational Research, 76*, 653–690.

Mueller, M. P., & Tippins, D. J. (2012). Citizen science, ecojustice, and science education: Rethinking an education from nowhere. In B. J. Fraser, K. Tobin, & C. McRobbie (Eds.), *Second international handbook of science education* (pp. 865–882). Dordrecht: Springer.
Mueller, M., Tippins, D., & Bryan, L. (2012). The future of citizen science. *Democracy and Education, 20*, 1–12.
Ohn, J. D., & Wade, R. (2009). Community service-learning as a group inquiry project: Elementary and middle school CiviConnections teachers' practices of integrating historical inquiry in community service – Learning. *The Social Studies, 100*(5), 200–211.
Weglein Kraus, J. (2008). Petticoats and primary sources: Lessons learned through public history. *Journal of Archival Organization, 6*, 141–150.
Weinstein, M. (2012). Schools/citizen science. A response to "The future of citizen science." *Democracy and Education, 20,* Article 6. Retrieved October 27, 2012, from http://democracyeducationjournal.org/home/vol20/iss1/6/

Kimberly Haverkos is an assistant professor at Thomas More College in the Education Department. The mother of four children, a re-enactor, and a former science educator, her current research interests lie in exploring the relationships between girls and their understandings of the environment.

Chapter 13
Teaching with Citizen Science—It's More than Just Putting Out Fires!

Stacey A. Britton and Deborah J. Tippins

Reformers in science education continue to stimulate thinking, debate, and changes in the way we conceptualize the preparation of science teachers, reflecting a shift in emphasis from teaching skills and strategies of teaching to providing conditions associated with prospective teachers' increased responsibility for their own learning. Yet, as Northfield (1998) points out, for the most part, pre-service teacher preparation programs are designed to present what "science educators believe new teachers need to know and understand to work in the profession" (p. 695). Researchers such as Aikenhead (2006), Elmesky (2006), Maulucci (2008) and Tobin (2006) suggest the need for changes in the way that science teachers are prepared to meet the demands of diverse communities who are often at risk socially and environmentally. Not surprisingly, a half-century after Sputnik, these science educators, and others like them point to the failures of science teacher preparation to align with criteria such as relevance, interest and justice underlying many of the pervasive questions of equity in science education and schooling in general. Thus, it is imperative that schools and universities come together to understand the intent of education in the twenty-first century and create a new vision of science teacher preparation, in which prospective teachers examine the way their assumptions come to be formed, and not only solve problems but discover how they originate. We share one perspective on how change can be enacted by drawing from research conducted in a secondary science teacher preparation course organized around the tenets of citizen science.

S.A. Britton (✉)
Desoto Center-Southaven, University of Mississippi,
5197 W.E. Ross Parkway, Southaven, MS 38671, USA
e-mail: sbritton@olemiss.edu

D.J. Tippins
Mathematics and Science Education, University of Georgia,
212 Aderhold Hall, Athens, GA 30622, USA
e-mail: debtippins@hotmail.com

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_13

I've Seen Fire and I've Seen Rain

The caravan of prospective science teachers heads out of town, driving towards the rural farmland where the university's environmental safety complex is located. After traveling through several twists and turns in the road, they soon see Lance,[1] one of their classmates, standing alongside the shoulder of the road in a brightly colored rain poncho directing traffic. Through the heavy rain, a small building with an oversized garage becomes visible, a structure surrounded by trees with few signs of civilization. This facility houses fire safety equipment, a building primarily used for training, repair and storage. The prospective teachers gather in a state-of-the art presentation room for a brief introduction to fire safety. Quickly engaged, they pose many questions about the different types of fire extinguishers, home safety, and the use of equipment such as pressure cookers in the science lab. After sharing their own experiences with fire, they follow the training instructor to an outdoor area used for putting out fires. The rain is still falling as each prospective teacher, together with Morgan, their course instructor, brave the soggy ground to put out a fire, using some of the extinguishers they encountered earlier. Morgan later explained how the experience of working together in the rain to extinguish fires in an authentic context, was a good way to build relationships and a sense of community among the prospective teachers. In her excitement, Rose, one of the prospective teachers, shared how the experience of actually using equipment to extinguish a fire was invaluable, providing her with the confidence and a level of comfort needed to incorporate investigations and labs in her future classroom.

The fire safety training at the environmental complex is typical of the kinds of experiences that serve as the basis for this "Methods[2]" course required for secondary science teacher certification. In contrast to a decontextualized set of skills and strategies that have too often characterized science teacher preparation, this course is designed to help the prospective teachers view science teaching and learning through the lens of ecojustice philosophy[3] with a specific emphasis on the pedagogy of citizen science.

Setting the Stage for Developing Philosophy

Twelve males and eleven females enroll in the Methods of Science Teaching course, and like many students, enter the classroom on the first day with expectations based on the university catalogue description of the course as "science instructional strategies and classroom assessment for students in grades 7 through 12" (University Bulletin 2009), as well as the stories of previous students. Emma, with her strong chemistry background, knows how to run a lab, but is worried about her ability to manage students. Bernie expresses the desire to learn how to create an interesting curriculum which will be well timed and meet the diverse needs of students. Lynn, who notes that she is a good tutor, wants to make sure that she can meet the national

Table 13.1 Identification of characters

Participant	Description of role
Bernie	Preservice teacher; chemistry background
Houston	Preservice teacher; biology background
Lance	Preservice teacher; chemistry background
Morgan	Professor; course instructor
Patricia	Arboretum faculty; co-educator
Paul	Preservice teacher; physics/chemistry background
Rick	Luna Farm manager; co-educator
Rose	Preservice teacher; biology background
Sarah	Preservice teacher; chemistry background

standards (Table 13.1). These students' expectations stand in stark contrast to Morgan's explanation of the course as an opportunity to develop a philosophy of teaching. Describing learning to teach as a philosophical process, Morgan explains the importance of a guiding philosophy in making decisions about the relevance of any new ideas introduced in the course and beyond. Rather than providing a specific set of methods or access to teaching strategies, he envisions that the prospective teachers will frame their understandings and make instructional decisions in light of a developing philosophy of ecojustice as the foci of the course.

Ecojustice

Researchers such as Bowers (2001, 2002), Mueller (2008), Mueller and Bentley (2007) and Tippins et al. (2010) describe the multiple dimensions of ecojustice philosophy. They propose that ecojustice: (a) considers making the global more local; (b) encourages decision-making skills; (c) challenges cultural assumptions, and; (d) promotes an increased awareness of the use of language. The essence of ecojustice is the relationship between society and ecological awareness, preservation and sustainability. Sachs (1995) explains that ecojustice philosophy is concerned with environmental issues in a variety of social ways including equity in relation to nonwestern cultures, abuse of tribal groups through land exploitation, economic prosperity in conjunction with land use, and modifications to lifestyles in ways that benefit the environment. In the context of science teacher education, Britton (2011) and Tippins et al. (2010) maintain that ecojustice philosophy helps in creating democratic learning environments with learning a process, which is mediated to encourage participation by multiple parties. In this sense, for the prospective teachers, ecojustice philosophy opens the door to learning in dynamic contexts, which creates the potential for challenging assumptions deeply embedded in the belief systems of each student.

Revealing the Characters

The prospective teachers in the aforementioned Methods of Science Teaching course internalize teaching science through a veneer of past experiences. For some, this façade develops into the grand narrative of school success and allows them to embrace a philosophy of ecojustice. They may develop a civic courageousness which enables them to speak out unabashed and with a moral position that leads to a generation of shared responsibility. Others are challenged to move beyond their comfort zones of measurable, standardized outcomes and unquestioning acceptance of "official" knowledge. In particular, we look more closely at the lives of two of these prospective teachers—Rose and Paul—for potential insights into how ecojustice fits within their changing conceptions of schooling.

Rose

Rose grew up in a predominantly rural, Africa American community as a child of Mexican parents who worked in the fields. Her love for biology and environmental sciences is steeped in early experiences that fostered a respect for the Earth. Rose is the first in her family to obtain a college education; she emphasizes how her immigrant parents instilled in her a respect for education, family and independence. Rose frequently recalls the rich cultural heritage of Mexico where she spent many years of her life. Although an excellent student during her K-12 school years, Rose notes that early on in life she lacked confidence in her ability to succeed until she realized one day that whatever decisions she made about life it would all work out. Rose did not initially consider teaching as a possible career. It was a serendipitous opportunity to work with Pre-K children in an outdoor setting, and later employment at a local environmental education center, that nurtured her interest in the teaching profession. In her future teaching, Rose expresses the desire to diminish students' fears about the natural world through direct experiences with nature and animals. She places little value in the memorization of isolated facts and information. Instead, she argues that it is more important to "make a difference, to share your passion with others and allow the enthusiasm you have for life to be evident in everything you do." For Rose, teaching is about making a difference and leaving the world better off than how you find it. Throughout the course, Rose was challenged to consider how citizen science might support her goals within a science education context of increased accountability and standardization for teachers and students.

Paul

Paul typically appears in class wearing a dark trench-coat with a thick novel clutched in his hand. A physics major, he hopes to one day instill a love for the subject in his future students. Paul grew up as a Chinese-American in a home with parents and other family members who are quiet and reserved. His parents emphasize the importance of maintaining and sharing their Chinese cultural heritage, preferring to speak Mandarin in the home. As a result, Paul feels that it is very easy for him to accept individuals who express ideas different from the norm. As a child, Paul rode bikes with other children in the suburban neighborhood where he grew up, before video games became popular and "took" them inside. He had little experience with nature or pets during these formative years. Paul describes himself as a self-proclaimed recluse, noting "I don't talk much to the people in class, I'd rather be alone." He suggests that he is saner than most people, and enjoys reading books rather than social interactions. He discusses his unique fascination with what can be learned from books, considering them the ultimate source of knowledge. Although reflective and solitary, Paul is not afraid to speak up when he has strong opinions. He often mentions ideas that are directly at odds with his peers, but gracefully listens to their perspectives. Occasionally, Paul contributes to the class discussions by posing a thought-provoking or startling question, creating an excitement among his peers that is refreshing but disconcerting. Paul admits that his future students might consider his class to be uninteresting, given his preference for lectures and reading assignments. He questions whether he will be an effective teacher, explaining that his inability to "read" others might make him seem uncaring. Throughout the course, Paul struggled to create a vision of what citizen science or ecojustice might look like in his future teaching.

Citizen Science as a Context for Learning to Teach Science

Implicit within the ideology of citizen science in teacher preparation is an emphasis on learning about the health of the local community, beyond the walls of the school. Citizen science has been traditionally characterized as a top-down approach featuring projects initiated by scientists who enlist community members to collect data on issues- with little immediate relevance to citizens' lives. However, this Methods of Teaching Science course recast citizen science as a pedagogical approach consistent with justice, which results, by its very nature, in aims for democratizing science education. Morgan presents citizen science as more of a bottom-up approach intended to promote students' interest in the community, the environment and lifelong learning. He wants the prospective teachers in the course to develop awareness and become informed about issues taking place in the local environment and construct knowledge that would ideally encourage them to seek ways of using science education to further the competencies and community involvement of their future students. As an innovative professor, Morgan clarifies his stance on citizen science as being about "becoming informed in a place, and learning what they (the prospective teachers) need to know so they can participate more fully in decision-making, policy-making and democratizing science." Recognizing that the prospective teachers are only transient members of the local college community, Morgan feels that by teaching ways to assess the health of communities through citizen science, the future teachers will develop tools that can be transferred throughout their lives. Some of the course activities, which were designed to increase the prospective teachers' understanding of citizen science include:

Monarch Tagging

Prospective teachers engage in an authentic experience with butterflies, learning about the science behind the *Monarch Watch Program* (www.monarchparasites.org). They learn about monarch diseases and the role of citizens and scientists in determining health and migratory patterns. They observe examples of parasites in infected butterflies and discuss the ways they can engage students in collecting monarch data in their local communities and environments.

Bee Hunt

The Bee HUNT! research project (www.discoverlife.org/bee) provides prospective teachers with an introduction to "citizen science". In this project, students locate goldenrod plants and document insects that serve as pollinators. The project uses digital photography and media to aid in data collection. However, standardized equipment and protocols are used as a way of encouraging consistency for comparison of data across larger areas of the globe. While Morgan considers the Bee Hunt! project to be a more top-down approach to citizen science, he believes the experience will provide the prospective teachers a basis of comparison with more bottom-up approaches (note that Bee Hunt! does not consider itself a citizen science program, but an evolving authentic research context for volunteer involvement).

The Back Yard Project

The prospective teachers' involvement in the *Back Yard Project* (BYP) is the result of collaborative planning between Morgan and Patricia, a staff member at the Piedmont Arboretum. The BYP project places an emphasis on how local knowledge of plant, soil, water and air resources is expressed in the community and highlights how students can enact citizen science differently. Working in small groups, the prospective teachers design protocols and inquiry lessons for exploring different aspects of the 'back yard'. One group creates a protocol and lesson for measuring trees and determining biodiversity. Another group focuses on water absorption and develops a citizen science rain garden project. In a reversal of traditional roles, the prospective teachers become leaders when they share their ideas for citizen science projects in a workshop presentation for local teachers and other co-educators (the BYP project incorporates the teachers' lessons into a workshop, where the beginning teachers teach seasoned teachers about the local habitat).

Mapping Your Community

Using individually constructed maps of their neighborhoods, the prospective teachers analyze questions about the local community such as: How do people in this community obtain their food? What kind of access to transportation is available? Where are outdoor spaces located in the community? The 'mapping your community' activity lends itself to the development of other course activities, such as situated learning at Luna Farm.

Learning at Luna Farm

Luna farm, a local cooperative or community supported agriculture project is situated about ten minutes from the university. It serves as the setting for a cool early November morning meeting for a first-hand experience with the local farming community. After parking in a muddy field, Morgan and the prospective teachers walk down a one-lane dirt road to an open area under a grand old oak. The early morning crowd appreciates the old farm house, talking about experiences they recall in other, similar places. Rick, the "caretaker" of the farm, joins the group with conversation about the types of crops, animals and farming practices that they could expect to see. He uses words like "pedagogy, action preferred and perennial truths"—in relation to education, science and the farm. The group starts down the dirt road, pine trees meeting the hardwoods lining the path. Stopping at an enclosure for a sow and her baby pigs, Rick cautions everyone to be careful so that they will not be shocked by the electric fence. Prospective teachers, some with great care and others with little concern, climb over the single strand of wire. The sow, having a relatively young set of babies, is lying on her side in a big pile of hay, under a shelter consisting of one solid back wall with four wooden posts holding up the tin roof. Rick discusses the age of the piglets, and Sarah whispers that her husband would say Rick was not a real farmer because he calls them piglets. Rick walks us up to the sow and describes the breed, the typical number of babies birthed each time, and the preparations needed to finish the hogs for distribution to restaurants. As the group of prospective teachers walks away, the baby pigs begin to nurse and one of the prospective teachers near the back asks 'why the babies butted against the bag so much.' Having grown up on a farm, I quietly explain my understanding.

As we move from the pig pen down the road, Houston shares a story with a small group of preservice teachers of how he and his grandfather used to castrate baby pigs. No one asks questions about that process! Rick directs us to meet at the chicken “tractors”—large rectangular frames enclosed in chicken wire with half also covered in plastic tarps. The “tracts” had handles on either end for ease in movement. Rick describes how the boxes are repositioned at least once a day for the chickens to feed on grubs and bugs found on the ground and in left behind cow waste. Rick also explains how at least 25 % of the chicken’s food comes through what they eat from the ground. He elaborates, explaining how this type of feeding is close to what it would be naturally, but with obvious dietary supplements. As we stand on a hill overlooking much of the farm, Morgan asks why the chickens over on the trucks are white and why the others are brown or guineas (grey). Rick talks about the many different breeds of chicken that exist.

Eventually, the group walks down a small hill towards the tree line to reach the garden plots. Rick asks the prospective teachers for their ideas about the garden’s location. Some suggest that it needs to be at the bottom of the hill for easy access to water; others hypothesize that it is because of the nutrients that are found along the creek. Rick agrees with them about the nutrients but talks about the drought and the effect of flooding on erosion at the farm.

Rather than dividing the prospective teachers into groups as was originally planned, Rick has the entire class move up near the truck to break apart garlic bulbs into cloves. Rick explains the purpose of Allium (family in which garlic is found), and asks for other examples in the same family. He explains, ‘Garlic is a great pest control plant and way of adding nutrients to the soil—it’s very cleansing.’ Lee is curious about whether garlic ends up being a clone of itself, since the larger bulbs are separated into cloves for planting. Rick acknowledges it as a

> good question, but is unable to answer it. Everyone gathers around the farm truck with boxes of garlic bulbs, laughing and talking with each other about recipes and their use of garlic; a real sense of community seems to have developed over the semester and is evident in the interactions today. Rick's instructions on how to plant the separated cloves consists of asking students about how deep they should be planted and in what direction. After some instruction, the students are sent down the row in different directions to begin planting. Some work in groups of three-four to make holes in the ground, planting and covering the garlic in an assembly line fashion. Others work alone in their own world of dirt, cold air, and garlic. Some of the prospective teachers are very organized in their planting methods—Houston was is very methodic as he pokes holes and stuffs in the garlic; after he finished a section of about three feet of poking holes and planting garlic, he moves back to cover the holes. Rose works across from him using the same process. It is a great bonding opportunity as everyone share the experience of getting dirty planting, laughing and taking pictures. When the last clove drops, I look up to see Bernie over to the side, wiping his hands in the grass. I ask what he is doing, and he responds, "cleaning my hands." I laugh and say, "that is what your jeans are for." He is very serious and solemn when he responds, "not these jeans." We laugh at him because he also is wearing a white sweatshirt with no dirt on it, after planting garlic in the thick, red clay.

The prospective teachers hold different understandings of the value in visiting Luna farm, and what they are expected to learn from the experience. The unique perspectives of the prospective teachers support the integration of this experience as a potentially pivotal learning event, while encouraging dialogue about shared knowledge. Evidenced in this story are the varied responses and memories held by each of the participants, reflecting an awareness of their surroundings on a deeper level than simply participation. Some, like Sarah, think it is a good experience, for those unfamiliar with farming, relating it to the current organic movement and suggesting that it can foster a better understanding of food production. Bernie, who has very limited farm experience, expresses his enthusiasm at seeing baby pigs and planting garlic, noting that the farm is a great place for showing students the relevance of science and fostering curiosity through questioning. While Paul recognizes the value of learning about the farm as a community resource, he struggles to connect the experience with any kind of instructional value for the physics classroom.

Embodied Learning

Teacher preparation courses often leave little room for beginning teachers to take responsibility for their own education in ways that develop their capacity to ask questions, challenge, make decisions and solve problems collectively. Throughout this course, however, the prospective teachers have continual opportunities to consider ecojustice philosophy and its' pedagogy of citizen science, amend the 'soils of philosophy,' and make their own decisions regarding its relevance to teaching and learning. Admittedly, Morgan does not expect all of these prospective teachers to accept and value an ecojustice ethic, explaining: "It takes time but I think a few usually get it (ecojustice philosophy) by the end, and a few more get the whole idea of citizen science, which works toward ecojustice." For many of the beginning teachers, learning to teach science with ecojustice in mind is an unfamiliar experience. Faced with the more holistic approach of ecojustice-oriented teaching, learning, and curriculum, the prospective teachers often find themselves outside their personal comfort zones. This is certainly the case for those few individuals, such as Paul, who with a physics or chemistry concentration think about ecojustice as pH values or energy in an ecosystem—something that relates but is different than the way they experience learning. Learning to teach through embodied experiences involves an integrated way of knowing, embedded in a community of practice. The vast majority of the students in the class, having biology concentrations, share natural ways of negotiating meaning about what matters, what to pay attention to, and what to ignore. It is not surprising that the three prospective teachers with physics or chemistry backgrounds, already set apart from the stories, routines, and ways of doing things common within the biology community, initially find it very difficult to navigate meanings in citizen science and likewise envision how they might integrate it in their respective subjects. Conversely, Rose, with her biology background, responds to the complaints of her peers about participating in outdoor activities during the midst of a rainstorm; holding an umbrella, she says, "it won't kill them." Rose values this type of experience because it allows her to see the true expressions of nature, be *within* an experience, and be encouraged to view that experience through both an insider and outsider perspective. For Rose, learning in the rain is truly an embodied shared experience, since she takes in the sounds, smells, complaints, and content which is visibly present while attempting to negotiate how she might incorporate these ideas in her future teaching.

The Fire Training, BYP workshop and visit to the Luna Farm are just a few examples of the many embodied learning experiences in the course. Stelter (2004) notes that, on a personal level, "meaning evolves by embodying the world, by relating oneself actively to the context, and by understanding and reflecting on the situation through a situated action" (p. 7). In other words, for Morgan, there is an inherent tension of trying to be attentive to the primary content his colleagues will hold him accountable for covering, while at the same time, removing the learner from a context that stymies to ideally encourage learning at a deeper level. Barab et al. (2007) describe the challenge of combining both content and context in ways that allow individuals to remain in the embodied experience. An integral part of the course is the emphasis on negotiating or co-constructing the meaning of ecojustice, and by extension citizen science, through participation in a community of practice. Morgan, albeit the professor for this particular course, is only one of many co-educators invited to actively participate in the class sessions. Ecologists, botanists, entomologists, farmers, science education graduate students and many other individuals comprise the course, and encourage the prospective teachers to ask questions and make sense of their encounters with citizen science, in light of their personal and professional interests. The semester is constructed of shared experiences; traveling for a weekend camping trip, taking hikes at the arboretum, and writing in nature journals while sitting on a basaltic rock outcrop, all contribute to the development of a community of practice. But more than any single activity, embodied learning is captured in the narratives and stories woven together in the process of planting garlic, extinguishing fires in the rain and teaching teachers how to design citizen science projects for their own classrooms. True to the tenets of citizen science are the ideas of participation and the existence of multiple knowledge holders, which are represented in the collaborations with co-educators (students included). Roth and Lee (2004) highlight the role of collaborators in their work as well and discuss the idea of embodied learning in science education, acknowledging the legitimacy of stakeholders in the community, and emphasizing the value of living what is studied.

Embodied Learning as an Impetus for Ecojustice Philosophy

Barton (2009) shares her belief that learning is about "deciding who you are, what you want to be, and actively engaging to become part of the relevant community" (p. 415). She also suggests that "knowing" is about connections between the sociocultural, material, and natural world "that give form to being." Learning in this way is a process of becoming something, a transformation that may entail qualities of what you are but also one that allows for the integration of new ideas, as a result of being and wholly taking part in the experience. Written as a feminist epistemology, Barton's (2009) discussion of embodied learning is especially relevant to the course focus around ecojustice philosophy. The positioning of nature-as-both-a-context-and-co-educator as well allows the prospective teachers to develop emotional, intellectual and physical connections to what otherwise may have been taken for granted. Though the prospective teachers are situated within embodied experiences, it is not at the level described by Barton, where the need for action or varying levels of advocacy generate a sense of embodied responsibility. Nevertheless, the experiences included in the course help plant the seeds, which may even sprout, given the likelihood that the prospective teachers can integrate similar practices within their future classrooms, and consider the shared possibilities of getting engaged and involved in the communities where they will eventually teach.

Barton (2009) emphasizes the idea of counter knowledge as that which is held by individuals who are considered marginalized. She argues that this type of awareness truly represents embodied knowledge. Embodied experiences position an individual for becoming a stakeholder and defending a location, people or an idea. While the prospective teachers do not develop this level of advocacy through the course, it can be argued that without first-hand knowledge and experience there is a slim chance for understanding the basic need for action in the first place. One of the significant challenges for those who talk about embodied learning is that it focuses on a social context and entrance into a world that is often counter to any individual's existing knowledge if s/he doesn't reside within the community. Barton (2009) argues for counter knowledge as integral to embodied responsibility through her description of a seemingly ecojustice-based project. The example she provides involves a geologist who uncovers evidence of environmental toxins within a low income community. The knowledge this geologist reveals is presented to the community members who then takes action and become experts and decision-makers, influencing their own lives and local environment in the process. Not all of the description Barton shares rings true to citizen science—specifically, the idea that a scientist is one that 'enables a disempowered community.' In our case, citizen science, as it is experienced in the Methods course and more fully developed by the involvement of teachers, provides opportunities for individuals to learn in a responsibly embodied way, construct knowledge, and develop a set of skills that encourages learning from the "soils" or ground up, while sparking individuals to take action. Roth and Lee's (2004) description of embodied learning as "engagement in" rather than "preparation for" science is consistent with the way in which citizen science is conceptualized in this course. Morgan's belief that teachers should develop their philosophy of teaching in his class encourages ownership for meaning making through practice and opportunities to be involved in learning in an embodied way.

Preparing to Teach Science: Reflections from Rose and Paul

Personal accounts of Rose and Paul are especially helpful in illuminating their philosophy of science education, and in turn their pedagogical understanding of citizen science. These accounts comprise the comments and observations over the semester, perspectives of the value placed in how and what they learn and acceptance for personal integration of a philosophy of education, which is inclusive of more than just societal expectations. As evidenced in earlier discussion, and further emphasized below, Paul and Rose share experiences because they are in the same class but express differing levels of appreciation for citizen science as a way of framing science instruction. The following reflections are based on documented comments by these individuals over the course of the semester.

Rose

Being outdoors was a good way to experience teaching. I understand why the chemistry and physics people in class had difficulties. To them it's just about getting dirty, but they could think of other things to use as examples for their teaching. It is important to get involved in the community, I want to do volunteer work and show the kids the whole citizen science thing so they have a choice to be outside rather than playing video games at home. Being an informal educator, I thought I had to change my teaching so that my class was more like how my own experience looked. I didn't know I could be that way, because…follow the book, that is the way I was taught. I didn't know we could have a choice in that, and I was hoping that is what I could do – but I didn't know it was a possibility. So I am learning that it is a choice in the way you could be a very alternative teacher, as long as you are following the standards.

Paul

There is only so much time to cover the standards in my class, so spending time on citizen science ideas (being outside) can be a useless endeavor. I also have a, most likely thoroughly unrealistic, expectation that students are able to draw connections on their own between general principles and specific cases. That they are able to read a newspaper article on a water pollution case and understand the difference between parts per million and parts per billion and be able to identify the general classification of the chemicals involved (usually heavy metals or organics). In some contexts I don't think the effort required to stretch and pull environmental science in is really going to be worth it. Depending on what you are teaching, a lot of it doesn't fit very well.

In discussing the challenges in outdoor science education, Rose acknowledges her own struggle to work as an "informal" educator in a traditionally "formal" context. Over time, her perception of the differences between informal vis-à-vis formal education may be blurred by her practice of teaching science through an ecojustice philosophy. The evident value Rose places on social awareness (e.g., volunteerism) and protection of the environment may translate into a sincere citizen science pedagogy that will encourage an embodied responsibility within her students one day. On the other hand, Paul expresses the opinion that citizen science is something content specific and not relevant to all areas of science. The evident dichotomy of thoroughly immersing science education within the community (Rose) and the implication that students are required to find their own relevance (Paul) is but one differentiation between these beginning teachers that presents challenges for teacher preparation today. Are these beliefs based on individual experiences? If so, how does a teacher educator move towards preparation that encourages ownership of and appreciation for diverse approaches to teaching in science education? How do we nurture the development of teachers who are instrumental in protecting and preserving local communities?

The Challenges and Possibilities of Citizen Science

Our study of citizen science as a framework for science teacher preparation provides insights for other educators into how courses can be modified to promote greater awareness for social and environmental justice issues. Using ecojustice philosophy holistically, with citizen science methods (e.g., collecting data, designing protocol) as a central organizer for science teacher preparation courses, presents interesting challenges. In the context of this course, one of the greatest challenges is in positioning teaching as a process of preparing students for more than simple education—to help them think of education as a means of sincere preparation for future endeavors. Prospective teachers in this study are encouraged to view their experiences as ways of learning science, but also allowed to think of the larger purpose of why students are taught science (i.e., farming practices, local economy and environment). The prospective teachers are very aware of the foci on content area preparation nationally, initially feeling that their job is to help students meet the state and national standards for science, often at the risk of curtaining out relevant science within the local community. When the focus of the course appears to be on local issues rather than the state standards, many of the prospective teachers express frustration and worry that they are not being adequately prepared. In their minds, following a set of rules such as national standards means "good teaching," and is often the only option they see as useful for their future as educators. Another challenge in this course is encouraging the future educators to consider the value of the outdoors as a learning environment (stepping outside of a normal classroom per se), and the significance of developing a sense of place in relation to the science learning of their future students. The outdoor learning environment includes rain, bugs, extreme heat and cold, and other uncomfortable issues that must be considered when learning to teach in such settings; these extremes prove especially difficult when prospective teachers are asked to contemplate using nature as a classroom. When Morgan and the other co-educators present alternatives to teachers' images of what learning to teach science should be like, tensions emerge. While these tensions create an uncomfortable atmosphere for some, ultimately, as productive movements of change, they lead to dialogue and questions of what really needs to occur in science teacher preparation. Using citizen science as a framework for learning to teach is easily recognizable for many life science teachers, but the physical science teachers have more difficulty seeing how the relevance ties together with what they will be held accountable for in their core subject areas. We can appreciate this apprehension and as already mentioned, more time for reflection may have alleviated these pressures.

Despite the challenges, there are possibilities to consider. Beginning science teachers in this course express value for gaining exposure to ideas which do not seem to align with their previous instruction; they appreciate learning about different pedagogical approaches. Many indicate that the course experiences help them to develop a greater appreciation for culture and awareness for the diversity which will likely transition into their future classrooms and outdoor experiences. They describe a growing recognition of how citizen science can provide these connections needed to celebrate multiple forms of knowledge. While they express concern about the value that all science teachers might find with citizen science as pedagogy, the emphasis on a developing community helps many to seek ways of at least conceptualizing their educational philosophy. This conceptualization involves incorporating ecojustice philosophy within their existing belief structures, potentially blurring the disciplinary lines. Consequently, citizen science is experienced as a pedagogy that has the potential, like other pedagogies, to blur the boundaries between and reduce the isolation inherent in teaching a single science subject. Moreover, the use of nature as a 'teacher,' presents these prospective teachers with opportunities to experience natural history, science, math, and language in interdisciplinary ways through authentic situations. The use of citizen science pedagogy as a framework for teaching involves an immediately accessible community (which takes time for the science teacher educator to develop—one huge drawback), but ideally with time, provides the prospective teachers with the kinds of tools they will need as they move to different geographic locations and seek to identify the resources their communities have to offer. This study highlights the possibilities of making ecojustice philosophy, embodied learning experiences, and we would add practitioner reflection central to the preparation of teachers who are equipped to meet the demands which tomorrow holds.

Notes

1. All participants of this semester-long research study sign consent forms and are assigned a pseudonym. A table of participants is provided at the end of this chapter.
2. "Methods" is used throughout in reference to the course, which serves as the research setting, aptly entitled Methods of Science Teaching. It does not refer to a belief of what the class should be, nor what the professor intends. However, the title enhances the prospective teachers assumptions of what the course 'should' entail.
3. Ecojustice philosophy recognizes the interconnectedness of the living and nonliving, and encourages action, which emphasizes and celebrates this diversity by challenging currently held assumptions and allowing us to consider the alternatives to those beliefs.

References

Aikenhead, G. S. (2006). *Science education for everyday life: Evidence-based practice*. New York: Teachers College Press.

Barab, S., Zuiker, S., Warren, S., Hickey, D., Ingram-Goble, A., Kwon, E., & Herring, S. C. (2007). Situationally embodied curriculum: Relating formalisms and contexts. *Science Education, 91*, 750–782.

Barton, A. C. (2009). Feminisms and a world not yet. In W. Roth & K. Tobin (Eds.), *Handbook of research in North America* (pp. 409–425). Rotterdam: Sense Publishers.

Bowers, C. A. (2001). *Educating for ecojustice and community*. Athens: University of Georgia Press.

Bowers, C. A. (2002). Toward an eco-justice pedagogy. *Environmental Education Research, 8*, 21–34.

Britton, S. A. (2011). *Citizen science as a framework for secondary science teacher preparation: A hermeneutic ethnography*. Unpublished dissertation for University of Georgia, Athens, GA.

Elmesky, R. (2006). Poverty and science education. In *Teaching and learning science: A handbook* (pp. 193–199). Westport: Praeger.

Maulucci, M. R. (2008). Intersections between immigration, language, identity, and emotions: A science teacher candidate's journey. *Cultural Studies of Science Education, 3*, 17–42.

Mueller, M. (2008). Ecojustice as ecological literacy is much more than being "Green!". *Educational Studies, 44*, 155–166.

Mueller, M. P., & Bentley, M. L. (2007). Beyond the "decorated landscapes" of educational reform: Toward landscapes of pluralism in science education. *Science Education, 91*, 321–338.

Northfield, J. (1998). Teacher educators and the practice of science teachers. In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education* (pp. 695–706). Dordrecht: Kluwer.

Roth, W., & Lee, S. (2004). Science education as/for participation in the community. *Science Education, 88*, 263–291.

Sachs, A. (1995). *Eco-justice: Linking human rights and the environment* (J. A. Peterson, Ed.). Washington, DC: Worldwatch Institute.

Stelter, R. (2004). Embodiment and learning. AGORA no. 6 (E-Journal, CVU Storkøbenhavn). Retrieved January 18, 2013, from www.cvustork.dk/agoranr63.asp

Tippins, D. J., Mueller, M. P., van Eijck, M., & Adams, J. D. (Eds.). (2010). *Cultural studies and environmentalism: The confluence of ecojustice, place-based (science) education, and indigenous knowledge systems*. New York: Springer.

Tobin, K. G. (2006). *Teaching and learning science: A handbook*. Westport: Praeger Publishers.

Stacey A. Britton is a science teacher educator at the University of Mississippi. Experience as a high school science teacher in rural Mississippi and bush Alaska instilled in her a deep appreciation for cultural diversity and the value of local knowledge. She uses qualitative research to merge these passions with science education.

Deborah J. Tippins is a professor in the Department of Mathematics and Science Education at the University of Georgia where she specializes in science for young children. She draws on sociocultural and anthropological methods to study questions of relevance and justice in relation to science teaching and learning.

Chapter 14
Carrizo Springs, Texas—The Story of the Systems Academy of Young Scientists (SAYS)

P. Elizabeth Pate, Andrea Guerrero, and Debby F. Dobie

This chapter presents a story plot of how citizen science and youth activism are embedded in a summer (2011) enrichment program in a small Texas town. A story plot includes exposition, rising action, climax, falling action, and resolution (Sebranek et al. 1999). The exposition is the beginning part of a story in which the setting, characters, and conflict are introduced. In the rising action, the characters try to address the problem. The climax, or turning point of the story, is the point where the characters come face-to-face with the problem. During falling action, story characters learn to deal with life "after the climax." And, finally, the resolution brings the story to a natural, thought-provoking, or surprising conclusion. This story plot is told through reflection, photo documentation, and project artifacts (Fig. 14.1).

P. Elizabeth Pate (✉)
Department of Interdisciplinary Learning and Teaching, College of Education and Human Development, The University of Texas at San Antonio, 2.210D Main Building, San Antonio, TX 78249, USA
e-mail: Elizabeth.pate@utsa.edu

A. Guerrero
Rivera/Zavala Elementary School, 901 Javelina Dr, Crystal City, TX 78839, USA
e-mail: Andi.guerrero@crystalcityisd.org

D.F. Dobie
PO Box 323, Carrizo Springs, TX 78834, USA
e-mail: drdebbydobie@gmail.com

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_14

Fig. 14.1 Middle of nowhere

Exposition—*Setting*

Take a trip to a seemingly "middle of nowhere" town where the summertime air is hot, dry, and dusty; the days last a lifetime; and the nighttime sky goes on forever. Take a trip to Carrizo Springs, Texas. Carrizo Springs, the county seat of Dimmit County, is situated in the brush country about 120 miles southwest of San Antonio, 50 miles east of Eagle Pass, Texas and Piedras Negras, Mexico, and 120 miles northwest of Laredo, Texas and Nuevo Laredo, Mexico.

The name of the town comes from the local springs, which were named by the Spanish for the cane grass that once grew around them. The town was founded in 1865 by a group of settlers. Until 1900 the local economy relied primarily on sheep and cattle ranching, but when artesian water was discovered to be a cheap source of irrigation, new settlers arrived and land prices rose. In 1910 the San Antonio, Uvalde and Gulf Railroad opened a spur into Carrizo Springs and by 1915 the community had grown to 1,200 residents. By 1916 Carrizo Springs had electricity. Carrizo Springs rebounded from drought and depression in the early 20s and by 1928 had a population of 2,500. In 1988 the town reported 7,553 residents and 109 businesses. In 1990 the population was 5,745, in 2000 it was 5,655, and in 2008 it was 5,325. According to the 2011 United States Census Bureau, the population was 5,433. The racial makeup of the city is predominately Hispanic or Latino (over 80 %) (Fig. 14.2).

The Systems Academy of Young Scientists (SAYS) takes place in Carrizo Springs. SAYS is an offshoot of the Texas Prefreshman Engineering Program (TexPREP).

Fig. 14.2 Landscape of Dimmit County

TexPREP, a component of PREP-USA (a national program with an emphasis on increasing the number of women and underrepresented minorities in these fields), provides a challenging academic summer program designed to motivate and prepare middle and high school students for success in advanced studies leading to careers in science, technology, engineering or mathematics (STEM) fields (Texas Prefreshmen Engineering Program, 10-31-2011TexPREP Mission Statement).

SAYS was conceptualized by Dr. Raul (Rudy) A. Reyna, executive director of the Pre-freshman Engineering Program (PREP) at the University of Texas at San Antonio, as an avenue to get younger students engaged in science, technology, engineering, and mathematics and to grow the pipeline of students who participate in TexPREP. During the Fall of 2008, Dr. Reyna was approached by Dr. Ricky Alaniz, then President of the Carrizo Springs School Board, to dialogue on what types of programs might be available for their students to expose them to STEM. TexPREP was discussed and the school district made a commitment to send middle school students to the Laredo TexPREP at Texas A&M International University during the summers that followed. In a subsequent meeting that fall, Dr. Alaniz, Dr. Dobie, and Dr. Reyna with then Superintendent Dr. Cecilia Moreno, presented a design concept for a systems academy and SAYS was born. In the summer of 2009, SAYS was conducted at the Carrizo Springs middle school and the rest is history.

SAYS is a summer enrichment program designed to provide intermediate level young adolescents with STEM knowledge information focusing on problem solving skills utilizing systems thinking and dynamic modeling tools. The original broader goals of SAYS include: (1) improved STEM content and pedagogical knowledge of teachers, (2) significant STEM partnering of a broad range of community members, (3) insight into the realities of teaching public school in the era of increased accountability and the perceived diminishment of the teaching profession, (4) greater awareness by educators, students, and the general population of STEM needs and opportunities, (5) greater understanding by STEM professionals of the needs of STEM educators and their students, and (6) in-depth insight into how to effectively address the needs of traditionally underrepresented populations and engage them in STEM. Citizen science and youth activism are also important goals of SAYS.

Much of the SAYS curriculum focuses on the context of Dimmit County. During the summer of 2009, SAYS curriculum focused on mathematics, watersheds, and systems—using the STELLA computer program. Summer 2010 SAYS focused on robotics, physics, and systems. Summer 2011 focused on systems thinking, robotics, and petroleum engineering. And, summer 2012 focused on systems thinking, robotics, and hydro-engineering.

Cast of Characters

Main Characters: Students and Teachers

During the summer 2011 program, the 75 SAYS students had just completed grades 4 and 5 and are considered to be "rising 5th and 6th graders." Short, tall, loud, shy, mischievous, and always entertaining—these are the main characters in the SAYS story plot. They are generally respectful to each other and to their teachers. They are curious about outsiders and are loyal to their siblings. Their smiles are genuine and contagious. They have a sense of place but talked frequently about the "outside" world—shopping trips to San Antonio or Laredo, college in Austin. Their names included Adrianna, Pedro, Emmett, Faith, and Benito. There are three students with the surname of Rodriguez and five with Gonzalez. There is only one McDaniel. Many of them are returning for their second summer in the program. Just like other kids around the world, they are eager to learn and share their learning. They want to make a difference in their community and the world.

The six SAYS teachers and one coordinator are also short, tall, loud, shy, mischievous, and entertaining. Their smiles, too, are genuine and contagious. They talk frequently about the world away from Carrizo Springs—shopping trips to San Antonio or Laredo, family visits in Dallas. They also talk frequently about their community—Carrizo Springs. Their names are Sally, Maria, Roehl, Carmen, Luis, Roxie and Andi. They have been involved with SAYS for 4 years. They are living and teaching in Carrizo Springs because it is where their families reside and because it offers a small town atmosphere. They, too, are eager to learn and share their learning. They want to make a difference in the lives of their students, their community, and the world.

Supporting Characters: Parents and Families, Administration, Others

SAYS parents and families are proud, generous, and responsive. They beam when they see a photo of their child during a presentation. Their eyes shift from side-to-side to see if other parents see what their child just accomplished with a robot or a computer program. Their smiles, too, are genuine and contagious.

Dr. Dobie is a retired "second-time-around" superintendent. She is the consummate advocate for SAYS. Sonia Z., SAYS director during summer 2009, is now responsible for Carrizo Springs Consolidated Independent School District (CSCISD) federal programs and for making the closing ceremony celebration cake. Dr. Reyna, PREP executive director, is a soft-spoken man who has the ability to get you to say YES without even asking you a question. Ben J. is a retired systems engineer who is adept at helping others better understand systems thinking. Dr. Elizabeth Pate, a university professor, is passionate about helping students gain confidence about their ability to make a difference in the world right now, rather than waiting until they are grown-up. She believes youth are citizens of today, not just in the future.

SAYS guest speakers include locals who share their knowledge about such things as the Nueces watershed, flora, fauna, water treatment/waste water, and drought impact, and, company representatives who share their knowledge about such things as "fracking" and the use of robots in the petroleum industry.

Story Conflict

Carrizo Springs is no longer a sleepy crossroads. It is now a boomtown of the largest magnitude. Oil companies from around the world have descended like locusts on a field of grain to draw gas and oil from the Eagle Ford Shale formation, which sweeps from the Mexican border across the state to East Texas. The Eagle Ford Shale formation is 400 miles long and about 60 miles wide, and stretches from the Texas-Mexico border to parts of East Texas. According to the Railroad Commission of Texas, an estimated 4,293 drilling permits have been issued in the Eagle Ford Shale in the recent year.

Carrizo Springs is still in the "middle of nowhere" and the summertime air is still hot, dry, and dusty. But, instead of driving on clear roads (well, sometimes you see snake roadkill) with fence gates leading to large hunting ranches, now you drive on rutted roads (with dead tires) with fence gates and people living in RVs who check you in and out of oil fields. Tankers, supply trucks, water trucks, and pick-up trucks are a dime a dozen. Lines of people are waiting to get a table for a quick lunch at the local restaurant or a hastily constructed outside eatery. RV parks and man camps are appearing overnight around every turn and behind every mesquite tree.

The Eagle Ford Consortium is formed to manage explosive growth in the region and to maximize economic opportunities. Leodoro Martinez, chairman of the Consortium who is urging towns in the Eagle Ford Shale to also plan for the long term, says,

> *If you know the history of the old oil and gas industry, it's the old boom and bust. My main concern is for our communities to end up looking a lot better than they were than when the first truck drove in* (WFAA.com Business News).

The oil industry is changing both the landscape and the residents of Dimmit County.

Rising Action

On May 27, 2011, on page A1 of the Business—Energy & Environment section of the *New York Times,* there is an article with the headline: Shale Boom in Texas Could Increase U.S. Oil Output. The article is about Dimmit County and Carrizo Springs.

The New York Times

Shale Boom in Texas Could Increase U.S. Oil Output
By CLIFFORD KRAUSS
Published: May 27, 2011

CATARINA, Tex.—Until last year, the 17-mile stretch of road between this forsaken South Texas village and the county seat of Carrizo Springs was a patchwork of derelict gasoline stations and rusting warehouses.

Now the region is in the hottest new oil play in the country, with giant oil terminals and sprawling RV parks replacing fields of mesquite. More than a dozen companies plan to drill up to 3,000 wells around here in the next 12 months.

The Texas field, known as the Eagle Ford, is just one of about 20 new onshore oil fields that advocates say could collectively increase the nation's oil output by 25 % within a decade—without the dangers of drilling in the deep waters of the Gulf of Mexico or the delicate coastal areas off Alaska.

There is only one catch: the oil from the Eagle Ford and similar fields of tightly packed rock can be extracted only by using hydraulic fracturing, a method that uses a high-pressure mix of water, sand and hazardous chemicals to blast through the rocks to release the oil inside.

(continued)

The technique, also called fracking, has been widely used in the last decade to unlock vast new fields of natural gas, but drillers only recently figured out how to release large quantities of oil, which flows less easily through rock than gas. As evidence mounts that fracking poses risks to water supplies, the federal government and regulators in various states are considering tighter regulations on it.

The oil industry says any environmental concerns are far outweighed by the economic benefits of pumping previously inaccessible oil from fields that could collectively hold two or three times as much oil as Prudhoe Bay, the Alaskan field that was the last great onshore discovery. The companies estimate that the boom will create more than two million new jobs, directly or indirectly, and bring tens of billions of dollars to the states where the fields are located, which include traditional oil sites like Texas and Oklahoma, industrial stalwarts like Ohio and Michigan and even farm states like Kansas.

"It's the one thing we have seen in our adult lives that could take us away from imported oil," said Aubrey McClendon, chief executive of Chesapeake Energy, one of the most aggressive drillers. "What if we have found three of the world's biggest oil fields in the last three years right here in the U.S.? How transformative could that be for the U.S. economy?"

The oil rush is already transforming this impoverished area of Texas near the Mexican border, doubling real estate values in the last year and filling restaurants and hotels.

"That's oil money," said Bert Bell, a truck company manager, pointing to the new pickup truck he bought for his wife after making $525,000 leasing mineral rights around his family's mobile home. "Oil money just makes life easier."

Based on the industry's plans, shale and other "tight rock" fields that now produce about half a million barrels of oil a day will produce up to three million barrels daily by 2020, according to IHS CERA, an energy research firm. Oil companies are investing an estimated $25 billion this year to drill 5,000 new oil wells in tight rock fields, according to Raoul LeBlanc, a senior director at PFC Energy, a consulting firm.

"This is very big and it's coming on very fast," said Daniel Yergin, the chairman of IHS CERA. "This is like adding another Venezuela or Kuwait by 2020, except these tight oil fields are in the United States."

In the most developed shale field, the Bakken field in North Dakota, production has leaped to 400,000 barrels a day today from a trickle 4 years ago. Experts say it could produce as much as a million barrels a day by the end of the decade.

The Eagle Ford, where the first well was drilled only 3 years ago, is already producing more than 100,000 barrels a day and could reach 420,000 by 2015, almost as much as Ecuador, according to Bentek Energy, a consultancy.

(continued)

The shale oil boom comes as production from Prudhoe Bay is declining and drilling in the Gulf of Mexico is being more closely scrutinized after last year's Deepwater Horizon disaster.

What makes the new fields more remarkable is that they were thought to be virtually valueless only 5 years ago. "Everyone said the oil molecules are too large to flow in commercial quantities through these low-quality rocks," said Mark G. Papa, chief executive of EOG Resources.

EOG began quietly buying the rights to thousands of acres in the Bakken and Eagle Ford after an EOG engineer concluded that the techniques used to extract natural gas from shale—fracking, combined with drilling horizontally through layers of rocks—could be used for oil. Chesapeake and a few other independents quickly followed. Now the biggest multinational oil companies, as well as Chinese and Norwegian firms, are investing billions of dollars in the fields.

The new drilling makes economic sense as long as oil prices remain above $60 a barrel, according to oil companies. At current oil prices of about $100 a barrel, shale wells can typically turn a profit within 8 months—three times faster than many traditional wells.

But water remains a key issue. In addition to possible contamination of surface and underground water from fracking fluids, the sheer volume of water required poses challenges, especially in South Texas, which faces a severe drought and rapidly diminishing water levels in the local aquifer.

At the rate wells are being drilled, "there's definitely going to be a problem," said Bay Laxson, a local water official.

Dave Thompson, regional production superintendent for the oil company SM Energy said the industry knew that water issues were "an Achilles heel." He said his company was building a system to reuse water in the field.

But unlike Pennsylvania and New York, where fracking for natural gas has produced organized opposition, the oil industry has been mostly welcomed in western and southern states.

Thanks to the drilling boom, the recession bypassed North Dakota entirely. Here in Dimmit County, Tex., the unemployment rate has fallen in half, and sales tax receipts are up 70 % so far this year, allowing the county to hire more police officers and buy sanitation and road repair equipment.

"In my lifetime, this is the biggest thing I've ever seen," said Jose Gonzalez, 78, a retired teacher and son of migrant farm workers, who leased mineral rights to Chesapeake for $27,000 and sold another plot for $100,000 to a company building an RV park for oil workers. "You can see I'm happy."

A version of this article appeared in print on May 28, 2011, on page A1 of the New York edition with the headline: Oil Hidden in Shale Sets Off a Boom in Texas.

This is our problem—the effects of an oil boom on a small Texas town. The New York Times article becomes the starting point for curriculum planning for SAYS 2011. We read, discuss, and research everything we can about the Eagle Ford Shale formation. We collectively decide to focus on systems thinking, robotics, and petroleum engineering. Systems thinking focuses on the study of how one component interacts with another component of the system—a set of elements that interact to produce behavior—of which it is a part. Instead of isolating smaller and smaller parts of the system being studied, systems thinking works by expanding its view to take into account larger and larger numbers of interactions as an issue is being studied (Aronson 1998). Systems thinking has its foundation in the field of system dynamics, founded in 1956 by MIT professor Jay Forrester and written about in *Industrial Dynamics* (1961).

We feel SAYS students must learn about the pros and cons of the oil industry (a system) so they can become informed decision makers—what we feel to be a critical aspect of citizen science and youth activism.

SAYS 2011 is a 5-week (4 days a week) program housed in one wing of an elementary school. Bus transportation, breakfast, and lunch are provided to students by the school district. The day begins at 7:30 am and ends at 12:30 pm. Each class is 1 h and 20 min. We have six teachers who form three teams—one team of two who teach systems thinking, one team of two who teach robotics, and one team of two who teach petroleum engineering. All teachers have knowledge of each area.

In order to integrate theory, content, and pedagogy, we use the design-down, teach-up lesson plan design based on the work of Grant Wiggins and Jay McTighe (2005) (*Understanding by Design*). Using this approach, for each course (Systems Thinking, Robotics, Petroleum Engineering), we design lesson plans incorporating a daily focus question (e.g., How is Robotics related to Systems Thinking and Petroleum Engineering?), identified prior and anticipated skills and knowledge, created assessments, and determined strategies, activities and resources. When each class is taught, resources are collected, students are engaged in developmentally appropriate activities, knowledge is assessed, and focus questions are answered.

Climax: Coming Face-to-Face with the Oil Boom

In Systems Thinking, students learn about systems thinking and system dynamics, brainstorm systems, play the systems games, make models, learn new vocabulary, and make forecast predictions about the oil boom using Stella computer software (Figs. 14.3, 14.4, 14.5, 14.6, and 14.7).

In Robotics, students learn about building and programming robots, investigate the use of robots in the petroleum industry, and engage in competitions using NXT Lego Mindstorm robots in oil field simulations (Figs. 14.8 and 14.9).

Fig. 14.3 Systems thinking—brainstorming systems

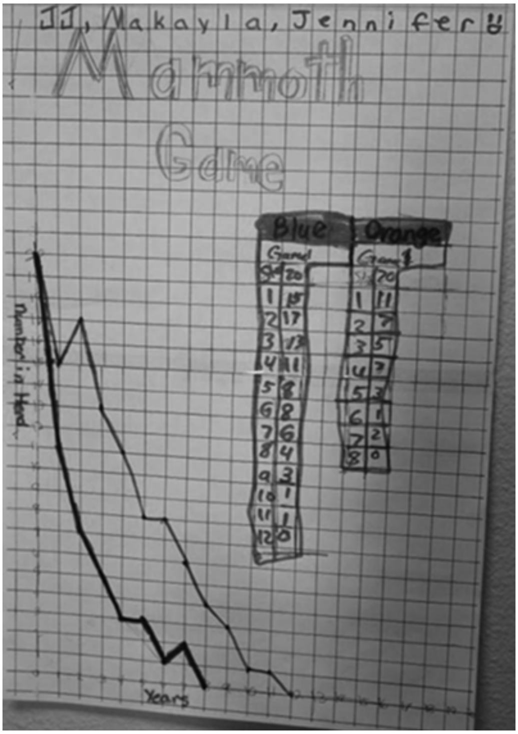


Fig. 14.4 Systems thinking—mammoth game graph

Fig. 14.5 Systems thinking—playing the friends game

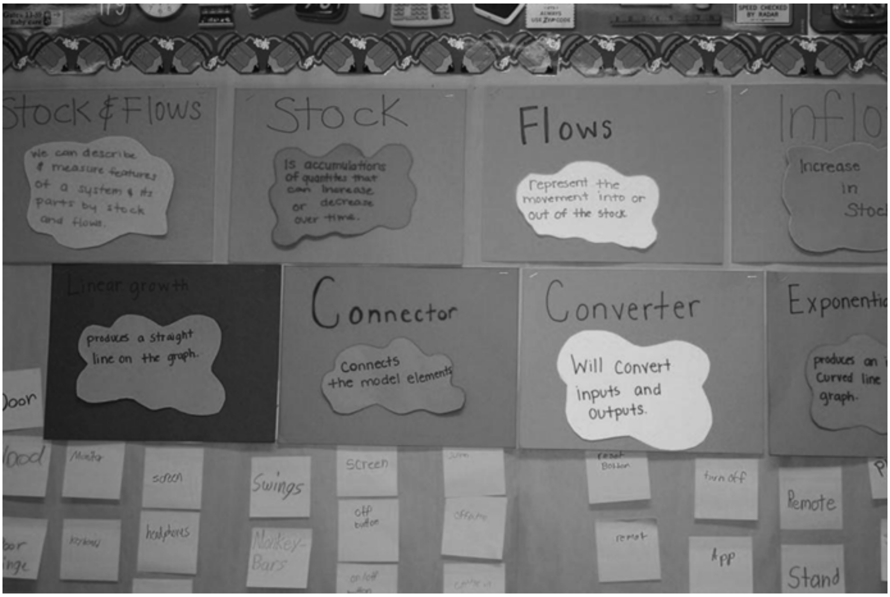


Fig. 14.6 Systems thinking—vocabulary

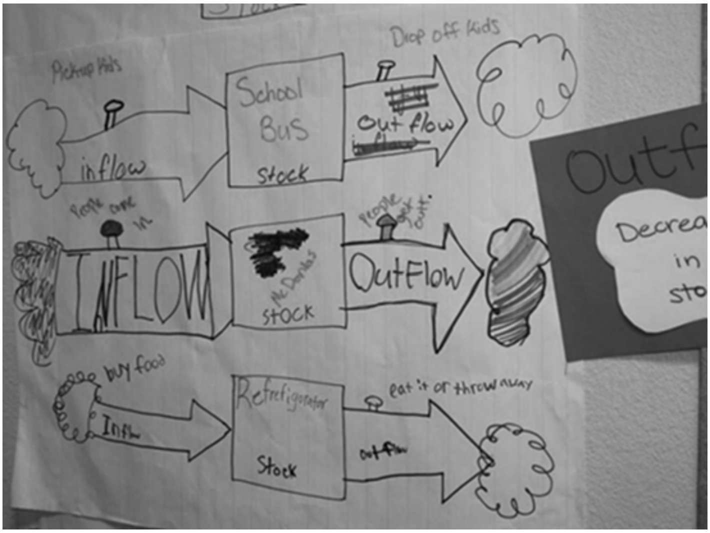


Fig. 14.7 Systems thinking—stocks and flows

Fig. 14.8 Robotics—building a robot

In Petroleum Engineering, students learn about fossil fuels, natural gas, oil traps, core sampling, "fracking", petroleum products, job opportunities, and petroleum engineering as a system (Figs. 14.10, 14.11, 14.12, and 14.13).

In order to meet the oil boom face-to-face, students go on a ride-about around Dimmit County. A ride-about is an observation strategy and may serve a variety

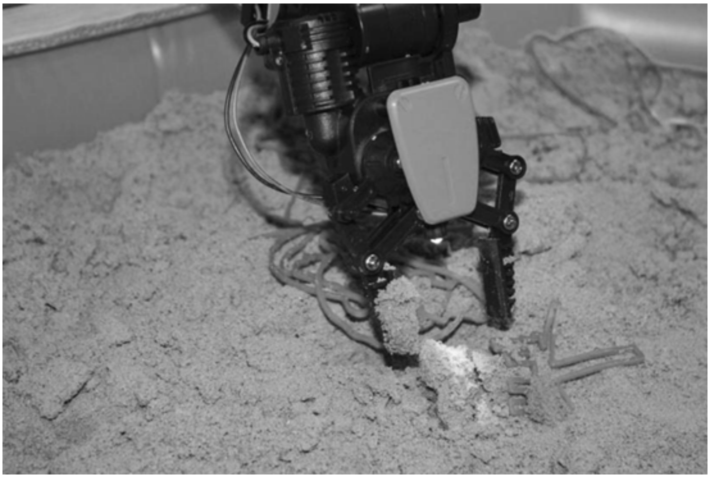


Fig. 14.9 Robotics—robots in the oil field

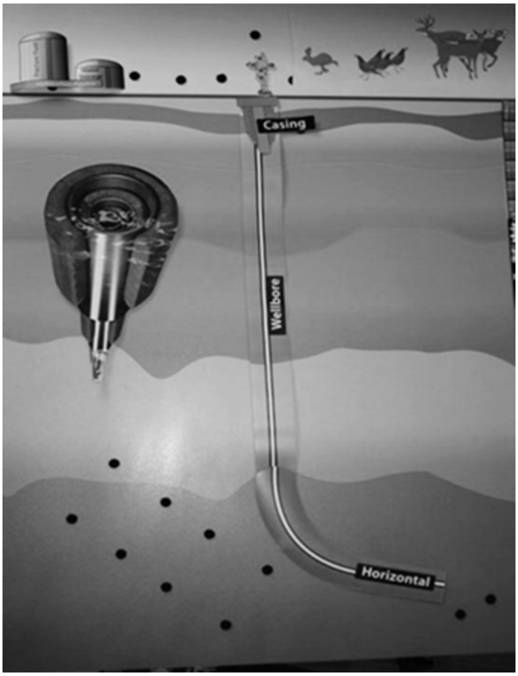


Fig. 14.10 Petroleum engineering—"fracking"

Fig. 14.11 Petroleum engineering—cake core sampling

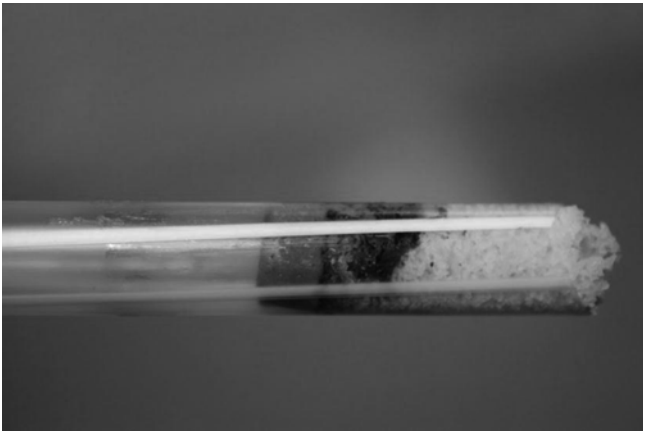


Fig. 14.12 Petroleum engineering—cake core sample

of purposes. It may be used to collect initial data regarding the needs, issues, or problems related to a particular community, or it may be used to focus in on the various factors affecting a previously identified need or issue. SAYS students use the ride-about to collect evidence on the effects of the oil boom. An inventory list is

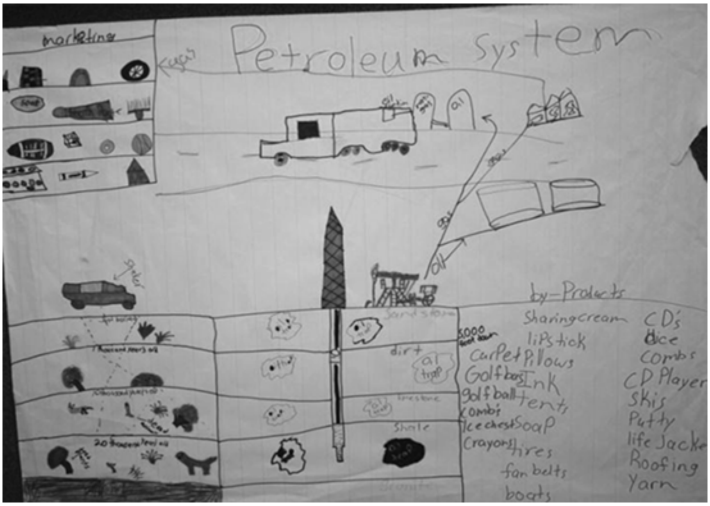


Fig. 14.13 Petroleum engineering as a system

given to each student on which to make tallies. No information on the ecosystems, in terms of plant and animal species was collected (Figs. 14.14, 14.15, and 14.16).

Inventory list		
	2008	2011
# of business establishments	205	
# of drilling sites		
# of RV/Trailer Parks	3	
# of population	5,325	
Average # of work trucks passing/minute	3	
Average # of tractor trailers passing/minute	5	
Names of new business establishments:		
Total number:		

Falling Action

How do SAYS students deal with what they learn during the summer program? They take what they learn and try to make sense of it. They create population projection charts. They create feedback charts. They brainstorm the pros and cons

Fig. 14.14 Ride-about—taking inventory

Fig. 14.15 Ride-about—RV/Trailer Parks

of the oil industry. And, they plan the culminating ceremony for SAYS 2011—the parent and community presentation (Figs. 14.17 and 14.18).

On Thursday, June 30, 2011, SAYS students hold a presentation for parents and community members. Following a welcome and introduction of special guests, a video show highlighting candid shots of students at work in learning is shared. The audience claps, cheers, and beams with pride. This video show serves as an advanced organizer to the next activity—a scavenger hunt. Using a learning center model (independent studies in which students go to classroom areas—called stations—where they do structured or unstructured work on a given topic or subject), participants traveled to four stations. In the systems station, students give

Fig. 14.16 Ride-about—tractor trailer

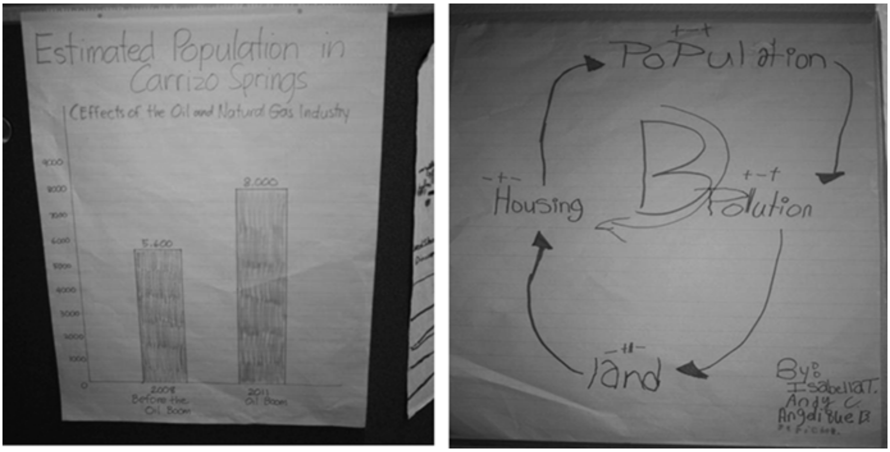


Fig. 14.17 Population projection

a short PowerPoint presentation about systems and systems thinking. This is what they share:

> *Systems thinking is the ability to think and look at something as a whole, to view all the individual aspects and their functions in a system. A systems thinker would not only consider the oil and natural gas industry as a system, but he/she would also consider the larger system.*

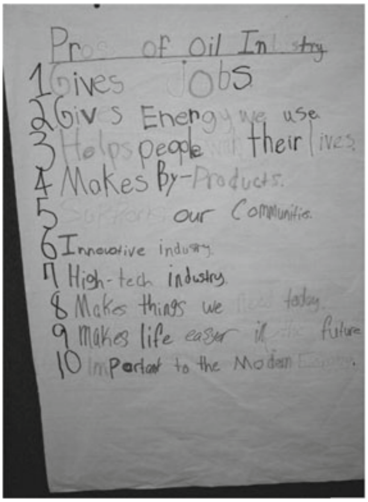
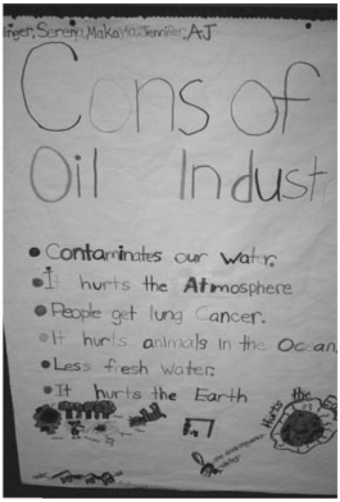
Pros of Oil Industry	Cons of Oil Industry
	
• Oil is cleaner than coal • Oil is an extremely powerful energy source when it is burned • No other fuel can move a car at such a speed • It is really combustable • The world's economy would not function without oil • Oil makes everything efficient • Oil can run day and night, providing a constant source of power • Economic benefits • They use sound waves to deflect the clan water so they don't disturb it • More jobs are provided in small towns • It helps makes by-products like shampoo to keep you clean, shoes to protect your feet, aspirin to take away pain, ink used in pens, markers, shirts, and gasoline to fuel carts, trucks, and, much, much more • Enhances the quality of life • Important to the modern economy • High tech industry • Vital to our energy future • Innovative industry supports our communities • Stewards of the enviornment • Provides millions of jobs • Helps people with their lives makes life easier in the future	• Oil is non-renewable which means it will eventually run out • Burning oil pollutes the environment by releasing CO^2 and other toxics into the atmosphere • Extracting oil from sand takes a lot of water • Drilling for oil is unpredictable—it takes a lot of time to search for oil • Oil leaks may occur which result in killing plants and animals • It is expensive and dangerous to transport oil • Oil fracking contaminates the water • Price of gasoline will go up because of the little oil we get from offshore drilling • The oil is found in limited areas • There is a possible outcome of oil spills due to oil worker's method of fracking • Since oil is non-renewable we might run out of supply before our next generation can make new resources • Air pollution is dangerous and bad for our health • If there are any more oil spills I fresh water we will eventually run out of our 1% fresh water on Earth • Companies might lose a lot of money because their employees quit to move to oil well companies because they give better wages than other jobs.

Fig. 14.18 Feedback loop

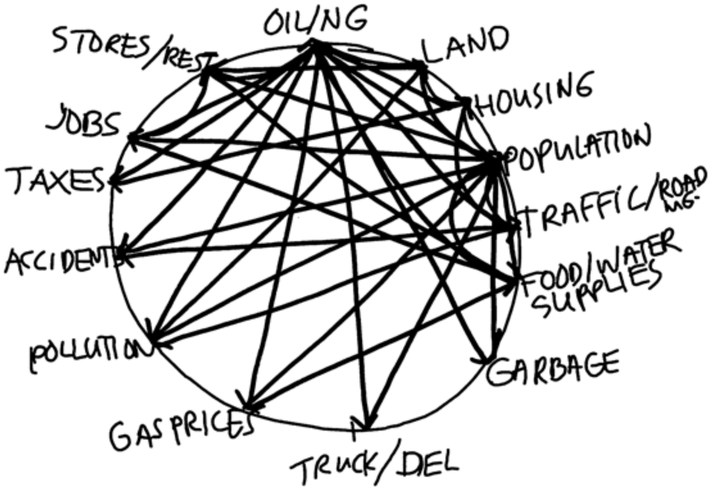


Fig. 14.19 Systems modeling

We played Systems Games to better understand systems and develop systems thinking. We also played the Friends Game, the Mammoth Game, It's Cool, the Infection Game and Connections Circles to understand how systems work and how they behave over a period of time. Systems dynamics is a method for studying and managing complex feedback systems. It is used to address every type of feedback system. It is also used to understand how things respond to changes.

Systems modeling shows how the system should be working. By drawing links between each system activity, it makes it easier to understand the relationships among various activities and the impact of each on the others. Systems modeling is important when an overall picture is needed (Fig. 14.19).

The STELLA computer program offers a practical way to dynamically see and communicate how complex systems and ideas really work. STELLA demonstrates a picture of change based on the variables.

Why did we do computer modeling using STELLA? Drawing a sketch of a system is actually very important since it forces you to think about the relationships. But that sketch is not capable of revealing the dynamics of the system. That is why we turn to a computer.

With a computer model of a system, we can learn the unexpected behaviors of this system by experimenting with it, by changing the starting conditions around and observing the effects. Using the STELLA program, it is quite easy to experiment, to ask "what if we change this?" and quickly see the results.

What was one of our assignments? We had to build a STELLA model to analyze how much oil is left in our reserve and how long it will last based on R/P calculation assumptions. We had to create graphs to represent the behavior of the Oil Reserves stock and how long it will last based on different percent's of the amount of oil recovered. Based on our model, we predict our oil will last for 39 years! (As opposed to the 100 years predicted by the oil companies).

In systems modeling, we also learned about the concepts of stocks and flows and the idea that behaviors can be graphed over time. Models are important for helping to convert abstract things into concrete things. A learner's ability to 'see' a system—what goes into a stock, where feedbacks exist—and then to run a model and see how the system works under different conditions, changes abstractions into real meaningful, concrete terms.

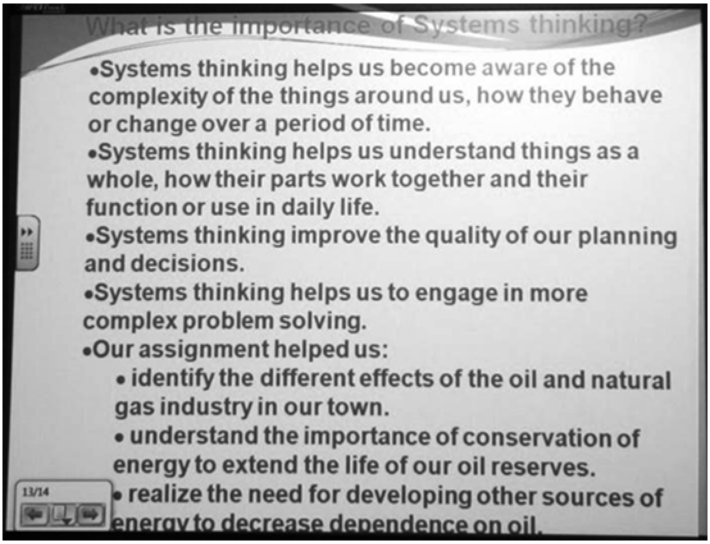


Fig. 14.20 Importance of systems thinking

Students conclude their systems presentation with a slide sharing their understanding of the importance of Systems Thinking (Fig. 14.20).

In the robotics station, students share how to build an NXT 2.0 robot. In the computer station, students demonstrate how to program an NXT robot and how they use STELLA to make forecasts using data they collected on the ride-about.

Parents and community members move from station to station hearing and watching student presentations and finding answers to the scavenger hunt questions. Many participants ask the students focused questions about the impact of the oil boom on their community—*I know they are drilling on land close to my home. Is that why my water smells bad now?* Following the scavenger hunt, everyone reassembles back in the library for graduation, award certificates, and closing remarks.

All parents and community members are in awe of the knowledge and confidence levels of the students. One parent says, "*The program was challenging for our son. To hear and see him wake up excited and eager to learn something new was great*." Another parent says, *"Our children are this community's future. What better way to ensure its safety and progress than to start with our children's early education towards making future contributing adults?"* Yet another parent says, *"You know, during the school year, my son fights getting up in the morning and does not want to go to school. With SAYS, he cannot wait to get to school, he's excited about what they are learning and doing in the classroom, he does not want to leave at the end of each session, and he does not want it to end!"*

Resolution

The resolution in a plot brings the story to a natural, surprising, or thought-provoking conclusion. The conclusion to SAYS 2011 is natural—it ends and summer begins for students and teachers. But, SAYS carries over into the next academic year. SAYS students pursue better grades so they can attend SAYS 2012 (and so do their siblings and friends). Reading, math, and science scores increase for SAYS students. The number of SAYS students with commended performance (performed at a level considerably above the state passing standard and have shown a thorough understanding of the knowledge and skills at the grade level tested) in science and math increases. According to the teachers, SAYS students become informed decision makers and make important contributions to the class discussions in all content areas. According to the parents, their children are more invested in their schooling and their community.

SAYS 2011 is surprising. Students work actively with problems, ideas, materials, and people as they learn skills and content; become active citizens while making contributions to society; increase their ownership of learning, have increased interactions with peers and community members; value their learning; demonstrate their learning in public settings and received public feedback; exhibit gains in self-confidence, self-esteem, and self-worth; gain career skills and career exploration knowledge; and feel that they can "make a difference" and make positive contributions to the community. While this is not necessarily surprising to the teachers, it is to the students, parents, and community members.

SAYS 2011 is thought-provoking. According to Martusewicz et al. (2010), "…ecojustice insists on reconnecting students and teachers to their own local communities…." (p. 19). SAYS 2011 reconnects students and teachers to their community through an examination of the effects of the oil boom. It becomes an opportunity for citizen science. Citizen science encompasses at least three major spheres of influence, all which play an appropriate and significant part in doing community and environmental monitoring, including cultural systems (ethical, economic, political), environmental systems (species and habitats), and virtual (heuristics, virtual based projects, ecological projections, and futurism) (Mueller et al. 2012). Cultural, environmental, and virtual systems are sources of influence as SAYS 2011 students engaged in community and environmental monitoring.

What we don't know about the ending of this story is what will happen to Carrizo Springs and Dimmit County. What we do know about the ending of this story is that there are numerous informed decision-makers—SAYS 2011 students—all of whom are citizen scientists. We cannot underestimate what they can and want to learn and do. We cannot underestimate what contributions they will make to their community. They are our future (Fig. 14.21).

Fig. 14.21 Our future

References

Aronson, D, (1998). *Overview of systems thinking*. Retrieved January 8, 2013, from http://www.thinking.net

Forrester, J. W. (1961). *Industrial dynamics*. New York: MIT Press/Wiley.

Krauss, C. (2011, May 27). Shale Boom in Texas could increase U.S. oil output. *The New York Times*. Retrieved January 8, 2013, from http://www.nytimes.com

Martusewicz, R. A., Lupinacci, J., & Schnakenberg, G. (2010). Ecojustice education for science educators. In D. Tippins, M. Mueller, M. van Eijck, & J. Adams (Eds.), *Cultural studies and environmentalism: The confluence of ecojustice, place-based (science) education, and indigenous knowledge systems* (pp. 11–27). Dordrecht: Springer.

Mueller, M. P., Tippins, D. J., & Bryan, L. A. (2012). The future of citizen science. *Democracy & Education, 20*, 1–12.

Sebranek, P., Kemper, D., & Meyer, V. (1999). *Write source 2000: A guide to writing, thinking, and learning*. Wilmington, DC: Houghton Mifflin.

Wiggins, G., & McTighe, J. (2005). *Understanding by design*. Alexandria: Association for Supervision and Curriculum Development.

P. Elizabeth Pate is a Professor in the Department of Interdisciplinary Learning and Teaching at The University of Texas at San Antonio. Her teaching interests include middle level education and curriculum and instruction. Dr. Pate's research agenda is framed by systems thinking and focuses on service-learning/community-based research, democratic education, and STEM curriculum, instruction, and assessment.

Andrea Guerrero earned her Bachelors in Education at Sul Ross University and Masters in Education at Texas A&M International University. She has worked, in one capacity or another, in the educational field since she was 18 as a public school teacher, grade/department level chairperson, assistant principal, and SAYS project coordinator. Andrea's professional goals include obtaining a doctorate with the hope of becoming a college professor.

Deborah (Debby) F. Dobie is the former Superintendent of Schools, Carrizo Springs Consolidated Independent School District. Throughout her extensive education career, Dr. Dobie always sought ways to authenticate the curriculum and to enhance problem solving skills with respect to the cost, the timeline, the benefits, if the model (SAYS), as presented, can be replicated, and how to sell it to the community and the board.

Chapter 15
Mediated Pedagogy in a Blended Environment: Impact of Processes and Settings During Environmental Monitoring of Dam Removal

Timothy Kieran O'Mahony

Previous attempts by other investigators (Young and Kinner 2008) who focused on middle school students' performance on tasks that were associated with knowledge in the outdoors, failed to demonstrate strong results of any learning measures. Their efforts, and earlier results from a pilot study that this author carried out in the same vicinity (O'Mahony 2008), helped refine ways to test the effects of different kinds of "expert mediation" for linking school–based and experiential learning methods and to test the effects of these methods on students' thinking and motivation. A philosophical framework that encompassed ecojustice ideals and sustainability of environmental habitats served as a backdrop to the study. A quasi-experimental two-group design was used to test whether different mediating tools would affect student-learning outcomes. Quantitative and qualitative tools were used in a mixed methods approach to collect and interpret data during a pedagogical intervention that posited better learning outcomes for students where mediation tools aligned teaching processes and settings in a purposeful way. We discuss how tools and contextual artifacts help learners notice key dimensions of their experiences (in the natural world) that "make visible" entrenched preconceptions; enable a process of conceptual change, and foster an emergent comprehension of everyday knowledge. Further, this study demonstrates how intentional alignment of instructional "processes" with "settings" facilitates student learning by linking counterintuitive concepts in the natural world to very real aspects of their culture and lives. But, more importantly, through energizing a sense of students personal agency and deep-seated engagement around their sense of place, the outdoor learning experience appeared to activate not only joy in learning in situ, it went a long way to enhancing a preparation for future learning.

T.K. O'Mahony (✉)
LIFE Center, University of Washington, 1100 NE 45th Street Suite 200, Seattle, WA 98105, USA
e-mail: tko2@uw.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_15

EcoJustice Science in Middle School

Science is typically popular with middle school learners. Teachers and parents will readily confirm a chorus of positive comments from their middle school students who say they "love" science, that it might even be their favorite subject. Yet, as described in many prominent educational journals (e.g., AERJ: Xu et al. 2012) many students often view "science" as foreign, distant, inaccessible, boring, irrelevant, and alienating (Basu and Barton 2007; Lee and Luykx 2005). There is evidence too, that science is equally inaccessible to students that are not normally classified as "minority" and who also find science irrelevant and boring (Mehan 1985; National Research Council [NRC] 2009; O'Mahony 2010). Inaccessibility is related to lack of interest, and indeed research has shown that students tend to invest in or withdraw from learning, depending on their level of interest (Singh et al. 2002). Interest is indeed key for learning according to a number of prominent educators (e.g., see: Xu et al. 2012) and has been found to promote a "variety of desirable outcomes" in children (p. 125), with evidence for learning through persistence (Renninger and Hidi 2002), task completion (Xu 2008), and science achievement (Hidi and Renninger 2006).

In many rural areas (and especially where this research project took place), there tends to be high levels of drop-out among high school children (rates as high as 51 % were reported in the school district where this project occurred). Educators and parents are often intuitively aware that children's interest in middle school academics influences future educational opportunity and career choices and indeed this trend has been borne out in empirical studies (Krapp 2000). It was not surprising then, that teachers and parents were very supportive of the Twin Dam intervention that we initiated locally, because the impetus momentum that science and engineering had received in the local community was prominent especially since dam removal and habitat restoration were headline news.[1] Indeed many studies appear to reinforce this notion; that an interest in science early in children's lives influences their decision to pursue a science-related career. Xu et al. (2012) report on findings from a National Science Education longitudinal study where researchers (Tai et al. 2006) found that students who reported an "interest in science careers in 8th grade were three times more likely to obtain a college degree in a science field than were those who did not show that interest" (p. 126). Xu and his research team further describe a study where researchers examined the experiences reported by 116 scientists and graduate students regarding their earliest interest in science. The majority (65 %) of the participants reported that the root of their interest in science took place before the middle school years.

It follows therefore, that meaningful criteria for student performance and classroom success might be associated with creating and maintaining interest in science in middle school years. Many researchers have identified successful strategies for increasing interest in the classroom, including offering evocative choices to students, especially those who displayed no interest in academics (Schraw et al. 2001). In this project, we focus on creating and maintaining interest in middle school science through the strategic use of ideas, which capitalize on pedagogical tools and mindsets that connote ecojustice in practice. Students in middle school years are typically not averse to taking on challenges that offer substantive change to the world as they perceive it. It is engaging to carry out work that bears civic and social responsibility in a local or indeed global arena. Ecojustice principles were no strangers to this community; social themes relating to justice and reform were well enunciated in the community where activists continuously evaluated very real connections between tribal culture and the natural systems that flowed from the river reconstruction, and often spilled into environmentalism, sustainability and geosciences (Cornwall 2009). In the implementation of this intervention, it seemed plausible that youth activism was a prominent attribute that contributed to interest particularly for participants (the historical cohort, described later) who exercised a significant degree of agency over their science endeavor. Likewise, this cohort of students seemed to be more fully cognizant of and individually involved in decisions concerning events and programs that tended to affect their community, their siblings and familial relations, and their local environment. Indeed, as final moments relating to the removal of the dams drew near, ecojustice and sustainability principles seemed to unite teachers, community members and students, inviting them to come together in order to evaluate and make decisions about critical issues that impacted (or were about to impact) their livelihoods, their sense of place and their wellbeing (Allaway 2004). This philosophic standpoint provided an encompassing lens for working through some really thorny issues that had evolved into divisive community problems (Freilich 2010). Ecojustice issues relating to the restitution of confiscated tribal lands to the Tribal Nation, once the lakes had drained away (this involved 100s of acres of open silt-laden landscape that had belonged to the tribe prior to their confinement in the reservation) were discussed in class and were prevalent in the home also (Valadez 2010). Interest in local issues of habitat restoration and land management was high among discussions in the home at dinnertime and beyond (O'Mahony 2009). There is a solid body of evidence that suggests that parents play a vital role in children's performance in school and in career choices in the sciences. Jon D. Miller (2012), director of the International Center for the Advancement of Scientific Literacy at the University of Michigan, offers empirical evidence that parents are the "essential root of scientific literacy" (p. 64).[2] We defer to Miller's view of scientific literacy as a child's capacity to engage with the world from a scientific standpoint, to ask questions, measure and assess their world using a scientific method.

This study, therefore, opens a new avenue of investigation where we identify a number of critical areas for connecting learning, motivated by issues of ecojustice and sustainability, with science relevance, interest and accessibility. In this next section we outline the settings and the situation that prompted this study. We compare two different approaches to experiential inquiry learning in an environment where expectations of engagement in learning were especially high. The Twin River dam removal project turned out to be the largest dam removal project in the world. Thanks to the rapid response capability of an NSF Rapid grant (NSF# 1014508), we were able to engage students in sustainability and environmental explorations prior to the dams being removed (two structures were brought down simultaneously at miles 12 and 23 up river from the mouth), with the expectation that later research would allow them and others to understand how the ecosystem had changed once the dams were down, and allow them create artifacts for teaching other students about the processes that took place.

Data were drawn from 217 middle school science students in the Peninsula Educational Service District (referred to here as Valley Middle School), an area near the dam removal project. The participants were eight graders, many of whom had low science achievement scores at pretest. This region is marked by high (~48 %) drop out rates and mixed ethnicity, including Caucasian, Native American and Asian. Student science achievement, as measured by Washington State's Measure of Student Progress (MSP), typically averages in the high 40s to low 50s (%). From the point of view of interest in science and love of outdoors schoolwork, these participants were fairly typical of middle school children everywhere. The following two figures indicate the students' (i) assessment of field trips for science in to the Twin River valley – 95 % said they wanted more, and (ii) attitude to work when they are interested in the topic – 93 % were willing to work hard in this situation (Fig. 15.1).

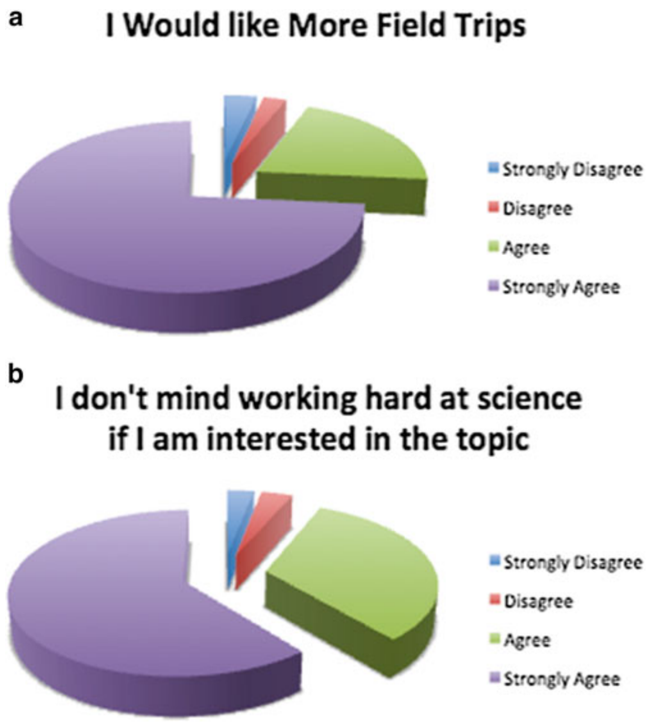


Fig. 15.1 (**a**) and (**b**) Participants assessment of outdoors schoolwork and science

We compared two different approaches to scientific inquiry. The first approach (referred to as Piecemeal), used widely by local park rangers and also by teachers in many other parts of the country (e.g., Young 2009), assigned students different topics related to environment and water quality (e.g., students were told to measure dissolved oxygen, pH, turbidity, and so on). Students gathered data in the outdoors and wrote up their project using a scientific framework that was derived from classroom texts supplied by Foss Kits (Chin et al. 2010). The end product was a PowerPoint production that each group (typically 4/5 persons) was responsible for delivering to peers and teachers.

The second approach (which we refer to as Historical) asked students to take a historical frame for their science inquiry and involved answering questions such as why the dams were there in the first place and for how long; how they affected the lives of people living in the community, and what kinds of changes in conditions were predicted once the dams were taken down. Similar to the first approach, these students did inquiry projects before and during the dam removal, but they had more choice with respect to historical information to include in their work, indicators to study, and techniques for showing their work (e.g., students created movies that integrated science in a historical frame rather than individual PowerPoint presentations on piecemeal water quality findings such as pH).

This research provided time and equipment for both groups of students to explore the Twin river system and the environmental habitat prior to and as the dams were being taken down, and to make predictions about the future (after the dams were taken down). For example, for the relatively near future, major impact was anticipated in the upper regions of the river once the river was again naturally connected with the ocean and marine derived nutrients would be brought back into the ecosystem (through returning salmon) after almost a century cut-off from this source (there were no fish ladders in the original dam structures). At the same time, scientists and students anticipated major changes to the emerging lake beds where massive amounts of sediment (30+ million cubic yards of silt) remain once the lakes are drained down. Significant changes were also predicted to occur at the mouth of the river where the Twin River enters the Strait of Juan de Fuca, because silt deposition and tidal exchanges should initiate the development of sandy beaches once more (Casey 2006).

Overall, all students spent 10 weeks on the Twin River project, which included taking the classroom outdoors for inquiry activities, bringing discoveries inside the classroom for small and large group discussions to prepare either a PowerPoint presentation or a historical movie. The multimedia work was undertaken with the help of the technology instructor in the school who integrated his classwork with that of the science teachers.

Measuring Students' Knowledge

We developed an instrument to measure students' knowledge before the intervention and again once the students had been exposed to several units of curricular materials and a field event. The instrument consisted of ten items that focused on the impact of dam construction and removal over time. For instance, the initial portion of the instrument (three questions) was oriented towards the past and focused on why the dams were built in the first place. The second portion (three questions) situated the student in the present – asking why the dams were being taken down brick-by-brick instead of blowing them up? Finally, the third section (four questions) had a futuristic orientation in its makeup and asked students to imagine that it was 2015 and that one morning their drinking water comes out of the tap like tar. The questions assessed students' ideas on what might have caused this to happen. We examined the 10 items using a statistical model (Cronbach's a) that verified the reliability of the instrument. Item reliability measured high at 0.886 (c.f., Nunnally and Bernstein 1994, pp. 232, 251–252).

Scoring

Four scorers, each blind to treatment group and time of test, independently used a rubric to score a common set of 20 randomly selected tests. Total test scores from each pair of scorers correlated at $\geq .80$, and interrater reliability among all scorers was .89. Disagreements were resolved through discussion with experts in the subject matter. Scorers then divided the remaining tests equally amongst themselves for independent scoring.

Here we describe findings that result from data collection in the classrooms and in the field. Measures include (1) Quantitative results of the paper and pencil knowledge test administered at pretest and posttest by teachers and scored by "blind" raters; (2) video analysis of students' interactions in the outdoor environment and as they prepared for their small group presentations; (3) assessments of the nature of students' presentations in the two instructional groups. In addition, we recount pertinent reactions by each teacher of their experiences and their observations of the experiences of their students.

Pre/Post Knowledge Test

As stated earlier, subjects consisted of 8th grade science students from a small rural population in western Washington that happens to be adjacent to a massive dam removal and habitat restoration project. Four science teachers and their students took part in the study ($N = 217$); two classes participated in the historically-framed science inquiry (Historical) condition, and two were in the comparison (Piecemeal) condition. Descriptive statistics (see: Table 15.1) outline the mean, standard deviation for both piecemeal ($n = 107$) and historical ($n = 110$) cohorts' pre and posttest scores.

A one-way analysis of variance (ANOVA) was calculated on participants' scores of learning performance. The test showed significant gains for the historical group

Table 15.1 Learning performance descriptive statistics

	Piecemeal (n = 107)				Historical (n = 110)			
	Pretest		Posttest		Pretest		Posttest	
Content area	M	SD	M	SD	M	SD	M	SD
Question 1	1.90	2.60	5.59	3.22	5.50	3.00	7.30	2.85
Question 2	2.40	2.30	5.62	3.25	4.00	2.50	7.07	3.03
Question 3	2.60	2.40	7.38	2.87	4.48	2.70	8.27	2.48
Question 4	0.80	2.40	7.00	4.08	3.70	3.20	8.39	2.65
Question 5	3.00	2.00	7.97	2.83	5.00	2.00	8.08	2.55
Question 6	2.00	2.00	6.71	3.43	4.00	2.00	6.84	2.87
Question 7	0.50	1.30	4.05	3.27	2.10	2.00	4.20	3.27
Question 8	1.01	1.97	4.90	3.68	2.10	2.09	5.09	3.09
Question 9	1.23	1.92	5.59	3.70	2.28	2.21	5.83	3.08
Question 10	0.94	1.93	4.06	3.90	1.68	2.03	4.92	3.46

over the piecemeal group in learning measures: $F(1,216)=5.557$, $p>.05$, $r=0.12$. This test of between subject effects indicates that on average, students who were taught with a historical context showed greater measures of learning than the comparison group.

Learning Interactions in the Field and Classroom

In addition to pre/post knowledge tests, we also examined differences between the two conditions by analyzing data in a qualitative paradigm. The latter provided a more sensitive approach to investigating how students interacted as they gathered data and prepared their presentations; for example data showed that those using the historical narrative achieved a deep understanding of the dam removal process and began to appreciate nuances involved in habitat restoration. We looked for indicators that might suggest greater engagement, deeper investment in their work and an ability to synthesize and abstract from local observations and theory. We undertook frame-by-frame video analysis of excerpts that highlighted data capture, data processing and project presentation.

Content logs (Jordan and Henderson 1995), which captured key moments of activity and discourse were created from the videotapes to aid analysis. Two researchers used these logs and video recordings to independently identify significant interactional episodes. Using standardized transcription conventions, content logs, and field notes, we reconstructed in writing what the learners said and did in relation to one another, preserving the temporal sequence of the interactions. Participant verbal interactions were transcribed and coded. Emergent categories and themes in relation to course content and participant engagement (through questions that stemmed from discussions and interactions) were documented. Verbal interactions were analyzed for sequences that captured participant meaning-making. Students in the Historical cohort appeared to view the world in a different way than students in the Piecemeal comparison cohort. Historical students exercised agency over their choice of project—they chose topics that had meaning for them. For instance, a typical choice is illustrated in the following segment, which comes from students interviewed on the shore of Lake Blue: (11/07/2010_Lake_Blue_Site).

Interviewer:	What is your study about?
Student_1:	We are looking to see if eagles are more plentiful here near the lake or up at the other dam or down at the mouth.
Interviewer:	Why did you choose this study?
Student_1:	I wanted to see if the dam has any impact on where the eagles hunt. My dad said there were a lot more eagles long ago.
Student_2:	We like eagles. I like to take videos of them.
Interviewer:	What do you think you will find?
Student_1:	Well, so far we didn't see any eagles here today.
Student_2:	We think we saw one earlier and I think I heard one … but it might have been something else.
Student_1:	Yeah, a raven … there was probably one here earlier.
Interviewer:	What about up at the upper dam?
Student_2:	We saw three eagles up there.
Student_1:	Two were circling high up. The other one we saw later… it might have been one of the first two again. Hard to say.
Interviewer:	What about down at the mouth?
Student_1:	We expect to find some down there. My friend says he sees them down there always. He lives near there.

Piecemeal Presentations

Ostensibly, the class teacher assigned topics to the control Piecemeal cohort – they didn't exercise any choice over the topic of their study. Each topic was made to fit the curricular material that was tasked with explicating the "Scientific" approach to learning science. In this approach, groups studied something like PH, salinity, turbidity etc. of the river. The following episode describes the understanding of a typical Piecemeal group gathering field data taken from live data: (11/07/2010_Between_Dams_Twin_River_Site).

Interviewer:	What is your study about?
Student_1:	We are measuring PH.
Interviewer:	What is PH?
Student_1:	Um. Ahmmm PH is… I don't really know (laughs)
Student_2:	Um… it is about acid… acidity.
Student_3:	We are checking to see if the water has high or low PH.
Interviewer:	Why did you choose this study?
Student_1:	Um. Our teacher …
Student_2:	It's our science project.
Interviewer:	What do you think you will find?
Student_3:	Um. Ahmmm… well the river is very muddy here so it'll probably be high PH. (laughs again)
Student_2:	Yeah… probably.
Student_3:	Maybe has high or low PH.

Overall, the students who had agency over their choices seemed to be more invested in their work and investigation, whereas students who were assigned projects by their teachers, while generally invested in the work, didn't appear to understand the reasons for undertaking the work. This kind of muddy thinking about why children are doing their school work fits with models that detail a misalignment of processes and settings (e.g., O'Mahony 2010). This model (See Fig. 15.2, Learning Processes and Settings) connects learning settings with learning processes and details performance results (i) when a good alignment enhances a learning moment, (ii) explains how a misalignment of settings and processes causes degradation to deep understanding and student performance. In the case of piecemeal teacher generated topic assignment, settings were outdoor, but process emanated from the classroom- a clear example of "turn in for grade" exercises or sequestered problem solving as described by Schwartz et al. (2005).

A similar finding was evident during the presentation of student projects at the end of the unit. All students prepared and presented as part of their small collaborative group. Presentations were first for classroom members; later for parents and teachers and in the case of some students there was a public opportunity to present at the local community college. This came about because of the interest in the dam removal by community members. Many interesting factors emerged as a result of the presentation format and enactment. We describe the highlights here. A number of observations are common to all participants across the board regardless of whether the student was in the piecemeal or historical cohort. All students participated. All students really enjoyed being part of the science and multimedia challenge.

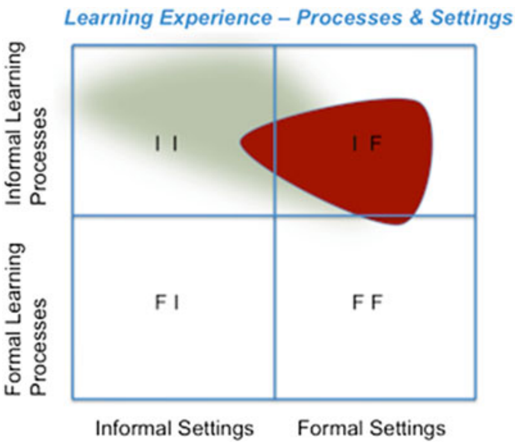


Fig. 15.2 Learning processes and settings (O'Mahony 2010) (Legend: *II* denotes Informal Processes and Informal Settings; *IF* denotes Informal Processes and Formal Settings; *FI* denotes Formal Settings and Informal Processes; *FF* denotes Formal Settings and Formal Processes. The shadow cast by IF impacts activities and attitudes in neighboring learning spaces)

Teachers agreed that the opportunity to perform in public (in front of peers, parents, teachers and some public) was "very beneficial to children and especially those who were introverted and withdrawn normally" (O' Mahony 2011).

Beneficial as it may have been for all students to take part in, and present a project (using PowerPoint or video), there were significant differences between results of presentations from each cohort. The most common distinction occurred in the piecemeal group and centered on meaning and understanding as regards to the work that the students were presenting. This aligns with findings described earlier with regard to students' perceptions of what they were measuring and why they were measuring it. For instance, whereas participants in the historical group connected deeply to their projects through narratives and questions that centered on ecojustice for their community, the students in the piecemeal group presented finished projects that reflected an arbitrary surface-level knowledge that appeared to have been gleaned from books and internet without fully comprehending why or what they were doing. The following example is a pervasive occurrence of this phenomenon. A PowerPoint slide (shown in Fig. 15.3) described the scientific "classification" element, which was prescribed by the scientific method used by the teacher pertaining to indigenous salmon species that the students were asked to describe. Three students read their PowerPoint in front of their peers.

1. Reader_2: Ahmmm this is our classification slide. The kingdom is … an… animalia ((struggles to get the word out))
2. Pullium ((sic)) is Cho…chodray. Class is um oo-ss. I don't know that word.
3. Reader_3: Order ---
4. Reader_2: ((uncomfortable laugh)) I don't know any of them.
5. Reader_3: Those words!
6. Reader_2: Yeah. ((giggle))
7. Reader_1: ((moves on to the next slide))

Many additional observations suggested a level of surface understanding exhibited by students in the "piecemeal" condition where the focus appeared to be on completing the teacher-assigned work rather than on a deep understanding of the concepts within the study.

Fig. 15.3 Piecemeal science project presentations

Historical Presentations

Presentations were much different for students in the historical cohort. The greatest difference stemmed from the fact that participants anchored their video productions in a narrative that involved ecojustice questions and theories that sprang directly from the colossal dam removal life episode in which they were living. Their videos contained footage of themselves, family and friends including interviews of people from the local tribal community.

The historical "video" group productions were different in two other respects also. First, since everything had to be encapsulated in the production (there was no narrator standing in front of the class introducing each piece), there was an expectation that the production was a movie with a beginning, middle, and end. This was not so apparent with piecemeal PowerPoint productions (indeed, some of these productions seemed to just stop at nowhere in particular), maybe because they ran out of material, or time, or both. Second, a movie came with a title, usually a subtitle, and start-up music. Then it entered into the body of the production where most of the content was configured within the narrative framework already mentioned. Finally, the videos were brought to a finish with a scrolling assemblage of contributors and actors accompanied by the students' choice of music again. Some students included an "outtakes" section that really captured the imagination of all involved and usually replayed scenes from the day in the field (lakebed mud and beach). One thing was sure, reported their teachers, "these kids won't forget this project anytime soon" (O' Mahony 2011).

All students in this cohort framed their videos in a narrative that described when and why the dams were put-in; what the impact of the dams had been on humans, flora and fauna, and landscape; and, finally, what might be the repercussions to all these stakeholders when the dams are taken down. Many of the students interviewed people (including Native American locals) and other local inhabitants to understand the history of the dam construction. As an example, the following interview was captured by three students (one worked the camera, two carried out the interview) and a couple of fishermen who stood waist-deep in the river near the mouth, their lines taut in the water. First they asked permission (the fishermen were delighted to talk to the students); then they set up microphone equipment and cameras and began the interview. (transcript:Hist_Gr_3_Twin River_Mouth_11/12/2010).

43. Student_1: Today, November 12, 2012 we are at the um, mouth of the Twin river. We met these two fishermen and asked them some questions. Good day.
44. Fisherman_1: Good day.
45. Fisherman_2: Howdy.
46. Student_1: Have you caught anything today?
47. Fisherman_1: No. Not today. It is a little unusual, because the fish are in there.
48. Fisherman_2: Yeah – they're in there sure enough, but they're avoiding two old men.
49. 46. Student_1: And what kind of fish are you seeing today.
50. Fisherman_2: Oh, salmon, Chum.
51. Student_2: We are wondering what do you think will happen when the dams are gone, will that affect the fishing.

52. Fisherman_1: When the dams are gone! You bet it will. When those dams are gone there will be lots more fish here. I remember when you could walk across the river on the backs of Sockeye.
53. Fisherman_2: Well maybe not on their backs, but there were lots more fish in the past. They can't spawn up there anymore. The big question will be – if they remember how to get up there. It has been nearly 100 years you know.
54. Student_1: What about the sediment? Won't that hurt the fish?
55. Fisherman_2: Yeah. That is true. When the dams first come down the sediment will probably be too heavy. Today, there is a lot of sediment, but not too much to hurt the fishing. But much more would be bad.
56. Fisherman_1: But over time, that sediment will go away, it will probably make nice beaches down here.

This excerpt describes a deep interest and local knowledge expressed by people who are engaged in living in the community. The narrative reflecting ecojustice principles including contentious questions that revolved around sediment, safe potable water supplies, whether the local tribes should own the land that emerged from the drained lakes as they did in the past, and other issues that had the potential to be divisive for the community. These were the questions and issues that emerged in the video productions. These issues did not surface in the PowerPoint productions. We posit a theory that prescribed formulaic teaching models prevented the students from engaging in the social and ecojustice issues that were ubiquitous in the community and readily available for their consumption and engagement.

In general, the video productions reflected a level of engagement and interest in the subject matter, because students had chosen their own topic of investigation and were using their own resources to collect data and create their finished projects. What was most illuminating was the level of attention and engagement expressed by the audience for video productions, with music, scrolling list of "actors" and especially the "outtakes".

Students' Role in an Ongoing Ecological Project

This study sought to understand different ways of making connections between outdoor learning experiences and classic classroom instruction. We asked if we anchored instruction in questions related to EcoJustice and habitat restoration; would it impact students' understanding of big ideas and their role in an ongoing ecological project. A large dam removal development provided the catalyst for controversial, often divisive, events and animated discourses that held the attention of just about all members of the community, including parents of the middle school students involved in this study and other stakeholder groups (e.g., local tribal members, agri-business, fishery and industrial investors). Questions we studied focused on whether engagement in issues of ecojustice and ecology might succeed in connecting traditional classroom learning with the natural world in a way that would help students gain a deep understanding of the issues involved and help prepare them for future learning.

Findings from this study suggest implications for teachers and learners. Results suggest that there are foundational advantages for teachers who approach their students' learning space with a solid understanding of how alignment of process and settings enables deep understanding and a preparation for future learning. What we found reinforces the idea that intentional alignment of processes and settings facilitated deeper connection to real-world concerns; and, a deeper understanding of the science and math involved in enacting colossal engineering projects (e.g., largest dam removal and habitat restoration in US history). A further take-away for learning scientists was that "agency" matters; middle school students who had choice over the selection of science projects were more engaged, more attached and, indeed, more connected to immediate situations and predictive investigations in the real world. These students demonstrated deep understanding of questions relating to ecojustice and environmental issues that cropped up around local decisions and outcomes of events in their communities and beyond. In addition, middle school students who approached their science projects from a historico-narrative cognitive envelope demonstrated an ability to connect their ideas and methods easily with meaningful knowledge that made their end-product presentations rich and meaningful to them and their fellow students. This was in stark contrast to similar middle school students who carried out work in a piecemeal fashion that was guided by norms of traditional structured inquiry method. These students followed a traditional prescriptive model that enabled them to produce presentations that met grade requirements for science exploration and method understanding. But in comparison with their "historical" class mates, their knowledge was more in line with what Whitehead (1929) referred to as disconnected and "inert" and, consequently, was less engaged in ecojustice and environmental questions that made meaning within a local community perspective. Finally, questions of ecojustice, ecological impact, and habitat restoration catalyzed lively discussions and enabled a deep understanding of concepts and issues within schoolwork that connected them to local environment and community questions. Discussions with students indicated that this facility with a deep understanding of real questions in their natural world, had an important impact for enabling a manifest identity around geo-sciences and STEM-related work and life opportunities that were otherwise outside the scope of their career radars.

Incidental measures, which had not been anticipated by the study team, appeared to corroborate the findings that are described above. These measures were of interest to the study principally because they were highly significant for the students since they raised visibility of their science projects for parents, teachers, and school administrators. While we cannot claim causality (we were not able to compare interventions/methodologies in other schools across the system), eighth grade results for state-administered science tests improved to an extent that captured the attention of everyone associated with the school and the study.

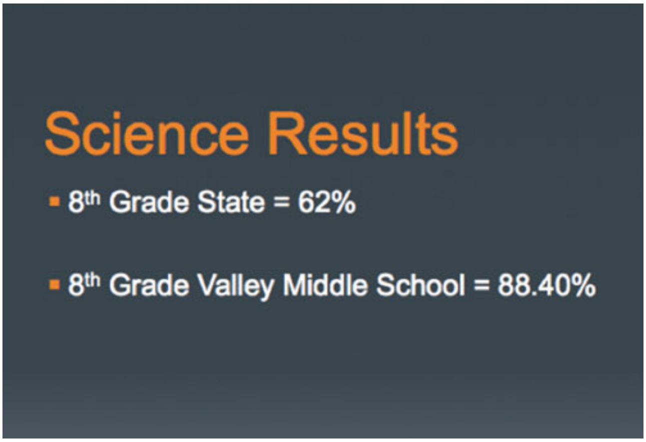


Fig. 15.4 Teachers and students attribute gains to ecoJustice science program

The following graphic illustrates a small sliver of a large banner that the principal had posted on the outside of the school after State MSP (Measures of Student Progress) results revealed a solid leap for student performance in 2010 – the year they were engaged in the Twin River science investigation (Fig. 15.4).

Independent MSP measures showed that a significant number of students in the project passed the State administered 8th grade science test compared to previous years and in comparison to same grade schools in the state. Year by year, state averages for passing these tests ranged around the low to middle 50s. For instance in 2008–2009 8th grade science results for the State of Washington were 51 %, Valley Middle School was just below that at 49 %. In 2009–2010, 8th grade science results for the State of Washington increased slightly to 54 %, Valley Middle School remained in line at 55 %. Once again, in 2010–2011 8th grade science results for the State of Washington jumped into the low 60s ~61 %. But this time, Valley Middle School displayed a conspicuous increase outstretching all previous performances to reach 88.4 %. While we do not claim responsibility for this positive outcome, the principal, teachers, students and parents were convinced that the results were directly responsible to the increased engagement, interest and knowledge about ecojustice questions that arose as a result of the dam project. From the perspective of school administrators, students and parents (who had witnessed high drop-out rates for years), this strong increase in science scores was a very welcome sight for the community. The enthusiasm that was shared by and among teachers who partook in this program is captured in exit interviews that elicited their comments and thoughts about the effectiveness of the intervention.

Figure 15.5 offers two samples of how teachers describe improved learning for students based on effective blending of classroom teaching methods with outdoors experience coupled in ecojustice concepts and ecology topics. It is evident that ~90 % of learners experienced a metacognitive moment by realizing

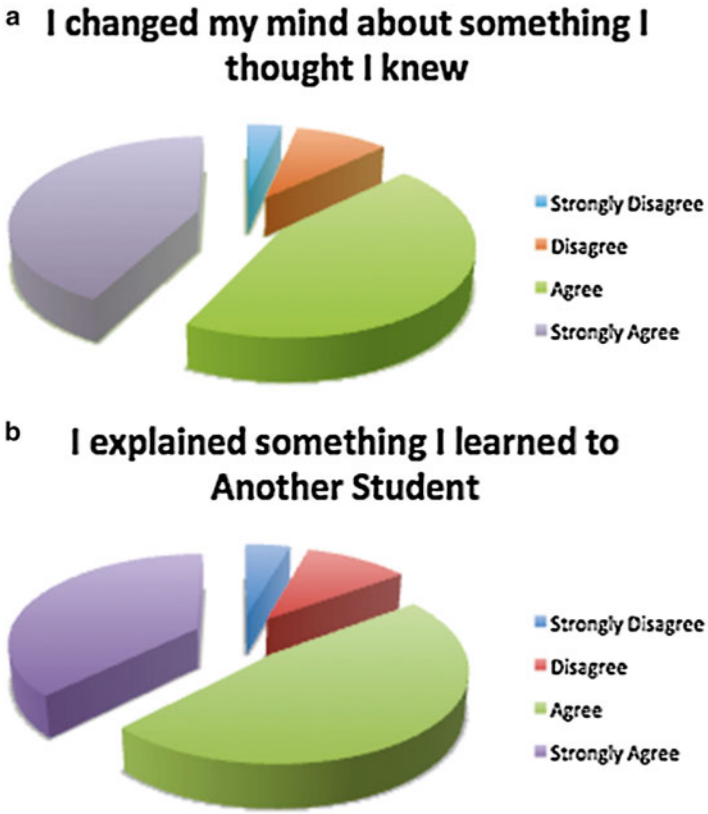


Fig. 15.5 (**a**) and (**b**) Peer-to-peer learning

their conceptual change with regard to letting go of preconceptions and gaining a new understanding of questions relating to this landscape and the science around dam removal. Similarly, a very high percentage (~95 %) of students were able to explain a scientific topic relating to their work to fellow students during the course of the study.

Lessons Learned

Future plans for this research endeavor include deepening the inquiry around issues of concern with regard to learning in informal and blended environments. For example, although this study was conducted in middle school science classes, it is conceivable that a well thought-out program might effectively engage younger children also.

We believe that similar interventions in junior grades would enable children to become more engaged in aspects of science and that they would gain skills that might remain life long and life deep.

Finally, the notion of scaling up this project is appealing – to make skills and knowledge that a community learns in a project of this breadth and depth – available to other communities where dams are being taken down and habitats are being restored (approximately 300 dams will have to be removed in the US over the next decade, for reasons that include safety and environmental degradation). Internationally, ecojustice questions around dam removal and habitat restoration are allied with serious ecosystem questions about sustainability and survival in a world that is quickly experiencing over-population and a consequential scarcity of resources. Lessons from Native American tribal people in the Twin River valley include managing meager resources, efforts to establish a revived fishing industry, and bringing geosciences to the fore in schools and classrooms. These are questions this study has experienced where new knowledge and resources might offer a voice for communities who are approaching this place in time.

Notes

1. This research took place at the same time and in the same location as the largest dam removal and habitat restoration project in the US. By Federal decree, two dams were ordered removed from the Twin River in Northwestern Washington, and to restore the river to its natural state.
2. Miller stated that; "Those who value science reflect that value in their choice of toys and books, in their use of zoos and museums, and in their own curiosity about the world in which they live. And their knowledge and interests have a profound influence on their children. Recent data from the Longitudinal Study of American Youth, through which my colleagues and I have been following 4,000 Generation Xers since 1987, show that 40% of children whose parents actively encouraged them in math and science planned to major in a STEMM (science, technology, engineering, mathematics or medicine) subject in college, as compared with only 8% of children who did not receive the same level of encouragement" (p. 64).

Acknowledgements My colleagues Dr. John Bransford, and Dr. Nancy Vye at the University of Washington LIFE (Learning in Informal and Formal Environments) Center, deserve huge credit for their vision and profound support in the design, implementation and analysis of this "dam" project. I would also like to thank the members of the Twin River community who shared their experience and knowledge with me during the implementation of the study. Finally, to the teachers and students in the Valley Middle School I owe a huge debt of gratitude for opening their classrooms to investigation and analysis without prejudice or fear.

*This study was partially funded by NSF RAPID Grant 1014508.

References

Allaway, J. (2004). *Understanding the Elwha: A strategy for research and education programs on the Elwha River* (pp. 1–32). Spokane: Huxley College of the Environment.

Basu, S. J., & Barton, A. C. (2007). Developing a sustained interest in science among urban minority youth. *Journal of Research in Science Teaching, 46*, 50–73.

Casey, J. (2006, January 6). Storm continues eating away at Angeles Point. *Peninsula Daily News*. Port Angeles, WA.

Chin, D. B., Dohman, I. M., Cheng, B. H., Opezza, M. A., Chase, C. C., & Schwartz, D. L. (2010). Preparing students for future learning with teachable agents. *Educational Technology Research and Development, 58*, 649–669.

Cornwall, W. (2009, April 22). Stimulus money will speed Elwha dam removal. *The Seattle Times*.

Freilich, J. (2010). *Glines Canyon Dam Lecture*. Seattle: University of Washington.

Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *The Journal of the Learning Sciences, 4*(1), 39–103.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist, 41*, 111–127.

Krapp, A. (2000). Interest and human development during adolescence: An educational-psychological approach. In J. Heckhausen (Ed.), *Motivational psychology of human development*. Amsterdam: Elsevier Science B.V.

Lee, O., & Luykx, A. (2005). Dilemmas in scaling up innovations in elementary science instruction with non-mainstream students. *American Educational Research Journal, 42*, 411–438.

Mehan, H. (1985). The structure of classroom discourse. In T. van-Dijk (Ed.), *Handbook of discourse analysis* (Vol. 3, pp. 119–131). London: Academic.

Miller, J. (2012, August). The value of bringing science home. *Scientific American*, p. 64.

National Research Council. (2009). Learning science in Informal environments: People, places and pursuits. Executive summary. In P. Bell, B. Lewenstein, A. Shouse, & M. Feder (Eds.), *Learning science in Informal environments: People, places and pursuits*. Washington, DC: The National Academies Press.

Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory* (3rd ed.). New York: McGraw-Hill.

O'Mahony, T. K. (2008). A visuo-spatial learning ecosystem enhances adaptive expertise with preparation for future learning. In *T-3 International conference* (pp. 1–76). Retrieved from http://ti-researchlibrary.com/ListsTI%20Education%20Technology%20%20Research%20Library/DispForm.aspx?ID=105

O'Mahony, T. K. (2009). *Stream: Research that advances STEM*. Paper presented at the American Education Research Association, San Diego, CA, San Diego.

O'Mahony, T. K. (2010). *Connecting formal and informal learning experiences*. PhD dissertation, University of Washington, Seattle, WA.

O'Mahony, T. K. (Producer). (2011, 9/15/2012). *Elwha watershed learning sciences project*. University of Washington: In the news. [Science Report]

Renninger, K. A., & Hidi, S. (2002). Student interest and achievement: Developmental issues raised by a case study. In A. W. J. S. Eccles (Ed.), *Development of achievement motivation* (pp. 173–195). New York: Academic.

Schraw, G., Flowerday, T., & Lehman, S. (2001). Increasing situational interest in the classroom. *Journal of Research in Science Teaching, 38*, 211–224.

Schwartz, D. L., Bransford, J. D., & Sears, D. (2005). Efficiency and innovation in transfer. In J. Mestre (Ed.), *Transfer of learning: Research and perspectives* (pp. 1–51). Greenwich: Information Age Publishing.

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest and academic engagement. *Journal of Educational Research, 95*, 323–332.

Tai, R. T., Liu, C. Q., Maltese, A. V., & Fan, X. T. (2006). Planning early for careers in science. *Science, 312*, 1143–1144.

Valadez, J. (2010). *Best practices for education with native students: Making history in the Elwha*. Paper presented at the Olympic Park Institute Teaching Skills with Native Americans, Olympic Park Institute, Port Angeles, WA.

Xu, J. (2008). Models of secondary students' interest in homework: A multi-level analysis. *American Educational Research Journal, 45*, 402–436.

Xu, J., Coats, L. T., & Davidson, M. (2012). Promoting student interest in science: The perspective of exemplary African American teachers. *American Educational Research Journal, 49*, 124–154.

Young, R. (2009). Elwha restoration project meeting. Level setting and planning.

Young, R. S., & Kinner, F. (2008). *The Elwha Education Project (ESEP): Engaging an entire community in geoscience education*. Paper presented at the American Geophysical Union, San Francisco, CA.

Timothy Kieran O'Mahony A fellow of the Royal Geographic Society UK, and a research fellow at the LIFE Center, University of Washington, Timothy Kieran O'Mahony explores the intersection of learning sciences, environmental education, and neuroscience. His recent research focuses on socio-cultural perspectives on cognition, learning, and technology in formal and informal learning environments.

Chapter 16
Why the Secret of the Great Smoky Mountains Institute at Tremont Should Influence Science Education—Connecting People and Nature

Lynda L. Jenkins, Ryan M. Walker, Zena Tenenbaum, Kim Cleary Sadler, and Cathy Wissehr

The Great Smoky Mountains Institute at Tremont (GSMIT) is an environmental education center located within the boundaries of Great Smoky Mountains National Park (GSMNP hereafter) near Townsend, Tennessee. Found at the southern end of the Appalachian mountain chain, GSMNP straddles the border between Tennessee and North Carolina and is the largest national park east of the Mississippi River. GSMNP is widely recognized for its rich biodiversity of plant and animal species, due primarily to the variety of climatic conditions and elevations within the park. Temperature and rainfall fluctuations within this region create numerous ecosystem types, which support a wide variety of species (Linzey 2008). This species richness, in addition to GSMIT being located within a protected park system, provides a unique environment that allows the center to have far reaching effects on student learning through citizen science.

L.L. Jenkins (✉)
The Galloway School, 215 West Wieuca Rd NW, Atlanta, GA 30342, USA
e-mail: l.jenkins@gallowayschool.org

R.M. Walker
University of Arkansas, Allen Hall 336, Starkville, MS 39762, USA
e-mail: rwalker@colled.msstate.edu

Z. Tenenbaum
Middle Tennessee University, 6720 Halls Hill Pike, Murfreesboro, TN 37130, USA
e-mail: zat2c@mtmail.mtsu.edu

K.C. Sadler
Center for Cedar Glade Studies, Middle Tennessee University,
PO Box 60, 1500 Greenland Drive, Murfreesboro, TN 37132, USA
e-mail: kim.sadler@mtsu.edu

C. Wissehr
University of Arkansas, 311 Peabody Hall, Fayetteville, AR 72701, USA
e-mail: cwissehr@uark.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_16

A Brief History of Tremont's Educational Mission

GSMIT identifies its overall mission as connecting people to nature. There are three strands at the heart of this mission: (1) sense of place, (2) understanding ecosystem diversity, and (3) stewardship. These concepts are woven throughout all aspects of the GSMIT experience and curriculum. *Sense of place* involves participants' realization that they are part of a larger cultural and ecological system. Participants gain an understanding of *diversity* when they are able to perceive the complexity of natural systems and how all components are interconnected and dependent upon one another. Finally, *stewardship* involves humankind's responsibility to learn about, understand, and protect these integrated natural systems.

Through internal assessment of GSMIT's impact on student learning, the educational leadership developed more concrete educational constructs that can be measured with a greater level of accuracy (Stern et al. 2008). Stern et al. identified four independent categories that represent the original three strands. *Connection with nature* (Nature): The connection-with-nature construct is based on four premises: (a) Students feel comfortable in the outdoors; (b) students feel that they are a part of nature, rather than separate from it; (c) students actively engage in observing their surroundings when in natural settings; and (d) students show interest in outdoor activities. *Environmental stewardship* (Stewardship): The stewardship index measures participants' attitudes toward environmental conservation and their intentions and actions regarding environmental behaviors. *Interest in learning and discovery* (Discovery): The discovery index gauges students' degree of interest in learning about natural history and cultural heritage and their degree of interest in directly exploring these topics in various settings. *Knowledge and awareness of the Great Smoky Mountains National Park and biological diversity in general* (Awareness): The awareness index measures knowledge of exotic species, biological diversity, and the national park. When utilized together, these four constructs have been used to provide an accurate measure of how the GSMIT experience impacts student learning.

Through examination of GSMIT internal documents, curricular resources, current research and interviews with the education director, Walker (2012) establishes that GSMIT objectives are aligned with three longer-term content areas of environmental education: (1) Ecological Principles, (2) Issue Identification and Solution, and (3) Civic Responsibility and Motivation (Table 16.1). Citizen science is a critical part of developing understandings within these areas.

Beginnings of Citizen Science at GSMIT

Citizen science projects, historically, have been initiated to meet the needs of professional research scientists desiring to collect copious amounts of data over large geographical areas (Bonney et al. 2009). Given the vastness of such a task, scientists often rely on citizen volunteers to do much of this work. As such, citizen science

Table 16.1 GSMIT objectives' alignment to established EE content areas

	Connection with nature (Nature)	Environmental stewardship (Stewardship)	Interest in learning and discovery (Discovery)
Ecological principles	Students feel that they are a part of nature, rather than separate from it	…	…
Issue identification and solution	Students actively engage in observing their surroundings when in natural settings	…	Interest in learning about natural history and cultural heritage and their degree of interest in directly exploring these topics in various settings
Civic responsibility and motivation	Students feel comfortable in the outdoors; Students show interest in outdoor activities	Attitudes toward environmental conservation their intentions and actions regarding environmental behaviors	…

Note: content areas for EE established by founding documents (NAAEE 2004; Stapp et al. 1969; UNESCO 1978; UNESCO-UNEP 1976)

can be valuable in an educational context. GSMIT recognized this and understood that citizen science presents a unique and exciting way of merging scientific research with educational objectives. As with the development of any new program, the incorporation of citizen science into the curriculum emerged slowly. At the beginning, interactions between GSMIT staff and scientists studying bear populations within the park allowed GSMIT directors to envision how research could be incorporated as a valuable experience for students who visit GSMIT. Catalyzed by several independent events, the park service began to recognize that GSMIT could contribute to ongoing research. To facilitate this, the park service provided introductory scientific training for Tremont staff, and helped develop the initial citizen science projects for GSMIT. The very first project developed was described as simply, "the moth project." When this project was initiated there was significant interest in learning what species of moths called the park home throughout the year. This project ultimately led to the discovery of over 100 species of moths previously unrecorded in the park.

Concurrently, the All Taxa Biotic Index (ATBI) was getting underway. The goal of the ATBI was to identify every species found within the park boundaries over a 10-year period. Additionally, the ATBI was to determine the distribution and density of each species, and the seasonality and relationships among different species (Linzey 2008). As the ATBI began, GSMIT hired its first director of educational research with the primary role of developing a citizen science program. Projects such as aquatic salamander monitoring, the citizen science internship programs, and science oriented summer camps were created. Thereafter, citizen science has been an integral part of Tremont's evolving curricula.

GSMIT Staff Interpretations of Citizen Science

Oral histories, interviews and observations with current and former staff members were used to establish trends with regard to the use of citizen science at Tremont. Two of the most significant of these trends relate directly to the larger context of science education: (1) Citizen science is a tool that facilitates excitement and curiosity, and (2) there is an emerging tension between formal science and education identities.

Excitement and Curiosity Through Citizen Science

Students having fun in nature is frequently described as an important part of what teacher-naturalists try to devise for participants. For example, Tricia, a teacher-naturalist at GSMIT, expresses that she wants to create an experience that feels like an awesome vacation. She tries to accomplish this by constructing an atmosphere where students enjoy the experience and develop lasting and meaningful memories. This is especially apparent when Tricia speaks of the Monarch butterfly tagging project. She describes this program as *"one of the most joyous things I've ever done"*—her face lights up with a big smile just thinking about it. When she is asked why it is so special she responds:

> I think it has to do with just watching people with a butterfly net running through a field. They look like they're frolicking. And even if you're not the person running through the field trying to catch butterflies, just watching it puts a smile on your face.

Allowing participants to simply enjoy being in nature is critical to developing a sense of place through place-based education. As described by Smith and Sobel (2010), the definition of place-based education is "an approach to teaching and learning that connects learning to the local" (p. viii). What better way to connect to the local environment than by being immersed in the place and experiencing the joy of catching butterflies? Having fun outside is a simple act that has significant consequences for the formulation of attitudes toward science and nature. It is theorized that these types of interactions can be formative in developing individuals who are more fully involved in their communities (Mueller et al. 2012). By embracing place-based education, GSMIT is working to increase the awareness of community issues and connectedness. Given the growing sense of 'community deprivation' that Smith and Sobel (2010) describe, the work that the teacher-naturalists at GSMIT are doing to connect lessons learned at their educational facility to the students' home community seem to be a significant educational remedy for this ailment.

Tension Between Science and Educator Identities—I'm Not a Scientist!

A second theme that emerges from this research is the attitudinal dissonance associated with science and education. There are distinct differences in whether the participants self-identify as an educator or as a scientist. For example, Stiles, a member of the GSMIT administrative staff, more than once expresses, *"I'm not a scientist."* Sarah, the citizen science coordinator, clearly holds a contrasting view. She states, *"You know, I was a biologist, strictly a private land wildlife biologist for a year and now I am both a biologist and an environmental educator."* Tricia, the teacher-naturalist mentioned previously, finds herself somewhere in the middle stating that citizen science, *"means helping people realize that everyone's a scientist."* Each of these individuals has a different interpretation of what "being a scientist" means, and in some cases, they draw a very clear delineation between these two worlds. Sarah is comfortable moving between these two perceived identities, and yet she still makes a distinction. For her, science is something that is separate and different from her role as environmental educator. Sarah also perceives this schism in other teacher-naturalists at Tremont, saying, *"It's just they are more educators than scientists. But, that's what they're here for. They're here to teach; they're here to be educators."* Despite this apparent dichotomy, citizen science blurs the line between the two identities and can merge them. For example, teacher-naturalists are being pushed to get out of their comfort zones and try on the different hat of a scientist, while those who are more science-oriented experience what it means to be an educator.

At the heart of this issue is whether non-professional scientists can conduct scientific research without the oversight of a professional. If a project does not involve a professional researcher, can it be termed science? Are those individuals who participate in and facilitate citizen science projects scientists? It seems that the current normative definitions of science and scientists may be too restrictive. According to Mueller and Tippins (2010), "science" knowledge has more to do with power and ideologies than with its usefulness or role in society, and we are reminded that science involves complexity, diverse knowledge, and different skill sets. Although Mueller and Tippins discuss "science" in relation to traditional ecological knowledge (TEK), this position is just as relevant in terms of educators discussing whether the data their students collect in a class setting is to be considered science and if they are, on some level, actually scientists. Citizen science opens up new educational opportunities and is viewed as a way to educate the public and democratize scientific literacy by encouraging individuals to take a step into the world of science where they may have previously been uncomfortable. Therefore, incorporating citizen science projects into the educational programming for schools at GSMIT has significant implications for science education.

Tremont School Programs

GSMIT school programs are offered from September through November, and again from February through May. Programs include students of all ages, although the majority of the students attending are in grades six to eight. The length of stay on the Tremont campus ranges from three to five nights. Eighty six percent of the attending schools participate in a cooperative teaching model that requires participating classroom teachers to teach a portion of the lessons during the GSMIT experience. In a detailed analysis of programs, Walker (2012) examined curricula and methods of instruction. His study revealed a dynamic relationship comprised of the school and on-site collaboration between teachers and naturalists. This section provides a brief background of the ideal curriculum and methods of instruction for environmental/ science education that are part of the GSMIT experience, Tremont's curricular objectives, and implementation of their program.

Implementing the Tremont Curriculum

GSMIT's curricular resources follow a format that outlines essential questions and desired learning objectives, including several inquiry activities that can be used in teaching. Observations of instruction reveal that all lessons are taught using varying levels of science inquiry to accommodate the needs of the students (Walker 2012). Specifically, materials can be used to teach the same lesson using a more structured or guided inquiry methodology for younger or less experienced students. A more open style of inquiry is used with older or more experienced groups. All lessons include a "backstory" or rationale for the activities involved that allows students to apply the activity to a real life situation. This reinforces the need for later action by participants or for connecting the ideas of what they are learning to the larger context of ecosystems.

Many schools request to participate in citizen science projects during their time at GSMIT. While citizen science projects can be an effective way to deliver science content, there are some difficulties associated with incorporating data collection into the school programs. First, since students stay only a few days, they do not see the entire scientific process. Most of the time, students are only involved in collecting data to be archived for a specific project. Although Tremont naturalists make an effort to explain to the students how these data fit into a larger project, often students are left wondering about the exact significance of these projects. Because most school programs attend GSMIT for only 3 days, students rarely get to experience a fully open inquiry process, and unfortunately those that do are not usually participating in citizen science projects. Another major issue with implementing citizen science projects is that teachers lack confidence with their own level of science content knowledge and their understandings of the scientific enterprise. This becomes a significant barrier when connecting citizen science projects back to the classroom. Very few of the teachers implement citizen science projects in their schools, giving students the faulty perception that nature is something that exists only at Tremont and not at home in their local community. In an attempt to overcome this barrier, GSMIT provides teachers an opportunity to participate in on-site instruction with naturalist teaching staff, which is described as the co-teaching initiative.

This cooperative model is unique to GSMIT and has been a major component of their educational vision for the past 27 years. From the beginning, there have been essentially two instructional models used by environmental educators to deliver outdoor education: (1) those that provide resources to teachers and allow them to teach the material, and (2) those that provide the resources to teachers, but use their own staff to deliver instruction. GSMIT's leadership and instructional staff have recognized the importance of including teachers as partners in instruction through the cooperative teaching model and continue to incorporate this model as a central component for achieving the objective of connecting people to nature. The underlying philosophy of providing teachers the support they need through cooperative teaching acts as positive reinforcement to successfully teach in an outdoor setting. Teachers are better able to apply what they have learned at GSMIT and their school site. This philosophy broadens the educational scope of GSMIT because these teachers can then provide students with additional opportunities to connect with nature whether or not they were able to attend the GSMIT experience. There is also a financial incentive for schools to participate in cooperative teaching. Because GSMIT can assign fewer staff members to the group, the school receives a reduced registration rate. In order to receive the reduced rate teachers must attend a focused professional development workshop prior to attending with their students. These workshops, referred to as *teacher escape weekends* offer the opportunity for teachers to meet one another, exchange ideas, and get to know GSMIT staff members. The teachers also familiarize themselves with the setting and program offerings. For GSMIT, the escape weekend is an opportunity to showcase new lessons or provide professional development that focuses on the most common sources of anxiety for classroom teachers: (1) lack of experience to teach the outdoors, (2) lack of content knowledge, and (3) the influence of a teachers' level of interest on student learning. *The classroom teacher's lack of experience teaching in the out of doors* may cause them to experience anxiety and an inflated sense of perceived difficulty for their students. The observed influence on instruction that results from this lack of experience includes behaviors such as teachers simplifying or watering down questions asked by the teacher-naturalists, providing hints, or even answering the questions for students. These responses from teachers may be an attempt to shield themselves from the embarrassment caused by the possibility that their students do not answer the naturalist's question. However, the interference caused by the teacher becomes a barrier to learning because students are not allowed opportunities to think about the information being presented. They often just simply wait until the teacher jumps in, instead of struggling with the new information from the naturalists. One teacher explains that she is in what she calls, "accommodation mode." She explains, "*I can't help but to give them hints to find* *answers. I know I need to let them work it out for themselves, but it's hard not to help.*" When the same teacher is asked if she accommodates students in a similar way in the classroom she replies, "*No, I don't, because I know what they [students] are capable of. The children are being challenged in different and new ways, and I respond to their difficulties. I am learning to resist that temptation to swoop in and help.*" This teacher recognizes that this action is negatively impacting student learning, but she fails to see that her perceptions are faulty. She thinks that the students are anxious or uncomfortable when, in fact, the students appear fine. They are being challenged in new and different ways, but these new ways of learning are not causing problems; it is the teacher's own anxiety that causes him/her to falsely perceive these difficulties.

Tremont professional development addresses this issue by modeling effective instruction techniques during escape weekends, as well as working with the teachers to deconstruct the experience. Having teachers participate as "a student" first gives them confidence to conduct inquiry in the outdoors from the learner's perspective. Deconstructing the experience is a critical component because it allows the facilitators to draw attention to aspects of instruction that may be overlooked by teachers. Using modeling as an instructional technique for professional development (and preservice science teacher education) is widely accepted because it provides teachers an example they can emulate (Supovitz and Turner 2000). It allows teachers an opportunity to reflect specifically about the nature of inquiry and conceptually link it to ways in which inquiry can be brought into the K-12 classroom (Windschitl 2003). After deconstructing the lesson, teachers have an opportunity to apply these instructional techniques with peer review or feedback.

The classroom teachers' lack of both content and pedagogical knowledge for teaching in informal settings causes them to develop a perceived sense that they need to be the expert. Classroom teachers often try to disguise the fact that they are not content experts. They may use vague language, which results in unclear instruction. Or proceed through a lesson at a fast pace requiring students to struggle to keep up and reducing the number of questions the students can ask. These are just some of the strategies teachers employ to mask insufficient content knowledge. Despite that, students are quick to see through the facade, and once they do, everything the classroom teacher says is questioned. Students typically turn to the teacher-naturalist for answers if they have a specific question, except when during cooperative instruction the teacher naturalists are not around. This means the students' question are not immediately addressed and goes unanswered. When teachers approach their role as someone who is learning along with the students, the situation creates a more stable learning environment for all parties.

Teacher level of content knowledge is addressed during the these escape weekends through an emphasis on effective questioning techniques where resist the urge to provide immediate answers to teachers' questions. In the professional development for classroom teachers, content knowledge is specifically addressed in order to alleviate teacher anxiety about the perceived need to be a subject expert. *The classroom teachers' level of interest* is arguably the most influential causal condition observed that impacts student learning. When teachers appear to lack enthusiasm, are disengaged or inattentive, the students become distracted and, in turn, use the same inappropriate behavior modeled by the teachers. GSMIT professional development addresses the teachers' level of interest through an explanation of the importance of modeling. Teachers follow the example of appropriate environmental behavior put forth by the naturalist instructors and are reminded to ensure that the parent chaperones that accompany the group also follow their example. Explicit instruction on this topic supports concepts extracted during the deconstruction of the modeling session. Providing examples of inappropriate behavior allows teachers an opportunity to identify such issues in situ. Furthermore, they act as an authentic assessment for teachers understanding of effective instructional strategies.

As a setting for outdoor environmental education, Tremont has the unique ability to inspire natural curiosity in both the students who attend as well as the teachers who participate in its programs. They do this by providing a spark, an idea, or a newfound enthusiasm for learning and participation in hands-on science investigations in the field. Most teachers say that they gain a new appreciation for the use of inquiry instructional methodologies and the outdoor classroom space. First-time teachers participating at Tremont are always skeptical of this type of teaching—they don't feel that they have the resources or the time in their standards-driven classroom. After participating in the Tremont experience these teachers quickly change their perspectives as they realize the importance of allowing students the time to struggle with new ideas and information. Many teachers also realize that a large space or natural area is not a requirement for cultivating the benefits of teaching in the outdoors. They can achieve their desired learning outcomes by taking their students into the schoolyard or small parks in urban areas. These shifts in teacher perception are in line with GSMIT's major goals and objectives. By connecting teachers to nature, GSMIT has the ability to significantly broaden the scope of its impact far beyond its geographical boundaries. This focus on teacher involvement makes Tremont very unique in the world of residential environmental/ science education and surely puts them on the forefront of educational research.

Summer Youth Science Leadership Internship

The goal of the Summer Youth Science Leadership (SYSL) internship program at the GSMIT is to provide communities with responsible citizens and new leaders in environmental fields. The SYLS summer internship was established in 2001 to provide area high school students with an opportunity to explore future science careers and encourage them to consider pursuing science, technology, engineering, and mathematics (STEM) related areas of study in college through the early exposure to citizen science projects at GSMIT. At GSMNP, these programs exist under the guidance of the Citizen Science Coordinator. One to three SYSL interns are hired each summer based on their area of interest and research skills and complete 300 h of scientific research and service. Because residential boarding is not available, all interns live within commuting distance of GSMIT. In addition to working on the ATBI and other citizen science projects, interns also assist with camp programs and generate weekly/biweekly reports, called the *Friday Science Report*.

Tremont's SYSL experience provides multiple entry points for understandings about the scientific process, natural history, environmental education and stewardship, plus an introduction to different career trajectories in science and environmental education. Although GSMIT administrators and funding agencies recognize the obvious advantages of providing young adults with applied summer field experiences, until 2009, a formalized study has never been conducted to support the merit of the internship. In 2009, a study was undertaken to investigate: (1) what SYSL interns perceive as an understanding of the natural history of the GSMNP as a result of their participatory citizen science research experience; (2) what interns perceive as an understanding of scientific methodology; (3) what interns perceive as an understanding of environmental stewardship and/or are sharing that understanding with others; and (4) whether or not interns pursue careers in environmental education and/or scientific research. Nineteen interns have participated in the SYSL experience since 2001; 13 agreed to participate in this study (4 males and 9 females). At the time of their internship more than 70 % were high school students or entering college freshmen, with the remainder already enrolled in undergraduate programs. The majority of interns heard about SYSL through family, friends, teachers or classmates in high school or college and nearly one fourth had attended a Field Ecology camp at GSMIT prior to being hired.

Findings from the analysis of research interviews and weekly science reports in this study reveal themes of *Experience*, *Self Confidence,* and *Sharing with Others* by interns about their internship (Tenenenbaum 2012). This relates to what the interns either observe or come to understand in regard to the science behind the research projects, learn about environmental stewardship, or feel about their ability to be successful in school coursework or seeking employment.

Perceived Understanding of Natural History

The SYSL interns develop an understanding of natural history topics as they work on science research projects with visiting scientists, the citizen science coordinator, and their peers. Weekly research projects, generally, include studying species diversity in GSMNP. Phenology of seasonal changes, ozone monitoring on plants, tardigrades, trapping insects, salamander and snake board checks, and bird counts are some of the internship projects that require natural history knowledge about a specific organism or ecosystem. The interns report enjoying the majority of the research projects because they are learning about natural history while working outside. More than one third of interns talk about assisting with the moth collection or bird mist net repair and find these endeavors to be tedious but also realize that maintaining a collection or equipment is important work.

Transcripts and *Friday Science Report* issues document intern accounts about the life history and ecology of their species of interest. For example, several interns work with microscopic animals in the Phylum Tardigrada. During an interview, one intern describes the characteristics of tardigrades and their survivability in a dehydrated state:

> They're microscopic animals. They're segmented. They have eight legs. They're kind of cute… One of the neatest things about them is that they can dry up. They live on lichens and moss generally. You can find them in water or on beaches. If water is scarce or other resources, then they dehydrate themselves into these tuns…. Some people think years. Some people think months. I think it depends on the tardigrade.

An example of an interns' natural history narrative in the *Friday Science Report* includes details about the life cycle of the dobsonfly found in many moth traps:

> The Dobsonfly belongs to the Megaloptera order, which has only 2 families and 46 species in North America. Before this insect can fly, it begins as a Hellgrammite, which resides in spring seeps, streams, large rivers, swamps, and ponds…The larvae are beneficial to the environment because their activeness can improve diversity in the community…. At times, the Dobson flies traumatize the research interns. Perhaps this is because there have been more than 10 of these beasts, as we like to refer to them, in the moth trap at one time…

Perceived Understanding of Scientific Methodology

The interns gain first-hand knowledge of scientific methodology as they observe, collect and report data for research projects. In addition, they interact with visiting scientists and present information about their research projects to others. The interns describe a wide variety of research projects either in their responses to interview questions or in articles in the *Friday Science Reports.* The projects they discuss include plant monitoring, trapping/collecting or identifying insects, salamander or snake monitoring, bird banding, ozone monitoring on selected plants, and stream monitoring. Although interns do not establish protocols or generate research questions, their experience and science skill development is evident. An intern describes in detail sampling strategies for salamanders, for example:

> … We have set up salamander bags which are bags made of chicken wire not tied at one end and filled with leaf litter and kind of left in the stream. The salamanders are attracted to the wet, moist, kind of nasty environment created by the decaying leaves… We empty the leaves and strain them and basically extract all of the salamanders. Put them in bags and weigh them and measure them….

For many interns, the SYSL experience gives them confidence in their ability to participate in scientific endeavors. Several interns express that they are more confident about engaging in future projects and working in the field. For example, when asked about research experience prior to the internship, one intern responds, *"I was familiar with it. I had taken biology with my friends in school. I had never applied it before in a real scientific project. It made me feel really confident and* *felt like I had a bit of an edge when I went to do research of my own because I had done it before."* In another example, a female intern struggles with her fear of snakes but realizes the importance of being a full participant in the research. She overcomes her fear and becomes more knowledgeable and confident about working with snakes:

> …I went in terrified of them thinking that I'm not even going to be able to do this. I went in with a closed mind when I was dealing with the snakes at first. I really had to break my own spirit. You're doing this, which means you need to be a full participant. You can't pick and choose. If you're going to do it, do it. But if not, then you need to tell them you can't do it. So that's when I really opened up my mind and was able to let my mind go. I started learning about snakes.

The internship gives her an opportunity to learn more about herself and to realize her potential. She reports, *"The self-confidence has to be the thing that I learned the most. I've never been a timid or shy person, but there were things that I set back from. I think that opened the door to my self-confidence and showed me that I was smarter than I was even giving myself credit for."*

Interns also mention learning something about self in regard to science interest and are able to see how the process of science works. One intern says, *"I did learn that I had an interest in science. I wasn't really confident about that before I took this internship. And then once I was able to do it and kind of see everything in action. It kind of brought it to life for me if that works. I got more interested."* Being a participant and not a by-stander in the process makes science something real to them. He expresses this best when he continues to say, *"…we were able to take what we learned and explain it to other people. It's important in the scientific world to be able to do that. But, also, it was kind of rewarding to us to be able to pass that on."*

Perceived Understanding of Environmental Stewardship

The interns develop an understanding of environmental stewardship/education and how to share it with others because they observe the staff and visiting scientists teach about these topics. In addition, they participate as leaders themselves. All of the interns say they learn about topics in environmental stewardship/education during the internship including recycling, saving or composting leftovers, environmentally friendly building practices, and wildlife as indicators of pollution. More than half respond that they learn it is important of sharing environmental knowledge with others and taking steps to make the world a more environmentally friendly place through actions such as recycling, purchasing hybrid cars, installing solar panels at home, or becoming involved with environmental programs at their school or work.

As a result of their experience, many interns become more confident in their ability to start EE programs in their community. One intern reports that he started an outdoor activity environmental club at his high school—which adopted a stream at GSMIT where salamander monitoring occurs. Another meets with the principal at the school where she works to help implement a program similar to GSMIT's efforts to save leftovers and maintain a compost pile.

Career Choice in the Sciences

Many students who participate in the internship program feel that the experience helps them to make decisions about a major in college. As a result of their SYSL experience, two interns become biology majors, one becomes an environmental education major in graduate school, and another reports that her internship helps her obtain a Fulbright archaeological research scholarship. All of the interns report interest in doing scientific research in the future with the majority expressing a desire to focus on research in basic and applied scientific fields; they believe that their internship experience will help them to obtain jobs or fellowships.

There are a number of studies in the literature about experiences that influence career choice in the sciences. The impact of family is important according to Adaya and Kaiser (2005) who find that parents, especially fathers, are more influential than teachers in a girl's decision to pursue a career in a STEM field. Having an opportunity to develop research skills is also found to be important in a study conducted by Kardash (2000), who analyzes the undergraduate research intern experience at Carnegie University and its effect on learned investigative skills for a future career in the sciences. The study finds improvement in these skills for both males and females. A study by Armstrong et al. (2007) explores African-American interests in the field of ecology. They find three factors influence career choice: family encouragement, ecology research experience, and knowledge that a career in ecology is worthwhile. These findings resonate with this study where interns live at home but are supervised closely by a GSMIT Citizen Science Coordinator as they engage in authentic field ecology research experiences and citizen science.

GSMIT is accomplishing the goals of its mission through the SYSL internship program. These goals include providing experiences to students so that they can appreciate the diversity of species in the GSMNP and learn to become stewards of the park. This study shows a glimpse of what citizen science projects and an internship program can do for the participants as they plan their future career goals. Overwhelmingly, interns admit they benefit from the experience and gain new knowledge and confidence. Many are also sharing knowledge gained from the internship about environmental stewardship with others.

The GSMIT Experience, Citizen Science, and Science Education

GSMIT's impact on environmental/ science education through citizen science initiatives, school programs, and internship opportunities provide a model for other organizations across the country and, indeed, across the globe. As shown by these studies, citizen science can connect students and participants more deeply to their communities and develop stronger environmental awareness. In addition, citizen science can make science interesting and relevant to children, young adults, and professional adult facilitators. This is a crucial step in developing a scientifically literate society. From these studies it is apparent that citizen science at GSMIT has the potential to be influential in peoples' lives whether in science or community involvement. However, we suggest that more exposure to citizen science and nature in the formal classroom context will be even more influencial in terms of encouraging youth to see themselves as scientists as well as allowing them opportunities to develop science process skills. It is for these reasons that we assert that science educators should more fully embrace what citizen science can offer the science curriculum. With the establishment of A Framework for K-12 Science Education (National Research Council 2012), students are now being asked to critically think at multiple levels and make claims based on evidence supported by reasoning. Citizen science permits the learner to engage in the process of scientific inquiry rather than be a by-stander with a worksheet in hand. Citizen science has a long history but many educators are still unfamiliar with it and how it could have significant impacts in terms of exciting their students about science. Schools need to invest in professional development and teacher education that focuses on how to teach outdoors and, more specifically, how citizen science can be used to meet the state standards while at the same time fostering student enthusiasm. It is then that science and environmental literacy will be significantly increased. In addition, communities would be strengthened as students are empowered to become directly involved in learning about the environment and issues of where they live.

References

Adaya, M., & Kaiser, K. M. (2005). Early determinants of women in the IT workforce: A model of girls' career choices. *Information Technology & People, 18*, 230–259.

Armstrong, M. J., Berkowitz, A. R., Dyer, L. A., & Taylor, T. (2007). Understanding why underrepresented students pursue ecology careers: A preliminary case study. *Frontiers in Ecology and the Environment, 5*, 415–420.

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen science: A developing tool for expanding science knowledge and scientific literacy. *BioScience, 59*(11).

Kardash, C. M. (2000). Evaluation of an undergraduate research experience: Perceptions of undergraduate interns and their faculty mentors. *Journal of Educational Psychology, 92*, 191–201.

Linzey, D. W. (2008). *A natural history guide to Great Smoky Mountains National Park*. Knoxville: The University of Tennessee Press.

Mueller, M. P., & Tippins, D. J. (2010). vanEijck and Roth's utilitarian science education: Why the recalibration of science and traditional ecological knowledge invokes multiple perspectives to protect science education from being exclusive. *Cultural Studies of Science Education, 5*, 993–1007.

Mueller, M. P., Tippins, D., & Bryan, L. A. (2012). The future of citizen science. *Democracy and Education, 20*, 1–12.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas* (Committee on a conceptual framework for new K-12 science education standards). Washington, DC: The National Academies Press.

North American Association for Environmental Education (NAAEE). (2004). *Environmental education materials: Guidelines for excellence*. Washington, DC: Author.

Smith, G. A., & Sobel, D. (2010). *Place- and community-based education in schools: Sociocultural, political, and historical studies in education*. New York: Routledge.

Stapp, W. B., et al. (1969). The concept of environmental education. In H. R. Hungerford, W. J. Bluhm, T. L. Volk, & J. M. Ramsey (Eds.), *Essential readings in environmental education* (2nd ed., pp. 33–36). Champaign: Stipes Publishing.

Stern, M. J., Powell, R. B., & Ardoin, N. M. (2008). What difference does it make? Assessing outcomes from participation in a residential environmental education program. *Journal of Environmental Education, 39*, 31–43.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37*, 963–980.

Tenenenbaum, Z. (2012). *A qualitative analysis of the long-term impacts of the Summer Youth Science Leadership Intern Program at the Great Smoky Mountains Institute at Tremont.* Unpublished master's thesis, Middle Tennessee State University, Murfreesboro, TN.

UNESCO. (1978). *Final report, Intergovernmental Conference on Environmental Education,* organized by UNESCO in cooperation with UNEP, Tbilisi, USSR, 14–26 Oct 1977. Paris: Author.

UNESCO-UNEP. (1976). The Belgrade charter. *Connect: UNESCO-UNEP Environmental Education Newsletter, 1*, 1–2.

Walker, R. M. (2012). *The relationship between middle level school science programs and a residential environmental learning center.* Doctoral dissertation. Retrieved from ProQuest Dissertations and Theses (Accession Order No. AAT 3522055). University of Arkansas.

Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education, 87*, 112–143.

Lynda L. Jenkins teaches biology and environmental science at The Galloway School in Atlanta, Georgia and is a doctoral candidate at the University of Georgia. Her doctoral research focuses on the use of citizen science as an educational context in science and environmental education.

Ryan M. Walker Science Education, Mississippi State University. Walker has worked with Tremont to expand their teacher professional development. His research interest included understanding the relationship between formal and informal science education and developing teachers confidence for teaching in the out of doors.

Zena Tenenbaum graduated from Middle Tennessee State University in 1994 with a degree in biology. She worked as an interpretive naturalist at the Martha Lafite Thompson Nature Sanctuary in Liberty, Missouri before returning to Middle Tennessee State University to complete her Master's in biology and environmental education.

Kim Cleary Sadler is an associate professor of biology and co-director for the Center for Cedar Glade Studies at Middle Tennessee State University. She is interested in questions related to out-of-school time learning and informal science education.

Cathy Wissehr received her Bachelors and Masters degrees from Southeast Missouri State University. After teaching in rural schools in southeast Missouri, she completed her doctorate in Science Education from the University of Missouri. She joined as the faculty of the University of Arkansas where she teaches courses in elementary science methods. Her research interests include science learning in informal environments and teacher misconceptions.

Chapter 17
Democratic Participation with Scientists Through Socioscientific Inquiry

Kristin Cook

Attempting to ground scientific knowledge in a relevant and meaningful context, the use of socioscientific issues (SSI) in the classroom seeks to encourage students to formulate a critical understanding of the interface between science, society and technology. While rhetoric on SSI in the science education community posits lofty goals such as citizenship education, enhancing students' connections to science, and empowering students for the betterment of society (Sadler et al. 2007), more research is now needed to investigate fully the potential of these targets. Most of the SSI research focuses heavily on the development of students' argumentation skills and consideration of multiple views in deliberation about controversial issues such as climate change and genetic engineering (Kolstø et al. 2006). While these are indeed valuable aims centered on important global issues, it is also imperative that SSI-focused education be situated in students' local communities, connected to their immediate interests, and tied to reflections upon their personal views and the critical dissection of multiple perspectives. Bolstering the SSI and local community connection provides opportunities for students to become active participants and contributors in their community (Hodson 2003).

Responding to calls for democratizing participation in science (Hodson 2003; Mueller et al. 2011) through the study of SSI, Claudia Melear (1999) argues that current preparation does not adequately enable preservice teachers (hereafter PSTs) to experience authentic inquiry participation in SSI and thus inhibits them from being able to provide these experiences for their future students. Consequently, we have seen in the research the multitude of reasons teachers reference as to why they do not feel comfortable teaching SSI in the science classroom (Hughes 2000).

K. Cook (✉)
Annsley Frazier Thornton School of Education, Bellarmine University,
2001 Newburg Road, Louisville, KY 40205, USA
e-mail: kcook@bellarmine.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_17

Melear recommends that training for PSTs should involve "hanging around with" scientists who have varying degrees of expertise, in order for them to be properly enculturated into the science they will be expected to teach. She argues that scientists have a unique role in the preparation of science teachers, and that pre-service teachers should be provided with research opportunities just as those opportunities are provided to students majoring in science. Her research suggests that science educators should work collaboratively and diligently with scientists to provide these kinds of opportunities for pre-service science teachers and moreover, they should be built into the teacher preparation curriculum. These aims were investigated in this study; thus, the question guiding this study is: *In what ways does incorporating a student-scientist collaboration into SSI-based instruction meet ideals of promoting democratic participation in science?*

Democratic Participation in Science

Frank Fischer (2000) provides a theoretical and pragmatic exploration of the relationship between citizens and experts, in questions of environmental management. Balancing expert perspectives with lay perspectives in policy discussions, which Fischer terms 'practical deliberation,' requires that lay-citizens be able to participate substantively in shaping discussions of local environmental concerns. Practical deliberation "seeks to bring a wider range of evidence and arguments to bear on the particular problem or position under investigation" (p. 78). According to this model, understandings of local environmental concerns can be normative and value-laden, but also incorporate knowledge funds ranging from direct observation of the effects of hazard exposure to interpretation of scientific claims in light of personal interaction with a contaminant. Studies theorizing *citizen science* characterize student participation in finding and implementing resolutions to environmental problems. These studies examine connections between (1) scientific uncertainty over environmental concerns, (2) the development of policies to regulate pollution and manage its effects, and (3) the contributions of lay publics to understanding and managing environmental risks. Irwin (1995) argued that local laypersons, or non-scientists, contribute unique and situated expertise and serve "not only in criticizing expert knowledge but also in *generating* forms of knowledge and understanding" (p. 112). It is here, within the exploration of SSI, that students can begin to understand as well as participate in scientific issues of personal relevance.

SSI's potential to increase students' democratic participation in science can be drawn from Chantal Pouliot's (2008) work with post-secondary students. She explains how students ascribed to a deficit model of citizen's knowledge and comprehension in public debates of SSI issues. She employs a framework that expands on the 1999 work of Michel Callon on the '*Deficit*,' '*Public Debate*,' and '*Co-production of Knowledge*' models of citizen participation in science. These models are differentiated in terms of the visions they provide of the legitimacy ascribed to the participation of citizens and scientists in debates, of the value and potential contributions of the knowledge held respectively by lay citizens and scientists, and of the roles of citizens in the production and dissemination of scientific knowledge. According to Callon (1999), the *deficit model*, as applied to citizen science, works from the premise that only scientists are able to grasp the full complexity of SSI. Under this model, exchange between scientists and citizens is predominantly unidirectional – namely, researchers inform a public that is considered to hold a deficit of the scientific knowledge needed to shed light on the issues being debated. The *public debate model* reconfigures the roles of scientists and citizens by encouraging interaction in spaces of public discussions. Citizens' knowledge, though different from that of scientists, is conceived of as enriching the problematization of SSI. The *co-production of knowledge model* is characterized by a redistribution of the roles of participation in the production of scientific knowledge that are integrated into the decision-making processes. Pouliot's (2008) case study of learners' perspectives within SSI illuminate that students ascribe to the deficit view of their role in science. She contends, along with many others (Roth and Désautels 2004) that SSI-based instruction ought to enable young people to position themselves as legitimate, competent partners in the SSI-related discussions with which their society must grapple.

A Class' Collaboration with Campus Scientists

A case study approach helped to define the boundaries of the unit of study (in this case, a class collaboration with campus scientists). Yin (2003, p. 13) asserts that a researcher chooses the case study design because he/she "deliberately wanted to uncover contextual conditions-believing that they might be highly pertinent to the phenomena of study." For this study, the phenomena of interest (PSTs' experience) and the context (a course which structured collaboration between PSTs and campus scientists) were intertwined in the case and a central part of the purpose of the research.

Twenty-four undergraduate PSTs enrolled (15 females, nine males; 2 African-American, 2 Hispanic or Latino, 20 White) in a Mid-western university class voluntarily participated in this semester-long study. The class, *Introduction to Scientific Inquiry,* was comprised of PSTs who expressed an interest in becoming elementary school teachers. PSTs were chosen for this study in response to literature asserting that science teachers often marginalize controversial issues in their classrooms and need opportunities to reflect on their deeper values and ideals with regard to teaching SSI (Reis and Galvao 2009). The overarching goal of the course was to engage students in authentic SSI-based inquiry. As such, activities throughout the semester centered on inquiry, the nature of science, data analysis and interpretation, and connecting learners with both the on-and off-campus scientific community with regard to local campus environmental science issues. The six participating scientists (three female, three male; ranging in age from 31 to 60 years) were selected because of their affiliation with the Office of Sustainability's project initiatives (i.e. transportation, water quality, energy usage, availability of healthy food options, greening computer usage, the adoption of e-books, campus community gardens…). The scientists agreed to attend one of the class sessions to brainstorm project ideas with the students and update on current happenings. They also agreed to communicate with them via meetings outside of class, phone, or email throughout the duration of the semester. Table 17.1 details the partnerships surrounding the SSI-based inquiry projects.

The data collection occurred during a semester-long period during the fall, 2010. Classes were held twice a week for 2 h each. Collaboration with the scientific community was held during class time. The author's reflective journal detailed field notes and ongoing commentary about student-scientist partnerships, which helped to aid in reflection on teaching and confronting assumptions about the collaboration between students and the scientific community. As well, PSTs maintained ongoing journals throughout the semester to reflect on their participation (see Appendix for specific journal prompts). The analytic process consisted of organizing the dialogical data (from field notes, interviews, and classroom observations) and identifying which data units were most likely to answer the research question (Carspecken 1996). Data were coded to classify the ideas and events that the participants referenced. Low-level codes were grouped together by constructing a hierarchy in which some codes subsumed others. This resulted in the formulation of a few large thematic categories that matched the analytic angles of the study- namely, agency, power, and empowerment.

PreService Teacher's Experience in Collaboration with Scientists

The findings stem from the construction and effects of a classroom experience that enabled an opportunity for democratic participation to occur with local scientists. In this study, "democratic participation" is investigated as a means to promote scientific literacy, i.e., employing scientific knowledge and skills to critically engage with contemporary issues and arguments (Levinson 2010). Furthermore, democratic participation here stands in contrast to research apprenticeships (Sadler 2010) or student-scientist partnerships whereby the student is meant to acquire the skill set of scientists and maintain an institutional hierarchy that largely neglects democratic participation. We see this in traditional citizen science programs as well- the essence of which has historically been for students to collect data that contributes to scientists' projects. As Angela Calabrese Barton noted, opportunities for democratic participation in these types of experiences are limited:

> Citizen science, as a tool, historically has not been about democratizing science-about offering multiple perspectives or transforming a knowledge base or a set of tools or resources- but rather has been about getting more work done (2012, p. 2).

Democratic participation by pre-service participants is thus aligned with Calabrese Barton's idea of *citizens' science* in which students employ deep and

Table 17.1 Description of SSI inquiry projects

Inquiry topic	Inquiry question	Project description	Science content embedded in project
Electronic waste	If provided with easy-to-access options for disposal, would students recycle their e-waste?	Group placed e-waste collection bins and educational flyers inside three residence halls to gauge amount of that could be recycled; conducted surveys to assess student awareness of and willingness to dispose of e-waste properly; their e-waste collection sites were adopted for use by the university	Environmental Science, waste effects
			Measuring, data collection, interpreting lab results
			Chemistry, elements, compounds
			Health, toxic hazards
Nutrition	Does nutrition awareness affect food choice among students?	Group conducted a pre and post analysis of ‘healthy’ vs. ‘non-healthy’ choices made by students after being made aware of nutritional facts; results helped develop a blog for motivating students to participate in a healthy eating campaign	Research-based guidelines for a nutritionally balanced diet
			Relationship between poor eating habits and chronic diseases
			Food processing effect on food quality, safety, nutrient content, and the environment
Energy	What motivates students and faculty to become more energy conscious and be actively involved in energy conservation?	Group surveyed students, professors, teachers assistants, and building managers from both the Chemistry building and a Dormitory in order to determine a plan of action for incentivizing energy conservation	Energy types, sources, conversions, and their relationship to heat and temperature
			Advantages and disadvantages to alternate forms of energy
			Inquiry process skills
Greening athletics	How much waste from our athletic dining halls could be diverted from the landfills?	Group conducted a waste audit at the athletic dining hall, sorting waste into Recyclable materials, Compostable materials, and trash to provide a percentage of waste that could be diverted from landfills	Advantages and disadvantages to alternate forms of energy
			Measuring, data collection, interpreting lab results
			Ecological degradation
			Advantages and disadvantages to alternate forms of energy
			Measuring, data collection, interpreting lab results
			Ecological degradation

critical analyses of their connections to community and their sense of place to leverage their contribution to conversations about science that directly or indirectly affects their lives. Here, democratic participation is assessed in the varied data sources through critiques of PST interactions with scientific community members and through an evaluation of all participants' analyses of the partnership.

PSTs Find Their Voices in SSI: "It Feels Like It Matters"

Opportunities to address problems of local concern allow PSTs to connect science in the community to their everyday lives. Basing their study of SSI in local issues is an essential part of curricular engagement as PSTs address problems of local importance and concern. In doing so, they are able to gather novel and important insights that give them an appreciation for the science in their lives and how it connects them to others:

> By working on inquiry projects on campus, I learned how science can directly affect our everyday lives. Between doing our hand-on experiments and researching online and in journals, I have come to see how one thing that seems small in science can have a big effect. This is the kind of thing where I find science most valuable; one scientific idea affects whole populations, including me (Amelia, Student Journal, 12.9.10)

The connecting of PSTs to environmental issues on campus immediately sets the tone of the classroom inquiry as one that focuses on the generation of solutions. PSTs naturally want to make their campus a better place and in desiring to do so they became easily involved in proposing solutions about what could be done to remedy a problem or create awareness about a campus environmental issue. In the poster below, developed by the group studying campus athletics for greener alternatives, PSTs propose the introduction of a composting alternative to waste management, based on their waste audit data of how much food is discarded at the stadium arena after football games. As one student in the group reflects (Fig. 17.1),

> I really liked how we engaged with interns on campus and have gotten a chance to explore real socio-cultural issues at our University. We acted like real scientists and stressed the importance of developing our own steps to fulfill this project's requirements, and got data we could work with to reach a conclusion (Brian, Student Journal 12.15.10)

Brian's fore-grounded claim that he 'acted like a real scientist' implies that he had to assume a role in which he could autonomously make decisions about what is important with regard to his chosen inquiry topic.

Jimmy echoed his sentiments about the authentic inquiry embedded in the projects due to their focus on local issues in which he felt he could take part:

> It felt like we did participate in the scientific community just based on the fact that we got permission to do a real project out and around the school. I have to say that it felt like it mattered as I compiled the data to come up with real interpretations. I think that is what I liked best about doing the project (Jimmy, Student Journal, 12.9.10)

The course curriculum fosters awareness of the science in students' daily lives, and also allows PSTs to experience authentic science within their place on the campus

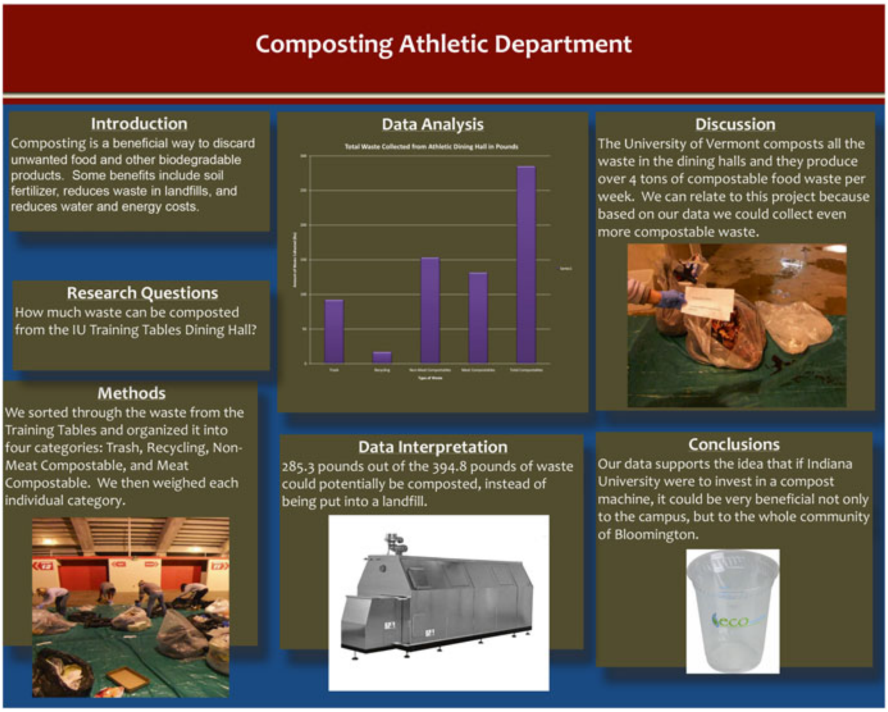


Fig. 17.1 Scientific inquiry project presentation developed by the greening athletics group (Classroom Artifact, 12.14.10)

environment, making science tangible and relevant. Moreover, locating the inquiry project in student's place also affords the opportunity for empowerment, as the information they uncover has the potential to be used by the campus community. The PSTs, through their inquiry experiences, come to view their role in science as important, often claiming they could affect the world through science:

> I did have some feelings about the environment and felt some remorse for what is going on in the world but there are something's that I felt were out of my hands. After taking this class I have realized that I have a lot more power then what I thought I did. (Richie, Student Journal, 12.9.10)

Richie's change in his role or identity with regard to science is an important part of the place-based inquiry that encourages him to engage in his project and get excited about his deepening understanding of science.

It is also important to note that the PSTs consistently reflect how, as future teachers, they will need to be able to draw out the experiences their students have with science in their daily lives: "*Students might not see an immediate connection, but it is a teacher's job to illuminate how science is involved with our daily lives*" (Student Journal, 9.1.10). As future teachers, several of the PSTs note this excitement when they think about their future profession:

> Ten years from now, as a teacher, I would like to be the one who does not decide to sit back, but help change the world instead of creating more harm while also encouraging my students to do the same (Addison, Student Journal, 12.9.10)

The PSTs, through their inquiry experiences, come to view their role in science as important. They immediately associate this new identity with their lives as future teachers. Even when unprompted, PSTs reference teaching SSI in the future, often claiming they could affect the world through science and hope to inspire their future students to do the same.

Challenging Assumptions About the Student-Scientist Collaboration: "I Worry That Students … May Come Off Sounding Naïve"

While planning this classroom experience for the PSTs, environmental issues are chosen to be the focus, as they allow for exploration of the science embedded in these topics and the societal implications inherent in them. A student notes in a reflection on his inquiry project, "*Environmental issues are part of pop culture, but also scientific and social*" (Charlie, Student Journal, 9.31.10). Along with my assumptions that everyone, even non-scientists, can offer something to conversations about the environment, I also assume that it is indeed possible for PSTs to enter into shared interests with practicing scientists where ideas are mutually valued. After all, none of the PSTs had worked alongside scientists in the past and their inexperience with this type of partnership led to concerns that they would not be adequately prepared to work with the scientists, to whom the work on campus environmental issues is their job. I worried that the PSTs involvement would be a possible hindrance to the scientists, and at best, irrelevant:

For his e-waste investigation, Tim Google mapped "electronic waste recycling" and did not get any hits for his Photovoice assignment. He concluded that there was no place in town to recycle unwanted electronic waste. Given the authors familiarity with this town and knowledge of a recycling center south of town that recycles batteries and computers, she advised Tim to dig deeper and research what the local recycling centers offer to take and became concerned about students' misrepresentation of data. "*Our Green Drinks presentation [with the campus scientists] is coming up next week and I worry that students may not be aware enough of the community/campus offerings and may come off sounding naïve*" (Researcher Journal, 10.13.10)

Because this experience is to be mutually beneficial to all, it is essential for the PSTs to be well-prepared, have the necessary understanding of terminology to talk with the scientists, and have unique knowledge to add to the discussions. In an effort to propose solutions to their chosen campus environmental issue, the students also realize they need to understand the background of their topic and what other universities or communities are doing. Also, because they know they will be collaborating with scientists on campus, they need to understand the science behind the topic rather than just the social implications of it. Their inquiry project (in which students investigate a testable question on their environmental topic by collecting data, analyzing the results, and proposing recommendations to scientists working on the issue) is based upon need-to-know information for their topic of interest:

> Prior to this class I knew the basic definitions that are involved with science, however after completing this particular course I now have a new understanding of the different vocabulary that is used. Rather than having little to no understanding as to why experiments are conducted and how different science approaches are useful, I better comprehend why different studies are performed and how scientists become so passionate about their topics of interest. My views on science have definitely broadened with the way this course is facilitated, based locally, and inclusive to the students (Keesha, Student Journal, 12.9.10)

The partnership, in essence, raises the ante of the learning as students are going to need to possess a deep understanding of the issues if they are to make valuable recommendations that will be well-received by the scientists.

Iteratively adjusting assumption about the PSTs' role in data generation became necessary. While I initially envisioned by the author that the PSTs would all conduct experimental investigations to contribute to the scientists' work, this, however, was not what the scientists wanted:

> I learned (in not so quickly of a time) that some of the Office of Sustainability's scientists want student perspective in the form of needs assessments. This makes sense because they want to have full control over implementation of their projects and full control over collaborations with necessary stakeholders. My students stepping in could confuse projects, roles, and perceptions. I have thus changed my initial requirement that students do experimental studies to allowing them to, when recommended, do descriptive studies. This qualitative data is no less scientific and is actually more useful for the campus scientists. As well, we have to wait for permissions for the experimental studies, which really slow our abilities to get started and progress (Researcher Journal, 11.8.10)

Instead of novel experimental designs, the scientists wanted to ascertain the students' perspectives and funds of knowledge on environmental issues on campus. Privileging experimental data collections as if that somehow made the students more helpful or legitimate as participants in the partnership did not meet with the expectations and desires of the scientists in this collaboration. The PSTs indeed are students and the scientists' interest in working with them is just that—to get the students' perspective. They want exploratory data showcasing public and student perceptions. My attempt to propel the students into being researchers were aimed at, in a sense, helping students become equals to the scientists rather than just allowing them to be students learning authentically and contributing to these issues.

Democratic Participation in SSI: "It Is of Vital Importance That We All Work Together"

The PSTs' involvement with the campus scientists is paramount in their feelings of inclusion in the scientific community. They frequently note that there is mutual benefit in their student-scientists partnership in terms of meeting their course goals as well as contributing data that would be useful to real scientists. In a class discussion about the tenets of the nature of science, Leona adds that her group's collaboration with all parties involved in the inquiry ought to be considered one of the essential tenets of conducting scientific inquiry:

> I feel that collaboration is such a big part of the success of science, and our group's success is no different. We have had to collaborate with the professor, the other people to implement our ideas on e-waste collection, the scientist who has been of the greatest help to us, and we have had to collaborate with the other e-waste group from the other class. All of these collaborations have been another key to the success of our project. There is no way only one of us could have done all of this research and planning. It was of vital importance that we all work together to come to an agreement and share our information and data on the project (Field Notes, 11.21.10)

Leona feels that the tenets of the nature of science need to include the 'collaborative nature of inquiry' as it is such an essential component of her ability to design and conduct her SSI-based research study. Thus, the experience of conducting their science learning outside of the classroom in an effort to impact and understand campus environmental issues necessitates a collaboration with those involved in environmental issues.

The PSTs also reflect on the importance of the scientists' involvement in terms of permitting them to conduct inquiries they feel are meaningful to the campus community. Hadley describes how her partnership with the campus food dietician is key to her group's ability to study and contribute knowledge to campus nutrition issues: *"She pulled a lot of strings for us so that we could collect data from a reputable chain restaurant. We couldn't have collected the data that we were able to, or even finish for that matter if it were not for the active participation that we received"* (Student Journal, 12.9.10). Hadley feels that the dietician is eager to help her group because she has an interest in their findings. Brian also works with the campus dietician and alludes to the important aspect of this collaboration in making his work on nutrition seem more like experiencing meaningful science learning. He says,

> I was doing many of the things that I thought scientists had to deal with such as setting up data collection and discussing with experts in the field. As for the data collection, it seemed very scientific. My group had to think through all of the possible ways to collect the data and decide which one would be most effective. As for meeting with professionals in the field, this was when I felt that the science was most legitimate. Raphael has studied nutrition for most of her life and collaborating with her on a project was really cool. She didn't control it though. We were still able to guide ourselves with her support. It worked really well and was enjoyable (Brian, Student Journal, 12.1.10)

Here, Brian illustrates that his experiences are 'legitimate' because they allow him to act like a real scientist, making decisions about how to collect and analyze data that a scientist would perceive as important and valuable. PSTs become more empowered to engage in science that affects their community as a result of working alongside scientists who consider their work meaningful.

Working with scientists on their inquiry projects allows PSTs to feel their impact on the scientific community is meaningful and valued, and that they are part of a team larger than just their class group. Having access to expert knowledge and obtaining permissions to conduct their various inquiries allows the PSTs to be in contact with the collaborating scientists throughout the semester. Therefore, the scientists are aware of the projects and make available opportunities to contribute meaningful data and recommendations that have the potential to be utilized by the scientists. For example, after conducting their food audits at the athletic dining halls, the PSTs are able to contribute the data they analyzed and make recommendations to the Office of Sustainability (which is closely working with the athletic departments to help facilitate more 'green' practices) that have an immediate impact on the campus. Based on their data, the PSTs recommend the use of a composting system and are able to inform others about the amount of food waste that would be re- directed into a potential alternative waste system. The PSTs' data is also used by scientists to advocate for funding for the composting system. Working closely throughout the project with their collaborating scientists, the PSTs discuss motivational issues to generate awareness among the athletes who frequent the dining halls about waste alternatives. The PSTs ask if they can create the design of a biodegradable napkin that can be placed at the dining halls for this purpose. It is unknown whether their design will be used in the dining hall, but the Office of Sustainability was provided with design and the permission to use it if they so wish.

This opportunity to generate knowledge that the scientists consider valuable and to create informational ideas to make other students on campus aware of the environmental issues they are investigating, helps PSTs feel that they are connected to the community through their engagement with science. Working with the scientists on their inquiry projects allows PSTs to feel that they can have an impact in the scientific community and that it is meaningful and valued. This close work alongside campus scientists throughout their conception, design, and implementation of scientific inquiry allows PSTs to be included in the scientific community whereby they have the potential of impacting real change on campus. Another contributing factor to the PSTs developing sense of empowerment through their inquiries is the fact that their research culminates in a final presentation at a symposium during finals week, whereby they have the opportunity to detail their experience and showcase the educational outreach component they develop as a result of this experience. Scientists and other students attend the symposium, and PSTs seem very eager to use their research to educate others about the prospect that their projects might make an actual difference on campus. Students are able to see the fruits of their labor culminate in a change on campus—namely, the opportunity made more readily available due to our focus on students' immediate community/place with which they have familiarity and ownership.

Science Education for Cultivating Activism

Many science educators support the idea that all students should have fair and equal opportunities to become scientifically literate through authentic, community-based science education (Roth and Lee 2004). However, this idea challenges teachers to find ways to help all students feel comfortable with and connected to science. This study provides insights into the ways in which a curriculum can be structured to meet the aforementioned goals. In effect, incorporating collaboration between students and scientists into the SSI instruction is essential to enhancing PSTs' connections to and feelings of inclusion in the scientific endeavor; however, it is paramount for opportunities for democratic participation to center on issues in and of student' communities and place.

Valuing Voice Through the Student-Scientist Collaboration

The structuring of this student-scientist experience closely aligns with citizen science (Cohn 2008) programs, though challenges the institutional hierarchy that historically has been associated with most citizen science programs (Calabrese Barton 2012). Attempting to account for the hierarchical approach to traditional citizen science programs, Wilderman et al. (2004) operationalize citizen science collaborations on a continuum of projects more directed by scientists (a "top-down" approach) to those more driven by learner interests and engagement (a "bottom-up" approach). Researchers have shown that bottom-up approaches to citizen science collaborations increase student (1) interest and engagement in the project, (2) ownership and understanding of the data, (3) building of community capacity, and (4) empowerment to act. Using Wilderman et al.'s guide to the categorization of citizen science, Table 17.2 shows the PSTs' collaboration with scientists to be characteristic of a bottom-up approach:

In this study, students identify the concerns and design their study, collect data, analyze and interpret the results. Finally, they turn their data into action. In this participatory process that centers in their own place on issues that have a direct or indirect affect in their lives, the PSTs' work alongside the scientists to seek solutions for campus environmental issues, allowing bonds of trust and mutual respect to develop. One aim of this project is to shift the power and locus of control for decision-making into the hands of learners and to build their confidence and capacity to gather and contribute knowledge for action in a participatory manner. Through this experience, the tight integration in the collaboration affords the PSTs to contribute meaningful data for the scientists, which is enabled through their developing research questions and data collection protocols created alongside the scientists. Having the scientists actually attend class early on in the semester is helpful in enhancing their burgeoning partnership. Through their discussions,

Table 17.2 Categorizing student-scientist collaboration using Wilderman et al.'s schema (2004)

Who defines the problem?	Who designs the study?	Who collects the samples?	Who analyzes the samples?	Who interprets the data?
Student	Student alongside scientists	Student	Student	Student

PSTs come to realize what information they need to understand to take part in community conversations about the environmental issues and increase their peers' awareness of these issues.

SSI to Promote Ideals of Democratic Participation in Science

Students may inadvertently possess a deficit model (Pouliot 2008) according to the manner whereby they conceive of themselves as legitimate participants in SSI. The deficit does not afford students opportunities to recognize the legitimacy of their unique lay knowledge, which stems from everyday experience, or the contribution of citizens to discuss science with scientists (Pouliot 2008). In this study, the curriculum empowers and encourages PSTs to develop a point of view concerning citizens' attitudes, interests and capacities that moves away from the deficit model toward a public debate model whereby they experience a two-way dialogic relationship with scientists. All of the PSTs experience a public debate model in their collaborative efforts with scientists. The materialization of their roles in the partnership depends on the structures of the student-scientists collaboration and the ways in which these malleable structures are flexed and negotiated.

Results from this study are consistent with research on apprenticeship programs whereby teachers work with scientists on their research. Sadler's (2010) review of research apprenticeships indicates that teachers feel more confident in their abilities to do science as well as teach science as a result of having experienced it firsthand through apprenticeship programs. Researchers have argued that increases in confidence levels result in a transfer of science research methods to classes where they teach or will teach in the future. It remains to be seen if the PSTs involved in this study will invoke community-based research alongside scientists in their future classrooms and moreover, if the structure of those partnerships will align with the goals for democratic participation.

With respect to SSI-based instruction, participation can be viewed through Callon's (1999) conceptual framework to further develop and enable learners to position themselves as legitimate, competent partners in the SSI-related discussions located centrally in their society. Participation in SSI-based environmental issues reflects a fundamentally different relationship between citizens and experts – one that requires the reciprocal sharing of power (Schusler and Krasny 2007). Regardless of whether or not their efforts are successful, engaging in collective action can enhance learners' understanding of social, economic, and political systems as they identify opportunities for and obstacles to realizing their vision. Ultimately, the privileging of student voice in the local community through student-scientist partnerships seems to be foundational for deepening the understanding and connection to science as a process. This underscores the authentic movement of PSTs into a fuller (and more empowered) expression of democratic participation in a scientific community shaped by inherent, yet malleable, boundaries. More importantly, the significance of this study lies in the extension of SSI curricula, which serves as a context for the empowerment and engagement of teachers.

Appendix: Journal Prompts for PSTs

1. Describe ways in which science is a part of your daily life.
2. Does the science you learn in school resonate with your own interests? In what ways?
3. Do you feel included in the process of science? How?
4. A section of the survey asked about your connections to environmental issues. What reactions did you have here?
5. How well have your science classes encouraged collaboration and cooperation between the students and the scientific community?
6. What kind of role do teachers play in the processes of science?
7. How would you describe the relationship you have with science?
8. Give an example of a time when you or other students had some input in the scientific community.
9. Do you think it's important for students to be engaged in the scientific community?
10. Imagine that the school made collaborating with scientists a requirement for all students. Would you agree or disagree with this decision?
11. Have you ever been involved with the scientific community? Why would this be a draw for students to join these communities?
12. What suggestions would you have for students collaborating with scientists?
13. Describe your experience at the community collaboration.
14. Tell me your understanding of the nature of science.
15. In what ways was the nature of science underscored in your collaboration with scientists? In what ways was it not?
16. Imagine an ideal experience of democratic participation in science. What does it look like?
19. Did you feel listened to by the scientific community? How important was your voice?

References

Calabrese Barton, A. (2012). Citizen(s') science. *Democracy & Education, 20*(2), Article 12.

Callon, M. (1999). The role of lay people in the production and dissemination of scientific knowledge. *Science Technology & Society, 4*, 81–94.

Carspecken, P. (1996). *Critical ethnography in educational research; A theoretical and practical guide*. New York/London: Routledge.

Cohn, J. (2008). Citizen science: Can volunteers do real research? *BioScience, 58*, 192–197.

Fischer, F. (2000). *Citizens, experts, and the environment: Politics of local knowledge*. Durham/London: Duke University Press.

Hodson, D. (2003). Time for action: Science education for an alternative future. *International Journal of Science Education, 25*, 645–670.

Hughes, G. (2000). Marginalization of socioscientific material in science-technology-society curricula: Some implications for gender inclusivity and curriculum reform. *Journal of Research in Science Teaching, 37*, 426–440.

Irwin, A. (1995). *Citizen science: A study of people, expertise and sustainable development*. London: Routledge.

Kolstø, S. D., Bungum, B., Arnesen, E., Isnes, A., Kristensen, T., & Mathiassen, K. (2006). Science students' critical examination of scientific information related to socio- scientific issues. *Science Education, 90*, 632–655.

Levinson, R. (2010). Science education and democratic participation: An uneasy congruence. *Studies in Science Education, 46*(1), 69–119.

Melear, C. (1999). Middle and secondary science teacher opinions about working in scientists laboratories during preservice preparation. *Electronic Journal of Science Education, 4*(2), 573–597.

Mueller, M. P., Tippins, D. J., & Bryan, L. A. (2011). The future of citizen science. *Democracy and Education, 20*(1), 1–12.

Pouliot, C. (2008). Students' inventory of social actors concerned by the controversy surrounding cellular telephones: A case study. *Science Education, 92*, 543–559.

Reis, P., & Galvao, C. (2009). Teaching controversial socio-scientific issues in biology and geology classes: A case study. *Electronic Journal of Science Education, 13*, 165–188.

Roth, W.-M., & Désautels, J. (2004). Educating for citizenship: Reappraising the role of science education. *Revue canadienne de l'enseignement des sciences, des mathématiques et des technologies/Canadian Journal of Science, Mathematics and Technology Education, 4*, 1–27.

Roth, W. M., & Lee, S. (2004). Science education as/for participation in the community. *Science Education, 88*, 263–291.

Sadler, T. (2010). Learning science through research apprenticeships: A critical review of the literature. *Journal of Research in Science Teaching, 47*, 235–256.

Sadler, T., Barab, S., & Scott, B. (2007). What do students gain by engaging in socioscientific inquiry? *Research in Science Education, 37*, 371–391.

Schusler, T., & Krasny, M. (2007). Youth participation in local environmental action: An avenue for science and civic learning? In A. Reid, B. Jensen, J. Nikel, & V. Simovska (Eds.), *Participation and learning: Perspectives on education and the environment, health and sustainability* (pp. 268–284). Dordrecht: Springer.

Wilderman, C. C., Barron, A., & Imgrund, L. (2004, May 17–20). Top down or bottom up? ALLARMs experience with two operational models for community science. In *Proceedings of the 2004 national monitoring conference.* National Water Quality Monitoring Council, Chattanooga, TN. Online: http://acwi.gov/monitoring/conference/2004/proceedings_contents/13_titlepages/posters/poster_235.pdf

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks: Sage.

Kristin Cook is an assistant professor of science education at Bellarmine University. She received her Ph.D. at Indiana University in Curriculum & Instruction, specializing in Science Education and Environmental Science. Kristin's research focuses on engaging students and pre-service teachers with the community of science through exploration of socio-scientific issues.

Chapter 18
Section Editorial – Ponder This: Science Education in Times of Challenge | Opportunity

Kenneth Tobin

Life can be complicated and manifest problems, and associated opportunities, abound. Whereas challenges can be occasions for gnashing of the teeth and wringing the hands, they also are resources for forging new pathways. Differences often can be a resource for disagreement – sometimes violent in a world that competes for energy and resources needed for myriad products for purposes such as construction of buildings, machines, weapons, transportation, communication, computation, and entertainment. Because the Earth's resources are finite there is competition to obtain what is needed to produce high-quality living. Inequities arise because of very uneven distributions of resources, including money and power. As problems arise they are fixed to the extent possible. However it is now time to take a close look at science and its relationships with the universe – identifying ways to sustain harmony and wellness. Respecting difference and collaborating with (different) others is a priority for science educators if they are to have relevance on the road ahead.

Consistent with a goal of enhancing literacy of the world's citizens, science educators might review their priorities to embrace goals such as harmony, wellness, and sustainability of the living and nonliving universe. As the chapters of this book attest, there is an urgent need for transformation on a global scale to reverse deterioration of the conditions necessary to support comfortable human lifestyles. Human initiated problems such as global warming have catalyzed changes in ecosystems that are deleterious to equilibria and patterns of life, not just for humanity, but for other organisms as well. A plethora of scientific reports suggest that human life will change for the worse because of human induced changes to ecosystems, with a possibility that mass extinctions could occur (Kolbert 2014).

Reporting in the Age on March 31, 2014 Deborah Snow and Peter Hannam used an eye-catching headline (Climate change could make humans extinct, warns health expert) to attract my attention to their article and a (then) soon-to-be-released United

K. Tobin (✉)
Urban Education Program, The Graduate Center, City University of New York,
36 South Shore Dr, South Amboy, NJ 08879, USA
e-mail: ktobin0@gmail.com

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_18

Nations report published by The Intergovernmental Panel on Climate Change (http://www.ipcc.ch; IPCC). I read with interest and growing concern about an interview with Helen Berry, one of almost 30 authors of Chapter 11 of the report, representing scientists from numerous disciplines and 15 countries. The newspaper article drew on a chapter from the IPCC report and a co-authored "Conversation" involving three Australian contributors to the chapter (McMichael et al. 2014). In contrast to most of the IPCC report, the Conversation focused on the threat that climate change posed to the life-support system. Anthony McMichael, Colin Butler, and Helen Louise Berry discussed climate change in relation to well-being, health, and human survival, connecting the consequences of climate change, and associated environmental conditions to human health. There was even a suggestion that humans might risk extinction unless corrective actions are taken, immediately, and globally.

If progress is to occur toward goals such as harmony, wellness, and sustainability, the public needs to alter its practices and values. In a context of public education seeking to produce and maintain literate citizenry to sustain the living and nonliving universe, we appear to have a long way to go. It is dubious that the best way is to focus on pre K-12 curricula since those who have participated in formulating goals for science education more often give higher priority to goals aligned with providing the United States economic and militaristic edges over other nations, and obtaining manpower needed for the growth of science to thereby attain the edges being sought (Tobin 2011).

What a person values, notices and regards as salient reflects the frameworks s/he uses to make sense of social life (Tobin 2008). These frameworks constitute a standpoint, and everyone has one, even if it is often difficult to articulate in its entirety (Harding 1998). Developing new standpoints can alter what a person experiences, notices, and values. For example, I regard knowing science as cultural enactment, which consists of schemas and dialectically related practices. Accordingly, I experience culture as patterned action, having thin coherence and associated contradictions, which I regard as resources for transforming social fields. To teach and learn about what happens in a field, it makes sense to emphasize schemas (i.e., discursive knowledge) and associated practices. Such an approach, which contrasts with traditional approaches that privilege discursive knowledge over its enactment, provides equal attention to both and explicitly focuses on what to do, when and how to act, and why practices need to be changed. Thinking about teaching and learning in terms of enactment raises serious questions for educational reforms which target only or mainly the pre K-12 population. There is no doubt that citizens spend much more time out of school than in it, and there are fewer restrictions to constrain what can be taught, how it can be taught, when it can be taught, and how learning can be assessed. It seems like a no-brainer! It is a priority for science educators to embrace the production and maintenance of literate citizenry, birth through death.

The K-12 curriculum revolutions of the 1960s and beyond did not make much of a difference to what was taught and how it was taught (e.g., Tobin 1987). Innovations occurred, flourished for a time, and died out as macro forces mediated science education. Somewhat ironically, macro forces, including a tendency to commodify learning, assess all students on specified standards, and hold individuals accountable for student achievement, appear to have sustained a status quo that has reproduced familiar problems associated with equity, declining standards, too few people in the science, mathematics, engineering and technology (SMET) pipeline, and failure of the US to attain the highest ranking in tests of international comparison. Problems such as these have preoccupied science educators who mostly have operated within a prevailing theoretical (mainstream) framework consisting of crypto-positivism, monosemia, scientism, and competitiveness focusing on using science education to bring out the best in individuals (Kincheloe and Tobin 2009).

In making an argument for expanding the number of science educators who focus on science education for public literacy, I acknowledge a need to continue to emphasize science education in pre K-12 schools and what some refer to as free choice institutions (e.g., museums, zoos). In a specific context of ecojustice and a larger framework of sustainability, I call for more science educators to change their professional practices to undertake scholarly activities focused on the public understanding of science. What this call implies is that more science educators will explore ways to educate through persuasion – situating their research in an increased number of fields in the lifeworlds of citizens, 7 days × 24 hours, as largely unexplored *opportunities* to educate the public.

What are the appropriate ways to educate citizens about science? Approaches will likely vary from country to country and within a country from location to location. Also, many demographics will make a difference to the resources considered salient. For example, I access and learn science through print magazines (e.g., Science, and National Geographic), the World Wide Web (e.g., sites such as CNN, BBC, the Age, and the New York Times). Also, more than occasionally I use Wikipedia and Google to identify science oriented pages that are of interest to me, and I purchase and access books electronically on my iPad. Other resources that contribute to my science education, to a lesser degree, include email, television media, print newspapers, social media (e.g., Facebook), and billboards. It seems important that science educators ascertain which resources different demographic groups from around the world consider salient for science education. Landscape studies are an essential next step so that paralllel research agendas can be formulated concerning how best to educate citizens of the entire world about harmony, wellness, and sustainability.

What Counts as Science

Western modern science (WMS) has flourished and the explosion of science knowledge has been exponential in many fields of science. As science has expanded its bounds other ways of knowing and being have been supplanted and devalued. Embracing parsimony and the mindset that science was a pursuit of truth, advances in science were seen as replacements for inferior ways of knowing and being. Science has expanded in many ways, possibly because of it being connected to economic development, defense capacity, comfortable lifestyles, and medical advances. Private and public resources support the expansion of big and little science to reflect global priorities of governments, global corporations, and wealthy philanthropists. Accordingly, the expansion of science is ideologically driven, focused on the priorities of neoliberalism and globalization – which still dominate many macro aspects of being in the world. Rather than WMS being accepted as a complement to traditional knowledge, it was seen as a substitute and viable ways of being and knowing were marginalized, discredited, and lost. The process of marginalizing and losing knowledge systems is connected to scientism and it is possible that their loss has contributed to some of the major problems that now confront us.

Monosemia can be thought of as a condition whereby one system of social truth is accepted as a viable referent for social life. Under such conditions there is little wiggle room for difference and deviations from accepted canon are regarded as errors. Right and wrong can be ascertained by referring to the canon. Scientism holds science as a superior knowledge system that is universally applicable, gradually evolving toward truth, its legitimacy being upheld by stringent peer review and adherence to established norms. What counts as science is often rigidly defined and efforts to accept other knowledge systems as scientific are frequently met with hostility. In contrast, polysemia is multilogical, embracing multiple knowledge systems as referents for viable conduct of social life. From this standpoint different knowledge systems can provide alternative ways of looking and experiencing social life. From a polysemic standpoint different knowledge systems would not have to cohere with other accepted knowledge systems since contradictions are expected and are viewed as resources to potentially improve the quality of social life. Hence, different knowledge systems are regarded as complementary rather than alternative.

Consistent with the promise of enhanced potential, science educators might engage in recovery research whereby they identify lost knowledge systems and study the viability of those aspects that seem applicable to present-day social life. For example, in our research on teaching and learning science in urban schools we have identified a high priority for developing a toolkit for all people to ameliorate intense emotions when and as necessary. As we have developed interventions as part of a dynamic toolkit we have noted that knowledge systems that have been in existence for hundreds and perhaps thousands of years are salient. For example, numerous practices derived from Jin Shin Jyutsu (JSJ) can be used to ameliorate emotions unobtrusively as social life is enacted. As we explored the vast JSJ knowledgebase it was apparent that its foundations could be regarded as complementary to medical practices grounded in WMS. Throughout social life there were possibilities to educate the public on self-help procedures to address specific health problems and maintain wellness.

Given the long history of JSJ it is no surprise to note that almost every medical problem can be addressed using well-documented practices. Since JSJ is not seen as replacing WMS, questions about what to do should not be couched as either/or choices to be made. This is an area in which science educators could take a lead. As we are finding in our research on emotions the use of breathing meditation to heighten mindfulness has many positive aspects, including changes in the structure and function of the brain, producing antibodies to fight sickness, and changing aspects of physiology such as body temperature, blood pressure, oxygenation of the blood, and pulse rate. We are now in a position to test whether meditating on holds and flows from JSJ can promote higher levels of wellness in the community. For example, to what extent can the application of practices from JSJ address successfully every day wellness problems such as high blood pressure, variations in body temperature, seasonal allergies, tinnitus, common colds, headaches, hemorrhoids, and sore backs, wrists, shoulders, and legs? It is possible that JSJ practices, which do not involve the use of pharmaceuticals, would have lower impact on global warming and deterioration of ecosystems. The dual challenges of undertaking research on the uses of JSJ procedures and educating the public about self-help possibilities are legitimate and high priority components of science education in the foreseeable future. A fertile field for science education involves the retrieval and reconstruction of lost knowledge systems, testing the viability of tenets that are applicable to social life, making desirable adaptations, and educating the public on how to enact healthy lifestyles using complementary knowledge systems.

I do not underestimate the difficulty of educating the public. Recently, a well-educated neighbor complained to me about ongoing problems he was having with tinnitus. After expressing my sympathy I inquired whether it was a problem at the moment. He said the problem was with him always and it was a source of annoyance and distraction. It was particularly bad during social occasions such as the one we were attending. I told him I might have a possible solution for this problem. He was both incredulous and interested. I explained how JSJ recommends at least four practices that are relatively straightforward – but one he could use immediately was to wrap the fingers of his right hand around his left ring finger. I instructed him not to squeeze too hard and to concentrate on feeling the pulse that can be felt during this hold. After about 10 min he could exchange hands, wrapping the fingers of his left hand around the right ring finger. I advised him that adopting this practice would minimize problems of ringing in the ears and might even eliminate them. He assured me he would give it a shot. “Do it now!” I urged him. With a laugh he grabbed his left ring finger and as I walked away I wondered – “how long will he do this?” I checked back with him over the next 90 min and every time I looked he was not holding his finger. Of course I chided him and he immediately grabbed his finger with a laugh. He did not expect it to work and felt that the practice was simplistic, especially in the light of a decade of failed pharmaceutical treatments. He was expecting to have to take something rather than accept an old way of thinking about wellness in terms of harmonizing energy flows.

Transforming Roles of Science Educators

Even though the production of knowledge in many fields of science is growing exponentially there is dire need to provide the public with access to this knowledge. Customarily scientists focus on disseminating their work to peers and relevant professional and academic groups. Most citizens cannot, and do not access what scientists write for other scientists. So there are some important questions to be answered – what scientific knowledge should be disseminated to the public? What resources should be used to disseminate contemporary science knowledge to the public? Should scientists communicate directly to the public, or should intermediaries also be involved? Questions such as these need answers if the community is to understand contemporary advances in science and adjust lifestyles to address wellness, sustainability and harmony.

Structure of the Chapter

In this chapter I focus on harmony and sustainability as requisites for wellness and the health of the universe. In my response to ways in which science educators can engage today's major challenges I address global warming, extinction of species, problems of dichotomizing matter as living and nonliving, and learning science from the media. In so doing I address the themes of expanding the roles of science educators to improve public understanding of science, increasing the focus of science education scholarship to cover the lifespan from birth to death, making sense of disagreements among scientists, and learning science from the media. If bold ventures of enhancing public understanding of science and right conduct are to succeed it is essential for learning to incorporate meaningful dialogues of all people using multiple discourses – not just WMS. For example, assigning different priorities to different forms of life have obvious connections to ethics and religion and extend far beyond science. Having said that, essential conversations must be multilogical and polysemic. After all, decisions about which organisms are considered food have obvious implications for harmony, wellness, and sustainability.

Global Warming

Is there a greater indictment on the failure of science education than global warming? It is striking to me that every political leader and politician is a product of science education. They all studied science at school and in many cases went on to take university level courses as well. However, it seems clear that their education fell short of providing them with the understandings needed to act decisively to minimize the buildup of carbon dioxide and associated rises in temperature. The release of the fifth report of the Intergovernmental Panel on Climate Change (IPCC) raises numerous challenges for science education. For example, throughout the world there have been dramatic headlines in the media concerning implications ranging from the extinction of humanity as temperatures rise by 4 °C in the next 100 years, thereby providing insufficient time for humans to adapt to global changes that impact the quality and harmony of the universe. As a whole the research emphasizes that humanity has adversely impacted equilibria within complex networks in ways that cannot be reversed and will greatly impact life as we know and experience it.

A chapter of the IPCC report summarizes the health risks of relatively rapid global warming on humanity, predicting severe hardship as a function of social class and related social categories such as nationality and race. Of course, not all of the many scientists who authored and edited the IPCC report accept its findings. For example, an economist resigned from the committee, arguing that the conclusions are exaggerated and overblown.

Extinction is certainly a dire prediction and it seems self-evident that humanity has never faced a more pressing priority for education and transformation. Can the situation be reversed? For that matter, what is meant by reversed? Obviously it is impossible to return exactly to an a priori set of conditions – so what is meant when reversal is contemplated? Clearly, appropriate action has ethical dimensions because even at a global level there are more living species to be considered than just humans – or just Americans – as the case might be. Accordingly, to make a claim that reversibility is not possible or that irreversibility is inevitable is in many ways trivial. The more important thing is to consider, when actions are planned, what macro conditions are being sought, in which parts of the world or universe are they applicable, and what are the benefits and harms of making efforts to re-create identified conditions? At the very least all citizens need to be educated to understand problems and how to enact new lifestyles that will not exacerbate global warming and myriad associated conditions. Furthermore, politics has to lead the way in ensuring that the entire community is reconstructed in ways that are fair and equitable. The solutions, if they exist, would have to transcend national boundaries and the divisiveness of self-interests, political parties, and international competitiveness.

How might science education respond to critical issues such as those I have addressed here? It seems self-evident that such a response needs to be immediate and yet we seem to be decades away from being ready to respond proactively. Science education is immersed in what it has traditionally focused upon. In order to be responsive and proactive, science educators will need to rid themselves of the shackles of the past! There are at least two broad components to be addressed – to understand the problem in ways that lead to commitments to personal and collective transformations. Learning needs to extend beyond language to embrace ongoing, continuous, never wavering change to sustain the universe. This must be associated with a moral value associated with sustainability and an abhorrence of deviations from pathways leading to sustainability. An important ingredient of what is learned is responsibility for all humans to act in ways that foster harmony across networks/ecosystems. Acting in ways that acknowledge interdependence of all living and nonliving components of the universe seems central to social life and an overarching goal for science education.

The scientists who authored the chapter of the IPCC report examined the implications for humanity of extreme weather events, the loss of habitable land, and changes in factors such as infectious disease, and mental health. In a separate article three of the chapter authors emphasized the necessity for pervasive and immediate change warning: “Of course, none of this matters if human well-being, health and survival means little to us. In that case we can emit all we like, then suffer, dwindle or even die out as a species and leave this planet to recover and thrive without us. One way or another we will then emit less" (McMichael et al. 2014, p. 5).

A question for science educators to ponder is what steps might be taken to afford levels of critical literacy that would allow all citizens to make sense of the problems we face and then to address them appropriately for the constituent individuals and communities? In conjunction with the planning and enactment of a curriculum for literate citizenry there are associated research priorities that take account of citizens knowing in ways that support appropriate and timely action. It is not just a case of being able to read, write, and talk about problems, but also of appropriately acting in the world. In this particular example appropriate action includes seeking other perspectives, understanding them, and examining their affordances. That is, seeking alternative perspectives rather than dogmatically adhering to a personal perspective. Being willing to listen and learn is important and so too is speaking in ways that expand the conversation rather than converge toward a narrow set of conclusions. On the other hand when inequities and unethical conduct occur, it is important for individuals to be courageous, speak up, and act in accordance with the motive of social justice.

Prioritizing Humanity

In a context of ecojustice, Heesoon Bai (2014) discussed implications for harmony of the tendencies of scientists to dichotomize matter as living and nonliving and thereby to create a hierarchy of values that prioritized living over nonliving and within each category to assign higher value to living and non living and then to give more weight to humans than other life forms.

Bai convincingly showed that animism is a way of thinking that does not distinguish between life and non-life, preferring instead to acknowledge the networks associated with different aspects of social life. For example, since life can only be sustained in a balanced ecosystem in which it is adapted it makes little sense to separate human self from the structures (i.e., resources) that sustain it. Significantly, it is not just what is present, but also the connections, networks, and strengths of relationship. Harmony cannot be taken as infinitely self-adapting and reproducing. Indeed, it can be argued that a human science might seek to understand how social life, as part of an ecosystem, would adapt to sustain harmony. Continuous exploitation of the ecosystem to benefit humanity may have extinguished networks and changed connections and bond strengths, forging new equilibria and types of harmony. In so doing new systems evolve and unknowable futures might emerge. The point is not to argue for a status quo, but to acknowledge the fragility of the equilibrium associated with harmony within ecosystems and to focus science on hermeneutic – phenomenological pathways that value wellness, sustainability, and harmony. Such a focus would assume re-visiting the historically grounded misfortune of dichotomizing living and nonliving and defining selves in terms of solitary bodies rather than all bodies in their sustaining networks: the failure of models to acknowledge inseparability of selves and non-selves may have supported the development of science as focused on a value system that distorts the emerging canon and its appropriation by institutions such as politics, medicine, media, and militia.

Educating the Public About Disagreements Among Scientists

Although disagreements among scientists are common, the public rarely sees them as a sign of strength. Instead, difference is seen as weakness and often is regarded as a pathway away from difficult choices. However, educating the public about disagreements and difference is a priority that extends far beyond science and science policy. Arguably, the public needs lots of practice at listening to and understanding different perspectives, especially perspectives that differ from their own. Also, as is the case considered in this section on epigenetics and in the next section, on global learning, it is important to be able to weigh options in terms of their potential to improve social life. It comes down to much more than deciding right and wrong. What is not so clear is what disagreement means for the different publics that consume and produce science (operating from a theoretical foundation in which each act of production is both reproductive and transformative). Science educators might address this issue as a priority so that programs can be planned to educate different people about how to make sense of difference and how to act in the wake of difference.

Michael Skinner asserts that chemicals can catalyze changes to gene expression that persist across multiple generations of animal species (Kaiser 2014). If this assertion applies to humans there are obvious implications for human health and the maintenance of an ecosystem that supports harmony. Many skeptics and opponents have strenuously resisted his claims, which are supported by an ongoing program of research. At the same time others enthusiastically endorse Skinner's research. Despite the salience of Skinner's research to all living things, there has been what Jocelyn Kaiser describes as "bumps in the road" (Kaiser 2014). These include the necessity to redact a paper published in 2009 because of inadequacies that Skinner perceived in the work of one of his postdoctoral associates. Also, his ongoing research has been funded through political earmarks, supported by Congress, through the Department of Defense. These studies have looked specifically at chemicals that soldiers might encounter – such as insecticides, jet fuel, dioxin, and plastic additives such as phthalates. This funding source ceased when the Congress banned earmarks.

There are many questions associated with literate citizenry that relate to the situation involving Skinner's research. For example, to what extent does research conducted with animals such as mice and rats extrapolate to humans? Whereas it is important not to expose any animals to a toxic environment, it is reasonable to assume that most will want to know the extent to which Skinner's research applies to humanity. Should citizens understand why Skinner's research was funded through the Department of Defense using earmarks rather than the National Institute of Health or the National Science Foundation? Does this pattern of funding represent the controversial nature of the research and the difficulty of it being funded because of peer review? Is it cause for concern that the research is no longer receiving government funding? Questions such as these pertain to sustainability of life because toxic environments can catalyze changes in the characteristics of offspring, which can then be passed on from one generation to the next. Skinner's research suggests that after three generations the implications of toxicity were evident in offspring.

The implications of epigenetics extend beyond whether Skinner's research is or is not funded by government sources. If polluted environments can change the biochemistry of offspring across multiple generations the implications for all organisms are profound. Just as global warming is a priority for harmony, well-being, and sustainability, so too are the implications of epigenetics.

Science in the Media

Science is well represented in the media and for that reason alone there is a pressing need for serious research to examine the representations of science in the media and ways in which the media educates the public about science. For example, the CNN home page has many links to science-related articles, often containing video clips and photographs that are related directly and indirectly to science. As is the case with reporting of the news on TV channels like CNN, particular reporters and shows reflect standpoints and associated ideologies that extend far beyond reporting news. Headlines on the website are designed to attract attention, lure readers to engage in the stories, and come back for more. Not only does the content of the CNN website reflect a political ideology, it also reflects macrostructures such as neoliberalism and capitalism. The checks and balances on the curriculum that might apply in institutions associated explicitly with educating children and older youth (e.g., pre K-12 schools, museums, zoos) are not in place when it comes to educating the public through the media.

Very different standpoints are incorporated into the science-related stories on the CNN home page (www.CNN.com) on May 8, 2014 when I accessed the website for the purposes of including examples in this chapter. In a story about shark attacks in Western Australia there is a strong sense that inappropriate and ineffective state level policies were enacted to address a perceived increase in human fatalities due to shark attacks. The evidence provided in the report is biased towards a conclusion that there really was not a significant increase in the rate of human fatalities due to shark attacks, draconian solutions trapped and killed many sharks, and trapped sharks were not of the same species responsible for the deaths of swimmers.

Précis 1: 172 Sharks Caught, 50 Killed

In Western Australia a government-sponsored program has caught 172 sharks and killed 50 of them as part of a culling program to protect swimmers. In the past 3 years, sharks have killed seven people. The report explained that the 3-month program, which ended last week, used baited lines attached to floating drums to catch sharks off popular beaches in Western Australia. When sharks were caught on hooked drum lines the policy permitted Tiger, Bull and Great White sharks longer than 3 m in length to be destroyed. However, none of the sharks captured were Great White sharks, the species associated with the recent human fatalities. Most of the captured shark species were Tiger sharks, which had not been involved in human fatalities for decades. Furthermore, in excess of 70 % of the captured animals (e.g., stingrays), were not large enough to be considered a threat to humans. The report noted that many of the sharks released alive from the hooks on the floating drums were found to be in a "state of shock" and sank to the ocean floor.

Presumably the public that reads this article has a great deal to ponder relating to ways in which humanity interacts with sea life. Questions emerge concerning the extent to which human recreation does and should impact the harmony of the marine ecosystem. Educating the public about the science related issues in this report might be a focus for scholarly activities of science educators. Obviously the research would extend far beyond CNN and its homepage and probably would involve the role of media in science education.

For example, on May 6, 2014 the White House announced the National Climate Assessment (http://nca2014.globalchange.gov), providing evidence of human-made climate change. The report emphasized that human action is needed immediately. The comprehensive report is a call to action and highlights a challenge that is central to this chapter and expanded roles of science educators, perhaps to research the efficacy of teaching schemas and practices in an integrated way to all citizens and, in research and evaluation, assign equal priority to both.

Précis 2: Bill Nye Battles with CNN Host

A contrasting example that typifies science-related reports in the media involves the TV personality Bill Nye the Science Guy. Because of the US national report on climate change Bill Nye was invited to appear on Crossfire, a political show designed to be volatile and argumentative, pitting the political left against the right in often-heated debate. It is not unusual for speakers to interrupt one another, raise their voices, show anger, disrespect, and disdain for others' perspectives. The viewing audience expects this format and probably accesses the TV version of the program to be entertained by the heated and controversial nature of the arguments. With this in mind guests are invited to appear on the show to present different standpoints.

To receive and maintain a turn of talk a speaker needs to understand the genre and participate accordingly. Usually it is necessary to expect interruptions and be prepared to speak quickly, fluently, and at times loudly and audaciously.

People who connect to excerpts from Crossfire that are published on the Internet would probably be attracted by the headline “Bill Nye battles with CNN host.” Although the headline is accurate it relies on the name recognition of Bill Nye to draw an audience. Presumably those who access this report know about Nye, his high profile TV series, and its contributions to science education. I accessed the report expecting to see Nye triumph over a bumbling CNN host, science trump non-science, and well-argued positions defeat political rhetoric related to self-interests. To my surprise the CNN host represented science and scientists as bullies, accusing Nye and people like him of shoving science down the public’s throats with little success. A short video clip selected from the television program began with a female reporter describing the report as “scare tactics.” Nye objected and endeavored to speak. However, the reporter insisted he remain silent while she presented data to the effect that only 36 % of Americans considered global warming a serious threat to their lives. She concluded with the query: “Don’t you need public consensus to move the needle on this?”

Probably flustered by the format of Crossfire, Nye resorted to rapid-fire talk and, rather than good science, he used economic rationalism to support his arguments. He spoke quickly, presumably to maintain his speaking turn. He mentioned Oklahoma and its recent tornadoes, Alaska with no particular reference to anything, New York City, and Super Storm Sandy – all the while focusing on economic effects and costs of rebuilding infrastructure because of global warming. Nye then turned to crop failures, and the economic costs of continued drought in California. A person selected to represent a counter view interrupted him, noting that he accepted the science: “but …” His speedily put argument was that the science was not solid and there were signs that the problems associated with greenhouse gases and burning of fossil fuels were being remedied already. He argued we should not disrupt good business with costly programs such as those being enacted through Democratic policies to reduce emissions and minimize the carbon footprint. Green practices were regarded as economically unviable – reducing international competitiveness. In an effort to move to a debate format Nye noted that: “we disagree on the facts.” This was not going to work. The politically right guest commented that not all scientists agree and the politically right reporter concluded the way she started: “it is a problem when science guys bully other people… The science guys have tried to shame anyone who disagrees with this – and it is not working with the public.”

Opportunities to learn science from the segment from Crossfire were limited to say the least. On another level the political nature of interactions reinforced a perception that what is and is not scientific fact is decided by a polling of public opinion. The debate over the facts was adversarial, superficial, and rapid. My thoughts were that the political left would identify with Nye and the viewers on the right would align with the argument of the host and her guest. This type of program might be a major setback for educating the public about science. The demographic that watches CNN is hardly representative of the citizens of the world, or for that matter the citizens of the United States. Science educators need to ask and seek answers to the question – what media resources provide an appropriate science education for literate citizenry? The examples I provide here, concerning two programs from CNN, can whet the appetite of science educators seeking to engage in meaningful scholarship.

Making Progress

My experience with transformations is that changes in practice always seem momentous when plans to change are enacted and, when viewed historically, they appear to be small steps from the prior trajectory. Accordingly, moves toward harmony, wellness, and sustainability will seem like giant strides when they are enacted and history will view them as tiny, but hopefully a turn in a better direction. What is to be accomplished? In even seeking to answer this question the cautionary bells are chiming loudly. Goals can be hegemonic and panoptic. Labeling is reductive. It is impossible to represent full meaning with words. The bells are tolling. Right action is needed now. More than seven billion humans need to change direction to make changes that are both individually and collectively appropriate with the umbrella goals of harmony, wellness, and sustainability as a guiding framework. Compassion appeals as a referent for reviewing what is happening, why it is happening, and what needs to be done next. But, more is needed and I would add to the mix, cogenerative dialogue, which includes right speech, mindfully speaking, and mindfully listening.

What research in science education in the past 60 years has led to significant improvements in the field? I am sure any science educator could generate a short list of studies that would reflect his/her epistemology, ontology, and axiology. Sitting with others to dialogue about their lists might be a good place to start in terms of listening and learning from others as they explain their lists and identify how they can be expanded to connect with harmony, wellness, and sustainability. Maintaining the status quo cannot be an option because from almost any perspective the stakes are high and there is work to be done. Individualism and competition are failed referents for producing the best in science education and commodification is inappropriate. Authentic inquiry is needed to produce individual and collective benefits that are global in scope, and involve a broad vision of the universe and the dynamic equilibria needed to sustain high-quality continuous being.

References

Bai, H. (2014). Peace with the earth: Animism and contemplative ways. *Cultural Studies of Science Education.* Advance online publication. doi:10.1007/s11422-013-9501-z.

Harding, S. (1998). *Is science multicultural? Postcolonialisms, feminisms, and epistemologies*. Bloomington: Indiana University Press.

Kaiser, J. (2014). The epigenetics heretic. *Science, 343*(6169), 361–363. doi:10.1126/science.343.6169.361.

Kincheloe, J. L., & Tobin, K. (2009). The much exaggerated death of positivism. *Cultural Studies of Science Education, 4*, 513–528. http://dx.doi.org/10.1007/s11422-009-9178-5

Kolbert, E. (2014). *The sixth extinction: An unnatural history*. New York: Henry Holt and Company.

McMichael, A., Butler, C., & Berry, H. L. (2014). *Climate change and health: IPCC reports emerging risks, emerging consensus*. http://theconversation.com/climate-change-and-health-ipcc-reports-emerging-risks-emerging-consensus-24213. Accessed 31 Mar 2014.

Tobin, K. (1987). Forces which shape the implemented curriculum in high school science and mathematics. *Teaching and Teacher Education, 4*, 287–298. http://dx.doi.org/10.1016/0742-051X(87)90021-7

Tobin, K. G. (2008). In search of new lights: Getting the most from competing perspectives. *Cultural Studies of Science Education, 3*, 227–230. http://dx.doi.org/10.1007/s11422-008-9109-x

Tobin, K. (2011). Global reproduction and transformation of science education. *Cultural Studies of Science Education, 6*, 127–142. doi:10.1007/s11422-010-9293-3.

Kenneth Tobin is Presidential Professor of Urban Education at the Graduate Center of the City University of New York. His research focuses on the teaching and learning of science in urban schools. Tobin is the founding co-editor of Cultural Studies of Science Education.

Part III
Youth Activism Section

Chapter 19
Youth Activism: Considering Higher Ground

Michael Dias and Brendan Callahan

We were raised in river cities. Brendan's first home was on the east side of the Susquehanna River, while Mike grew up near the confluence of the Tennessee, Cumberland and Ohio Rivers. Water flows some 1,200 miles to get from Harrisburg to Paducah, yet one event joined our thinking as sure as the flow of the rivers. On March 28th, 1979, a partial nuclear meltdown occurred on one of two reactors at the Three Mile Island plant in Dauphin Island, Pennsylvania. This environmental disaster in Brendan's "backyard" made international news. Although neither of us remembers many details of that accident, we have always been skeptical of nuclear power as an alternative to the hyper-fossil-fuel-based society in which we live. Perhaps because the proliferation of nuclear power plants never progressed in the United States following this accident, or maybe just because we were kids who thought more about sports and other ventures than the environment, this event did not inspire us to learn or do anything.

Fast-forward about 30 years. That young boy Brendan from Harrisburg became an adult, a husband, and a father to three children. He recalls a moment of spontaneous activism of his 7-year old daughter Caitlin:

> I was in the neighborhood with my family and a neighbor and his daughter. The two girls often played together. All of a sudden the neighbor's daughter started screaming. We rushed to her to find out that my daughter had thrown an orange at her. Shocked parents as we were, as our daughter was not prone to violence, we tried to determine the cause of the offense. My daughter's response was that the other child had killed a bee, and she thought it was wrong. Caitlin has always loved animals, and maybe it was this love of nature, or perhaps it was *Bee Movie* that encouraged her to take environmental action, albeit in an inappropriate way.

M. Dias • B. Callahan (✉)
Department of Biology and Physics, Kennesaw State University,
370 Paulding Ave., Kennesaw, GA 30144, USA
e-mail: mdias@kennesaw.edu; bcallah7@kennesaw.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_19

The world over, there are young people making a difference in their communities. Arnold et al. (2009) studied a group of youth (16–18 year old) activists for the environment. They found that these young adults were motivated either by influential experiences or by influential people. Influential experiences were often interactions with nature (generally time spent outdoors) or educational experiences outside the classroom. How vital, this time outside for inspiration! Research (Arnold et al. 2009; Blanchet-Cohen 2008) suggests that youth are initially motivated by direct experiences with nature, then use books and media as sources for further learning about the environment. Friends, role models, and teachers are often cited as influential people, with parents typically providing the support for sustained action, rather than the origin of their passion for the environment.

The environment is probably the most visible context for activism in general, but it is less dominant when we consider various ways that youth act on the issues that produce tension in their everyday lives (bullying for example). This section opens with perspectives from Paul Theobald and John Bedward who provide a short history in the purposes of education, if not for acting more fully within the confines of lives, then what? They argue that education has been designed to benefit modern economy, often at the expense of people's wellbeing. This continuous rise in industrialization has been supported by politicians and the media, and as such has become ingrained in the collective consciousness of our society. Theobald and Bedward explain that as the primary goal of education shifted from civic responsibility to economic utility, we lost our connection to the Earth. Do we work to improve societal conditions? How does education shift back to a balance between economics and civics? Do we educate our students to be problem solvers? Are they higher order thinkers? Do they evaluate the benefits and costs of actions? To what extent do they have an understanding of the natural world?

Jack Hassard is among the scholar activists who have been helping science teachers and students respond to these questions for quite some time. The section in this book on youth activism ends with an early example of cross-cultural youth activism, as Jack describes the *Global Thinking Project*, (GTP) a 20-year Track-II Diplomacy Project that became a teacher and student exchange program between the U.S. and the former Soviet Union. The project involves hundreds of teachers, researchers and students from several countries in cross-cultural environmental education. GTP is rooted in citizen science, youth activism, global collaboration and ecojustice. Read this historical account and consider Jack Hassard's context for youth activism as you assess his claim that "When ordinary people are brought together to discuss common interests and concerns, actions can emerge that would be surprising even to the most progressive among us."

Larry Bencze, Steve Alsop, and Allison Ritchie focus on the role of power and agency as students negotiate, and act on, social issues of their choice. Student choice reveals much about relevance and responsive pedagogy for a range of social issues that evoke from youth the desire to learn and take action. Why, in this case, do teenagers prefer to study social issues related to technology, such as internet stalking and child pornography, rather than the issues of nuclear power, climate change, or stem cell research more typically addressed in school science? Is activism amongst youth shifting from the accepted paradigms? The students described by Bencze's group believed they had very little ability to change the minds or actions of others. In some instances, this "powerlessness" stemmed from their age – but is it immaturity? What about the 12-year old who, for some reason, is rapt with sustained concern after hearing of the Deepwater Horizon BP oil spill? So often, it is the case that others do not take youth seriously because they are young. Or is it the case that they do not have the knowledge or resources to affect change? What if they had these things? Also in this chapter, there was a sense among youth that if they spoke out against the dominant group, their future prospects could be harmed. Are youth so concerned with their futures that they will not act to effect positive change for the society in which they live? These are interesting questions in light of the curiosity and idealism of youth, the requirements of activism, and the apathy that fills an agency void.

Desjardins, Hauser, McRae, Ormond, Rogers and Zandvliet offer a most innovative approach to young-adult activism. Their dialogue-driven project focused on improving campus sustainability as a context for enacting positive social change will have wide appeal and application. These scholars remind us that despite the growing value for sustainability or activist education, "…little has changed in education to facilitate this shift." Why is this? As its own form of activism, the *Change Lab* responded to this issue. In their case study, Desjardins and colleagues explore a two-semester experiential course designed to provide social change education for undergraduate students, with activism channeled toward improving campus sustainability. Participants are given tools and access to mentors for the development of activism projects during the first semester. They then implement these projects in the following semester. Authors describe an *action competence* that serves as a point of reference keeping these scholars on course throughout the project. Action competence is a form of democratic voice involving engagement through the capacity to collaborate with others in the work of shaping a more humane society.

Tania Schusler and Marianne Krasny report on capacity again, that is, the capacity for "good thinking." But what is good thinking? Could we do more to support the capacities of youth to engage in the critical analysis of scientific evidence germane to social, environmental and moral-ethical issues? Or should youth trust the experts? Viewing environmental action as a productive context for teaching adolescents to participate in both democracy and science, Schusler and Krasny interview 46 adolescents, each of whom are involved in school or community-based environmental action projects in New York State, to investigate how experiences with environmental activism shapes youths' perception of science and civic engagement. What do they find?

In *Hitting the Big Screen* (Chap. 24), Stephanie Hathcock and Daniel Dickerson detail their brilliant project that combined student use of digital technology, environmental advocacy, and intergenerational learning. This was achieved through *River Quest*, a weekly residential summer camp serving 36 urban adolescents, located where the Chesapeake Bay watershed meets the Atlantic Ocean. In response to studies indicating a decline in youth activism overall, and specifically, that urban youth are less likely to participate in activism when compared to middle class youth, *River Quest* offers opportunities for urban youth to increase understanding of local environmental issues while engaging in environmental advocacy and knowledge production through creation of documentary film for a local audience. See how this project helps adolescents become science insiders by positioning them at the confluence of creativity, critical thinking, community issues and career opportunities.

While many of the chapters in this section focus on adolescents, Burek and Zeidler argue that we must provide experiences for younger learners, those elementary aged children who typically abound with wonder, curiosity and connection to nature. While there are many opportunities to explore nature, there are fewer opportunities for children to actively reflect on environmental issues. The pairing of informal science education and a socioscientific issues-based framework may provide the needed relevance and knowledge growth for students to become more active in their adolescent and young adult years. Informal, community-based science education settings often facilitate affective learning at a depth rarely reached within the classroom, and as such, these are valuable settings from which to discuss the moral and ethical implications of socioscientific issues. Burek and Zeidler have much to teach us in their chapter.

Youth Activism and Visions of Science/Scientific Literacy (SL)

The knowledge of science needed for personal decision-making, civic engagement and activism has been emphasized across the globe in science education reform for well over a decade. Efforts to educate a more scientifically literate U.S. citizenry through the 1990s to the present time have been informed in large measure by the *Benchmarks for Science Literacy* (AAAS 1993). Roberts (2007) provides contrasting views of scientific and science literacy (both designated as SL). Vision I is concerned with the "products and processes of science" (what knowledge science has generated and how science is done). This "…thorough knowledgeability *within science*" was the view of SL promoted by the American Association for the Advancement of Science in *Benchmarks* (Roberts 2007, p. 730). At the other end these idealized extremes, Vision II examines the intersection of science and society. Vision II is a view of science that applies to "…thorough knowledgeability about science-related situations," the events and issues that students will encounter as citizens. Our understanding is that Vision I represents *scientific* literacy while Vision II represents *science* literacy.

We value Robert's "SL" designation in place of the above semantic nuance, and regarding his SL Vision 1 and II continuum, we join the "…increasing number of voices (stressing) the importance of starting with Vision II, that is, with situations, then reaching into science to find what is relevant" (p. 730), for this approach is more culturally and personally engaging for adolescents. Vision II situations involve myriad considerations, including questions and perspectives beyond the scope of science. The socioscientific issues (SSI) framework has been described as being a part of a more inclusive view of Vision II than Roberts had originated (Zeidler 2007). The SSI framework involves students in decision making about moral and ethical societal issues that are better understood with knowledge derived from science.

While the mechanism for SSI instruction is typically externally focused (debates, social negotiation, shared consensus) the effects of an SSI curriculum are largely internal (reflection about an issue, understanding of scientific content and concepts, critical thinking development). While the SSI framework focuses on environmental awareness, as evidenced by Chap. 21 in this volume, there are others who are expanding the boundaries of Robert's Vision II even further by engaging in environmental action.

Cognitive and affective factors are critical for success when engaging students in environmental activism. Projects that were voluntary tended to have more success than projects that were part of an assigned class. Students who were interested and engaged in the project learned the most, while the students who were not engaged in the project self-reported that they did not learn as much from the experience.

The age of the students is not a factor when examining youth activism. These chapters represent a range across grade levels, from elementary to college undergraduate. It is important to note, however, that structured experiences must be congruent with the talents, needs and interests of participating youth. Well-planned learning experiences in nature may increase childrens' environmental awareness, which is a precursor to environmental activism. Socioscientific discussions and debates help learners critically examine their assumptions about situations and promote application of lived experience and science knowledge to the learning process. These SSI learning experiences seem to be a necessary first step for increasing activism.

The Next "Reform" of Science Education

Personal Relevance and Scientific Reasoning

With its emphasis on directing students into STEM careers, the Next Generation Science Standards for Today's Students and Tomorrow's Workforce (NGSS 2013) represent a shift away from Roberts' Vision II back towards (the pre-*Benchmarks*) focus on Vision I. Ever since the post-Sputnik wave of new science curricula that were developed following the Soviet Union's 1957 launch of the world's first artificial satellite, many dedicated, intelligent people in the U.S. have been "reforming" science education. NGSS, our current science education reform surge, conveys that our professional mission must be primarily in service of job-preparation for students and economic security for the nation. A consumerist paradigm is revealed in the pipeline argument that implies human learners as commodities and science educators as functionaries in "making" scientists and engineers. Equipping learners for productive work (including that of scientists and engineers) is certainly a part of, but not our entire mission. Furthermore, we see great potential in all three dimensions[1] of NGSS to renew and enhance K-12 science teaching practice. While a strong conceptual understanding is necessary for knowing how the world works, this knowledge is of greater value when applied to serve society and environmental sustainability. We assert, with a range of evidence from the following chapters, that cultivation of critical science literacy for all learners, amid the Dimensions of NGSS, is the higher ground from which we will see the best (next) renewal of science education.

The OECD Programme for International Student Assessment (PISA) views science achievement in a different manner (OECD 2011). PISA explores scientific literacy in 15 year olds by examining their scientific knowledge both in terms of content and the process of science. Many of the questions are given in everyday contexts, rather than as isolated science concepts. Students are often asked to provide an explanation. We believe the view of scientific literacy assessed by PISA may provide the background needed for students to become more interested in the science that affects them directly. This knowledge may catalyze environmental action. The Trends in International Mathematics and Science Study (TIMSS) Science Framework from 2011 supports the cultivation of science and scientific literacy as well. This international examination focuses on both content and cognitive domains in mathematics and science to be tested at the fourth and eighth grades. The most advanced cognitive domain surveyed in the test, reasoning, comprises 30 % of the test questions. Scientific reasoning is considered fundamental to scientific literacy, and its inclusion and emphasis in international assessments highlights the importance of this skill.

Even as we move towards a “science in context” paradigm, most curricula fall short in affecting positive change. As science education evolves from a traditional, teacher-directed methodology to a more student-centered pedagogy, we must continually support those whose efforts push the boundaries of what is possible. While it is certainly laudable to get students talking about contemporary issues, deeper learning occurs when understandings are applied to action. In varied ways, these youth activism chapters present people coming together around a common experience, learning from each other, and taking action that is, at times, transformative for individual or community.

Our current work as collaborators with middle school teachers in developing socioscientific curricula is informed by all of the writers in this section. These chapters present a continuum from environmental awareness to environmental action. Awareness of environmental issues is often presented in the form of socioscientific debate. This negotiation of socioscientific issues, in addition to raising awareness of environmental and social ills or controversies, has the potential to increase higher order thinking skills. Today’s youth are so immersed in their use of technology as entertainment media that their enthusiasm for the latest technological fix outpaces their use of technology tools for learning, creating, and acting on their concerns. Far too rare are youth activists who recognize their individual impact and potential influence in the world.

Information Technology, Science Education and Activism

We are living in a world with virtually unlimited technological resources. Gilbert Scott-Heron (1949–2011) was a jazz poet, a spoken word artist, and a voice of Black protest culture in our youth. In 1971 Gil recorded *The Revolution Will Not be*

Televised (Scott-Heron 1971). At one level, the lyrics challenge a culture that was distracted from important social issues by television. After dozens of cultural references, the memorable last line is "*…the revolution will be live.*" Gil mixed art with activism, and with these lyrics, created a message that remains relevant, both for what he could and could not envision. In his time and place, television was the time-sink medium, and most of what television offered would not influence human values and knowledge enough to generate sociopolitical activism. We wonder what Gil thought of the internet and social media in his later years, for these resources give new meaning to "*…the revolution will be live.*" Today, technology has the capacity to make the world seem smaller by allowing billions of people to know about daily happenings from all over the globe. A multitude of world events, including revolutions, are televised and posted to social media. We are not naïve or overly idealistic. All this information is not accessed by everyone, but clearly, access to the Web is widespread and on the rise. The key difference is that today's social media dispenses an exponentially greater array of perspectives, while contemporary technology tools allow more and more people to not only consume, but also create knowledge. "*The revolution will be live*" has always meant that something has to change in each of us to trigger our activism, but today's technological context provides far greater individual access to information and opportunity to voice and act on one's convictions. For good or for evil, a *live* revolution is about individual power (not only corporate power) to convey a message and influence the masses.

Though we have access to unlimited information, the proliferation of technology often disconnects us from the world around us. The Kaiser Family Foundation (Rideout et al. 2010) found that teens are spending 7.5 h a day consuming media, including television, music, Web surfing, video games, and social media[2]. Combined with nearly 8 h of school, and 7 h of sleep, students are reasonably disconnected from nature for 22.5 of the 24 h in a day. While the above statement comes with some assumptions (students are not on their mobile devices at school, students are getting 8 h of sleep) the point can be made that students typically are not spending enough time outside enjoying nature. If students have lost the aesthetic attachment to the environment around them, then nature demands less of their emotional energy and their emerging identity.

Nevertheless, we can use the technological resources to our advantage. Science teachers and teacher educators can lead students in balancing virtual and physical learning. Children are typically curious and we have historically channeled that sense of wonder through nature study. As we continue the nature study approach and add engineering design tasks for learners of all ages (NGSS 2013) we should guide children in scientific inquiry and thoughtful discussion. As our learners grow to adolescence, we should continue providing experiences that allow students to investigate phenomena and work out explanations based on evidence. This type of reasoned discourse is, of course, facilitated by empirical investigations. Socioscientific issues are equally fruitful for supporting evidence-based reasoning and the respectful interactions that mark a thoughtful learning community. From the elementary grades to adult education, the information and communication affordances of technology offer a challenging yet profound opportunity to educate citizens with the understandings that build critical science literacy and agency.

The writers of the following chapters concur with this view as they detail philosophies, programs, and instructional practices that develop learners who can think critically about complex issues, sharing thoughts and taking action to make positive change in response to issues of personal relevance. This represents science education at its best.

Moving to Higher Ground

We opened this chapter with reference to our river-city heritage and the Three Mile Island nuclear accident. That event, despite its national and global significance, evoked very little reaction from us 35 years ago. We had no understanding of nuclear power plants, their workings, and what might go awry, hence, we had no capacity as individuals to act on the issue. Had we been interested we might have asked our parents, or a science teacher, who might have offered some information. Had we a deeper concern, self-directed learning would have been limited to what we could see on television news (only a few channels in 1979), or read in newspapers or news magazines, encyclopedias or books. Contrast that situation with the instructional resources and information exchange of today's Internet. A Google search on *nuclear energy* just generated 317,000,000 results in 0.3 s. An astounding body of information to wade into, yet it is not unlikely that a motivated adolescent could direct his/her own learning, supported by dialogue (virtual and face-to-face), constructing the knowledge that supports agency on this issue.

In Chap. 18, Schusler and Kransy relate critical scientific literacy (Hodson 2011) to activism. This clarifies for us, some fundamental experiences that may predicate all activism. From the simple to the profound examples of activism, we can easily identify how the elements of critical scientific literacy supporting activism. Using Caitlin's reaction to a dead bee as a simple example, the little girl knew about and valued bees, she recognized an injustice in her environment, and this prompted action. Her knowledge compelled her to throw an orange at a child who killed a bee; certainly not a sustainable plan for conserving these pollinators, but a noteworthy conviction for a 7-year old girl. It is good to see Caitlin thinking, valuing, and taking independent action. Though she reacted with little thinking or planning, we science educators can certainly build upon her love of nature and her early bent toward eco-justice. The essays that follow demonstrate the role of science educators in transforming Caitlin's childlike response toward more informed, critical, and ethically-mediated action to affect positive change.

These chapters provide insights and examples for developing in adolescents and young adults, the conceptual understanding required for both scientific literacy and activism. Note however, that all too often, after-school programs were required to accomplish this type of teaching. Why is it relatively rare for school science to engage students in using science knowledge to evaluate and discuss social issues? As we science educators move into a renewed effort to foster scientific literacy, we must find space for socioscientific issues (SSI) among the traditional science content-based courses common throughout the world. A lack of SSI representation in standards will increase the challenge of promoting science teaching that fosters critical thinking and moral/ethical reasoning as dimensions of scientific literacy. As argued by Desjardins and colleagues (Chap. 17), "…activism and education are a controversial pairing. For many, education is seen as impartial and should focus solely on preparing children or young adults with the skills to participate positively in society". This begs the question, "What does it mean to participate positively in society?" Whether our K-12 learners choose to work in science or engineering fields *or choose any other option*, their education certainly must supply the required foundation. All citizens, over the course of their lives, will encounter many personal dilemmas and social issues best managed with an understanding of science. Given this certainty, positive participation in society demands a preparation ethic that continues the *Science for All* equity imperative of previous "reform standards". The following chapters lead us to a deeper understanding of how we might achieve the high ground of science literacy – a critical understanding of issues and interdependence that compels people to take action.

Notes

1. (1) *Practices* of science and engineering may serve to extend our notion of inquiry learning, (2) *Crosscutting Concepts* should broaden the scope of student understanding of a range of science disciplines, and (3) *Disciplinary Core Ideas* could help focus the K-12 science curriculum.
2. This article argues that "media multitasking" allows teens to average 10 h and 45 min worth of media content in those 7.5 daily hours!

References

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy*. Washington, DC: Author.

Arnold, H. E., Cohen, F. G., & Warner, A. (2009). Youth and environmental action: Perspectives of young environmental leaders on their formative influences. *Journal of Environmental Education, 40*, 27–36.

Blanchet-Cohen, H. (2008). Taking a stance: Child agency across the dimension of early adolescents' environmental involvement. *Environmental Education Research, 14*, 257–272.

Hodson, D. (2011). *Looking to the future: Building a curriculum for social activism*. Rotterdam: Sense Publishers.

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: The National Academies Press.

OECD. (2011). *Lessons from PISA for the United States, strong performers and successful reformers in education*. OECD Publishing. http://dx.doi.org/10.1787/9789264096660-en

Rideout, V. J., Foehr, U. G., & Roberts, D. F. (2010). *Generation M2: Media in the lives of 8- to 18-year-olds*. Menlo Park, CA: Henry J. Kaiser Family Foundation. Retrieved from http://kaiserfamilyfoundation.files.wordpress.com/2013/01/8010.pdf

Roberts, D. A. (2007). Scientific literacy/science literacy. In S. Abell & N. Lederman (Eds.), *Handbook of research on science education*. Mahwah: Lawrence Erlbaum Associates.
Scott-Heron, G. (1971). The revolution will not be televised. On *Pieces of a Man*. New York: Flying Dutchman Records.
Zeidler, D. L. (2007). *An inclusive view of scientific literacy: Core issues and future directions*. Paper presented at the Linnaeus Tercentenary 2007 symposium "Promoting Scientific Literacy," Uppsala University, Uppsala, Sweden.

Michael Dias taught biology, chemistry and physical science in public high schools for 14 years and now coordinates undergraduate Biology and Chemistry Education at Kennesaw State University. Mike's service and scholarship focuses on science teacher development and mentoring, and teaching practices that promote thoughtful dialogue and community among adolescent science learners.

Brendan Callahan taught chemistry and biology for 9 years and is now an assistant professor at Kennesaw State University. Brendan's research focuses on the role of socioscientific issues in developing critical thinking and literacy skills in secondary students. He is also interested in the epistemology of science.

Chapter 20
Balancing Economic Utility with Civic Responsibility

Paul Theobald and John Bedward

The United States may be a largely monotheistic nation, but certain societal elements have nevertheless acquired god-like status. The late Neil Postman famously described this process in his provocative book, *The End of Education* (1995). With respect to the educational endeavor in the United States, Postman identified the largest and most powerful god as one concerned near-exclusively with economic productivity, that is, the god of economic utility. Why do we go to the trouble of providing free schools for all children? Ask any politician in the United States today and you will hear some reference to the economy. One or two of the more thoughtful politicians might add something about citizenship as an afterthought, but make no mistake about it, the common sense, and commonly-held, opinion among politicians and the general public is that schools are designed to serve society by producing youth who are equipped with the skills required by the world of work.

This near-exclusive embrace of economic wherewithal as an end goal for public education is at odds with a growing understanding that effective citizenship requires fairly sophisticated public engagement. In the wake of decades of neglect in America's public schools, our concept of citizenship has withered, creating a void in the nation's political life that corporations and the ultra-wealthy have been all-too-willing to fill.

These prophets of the god of economic utility, CEOs from major corporations, seemingly have no qualms about berating the nation's public schools for not doing the job to their satisfaction. Yet these same CEOs collectively spend billions each year trying to create unthinking, irresponsible consumers out of our children. Our kids are battered with messages telling them that whatever it is they want, "it's priceless"—or that they should "live richly." No need to work for anything—just

P. Theobald (✉) • J. Bedward
School of Education, Buena Vista University, 610 West 4th St., Storm Lake, IA 50588, USA
e-mail: TheobaldP@bvu.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_20

use the card. They are told, ceaselessly, that in order to be cool, in order to have friends, in order to be loved, they must look a certain way, buy a certain product, and remain faithful to certain aspirations. In short, they must "be like Mike." The commercial messages aimed at our youth are distracting at best, in terms of the educational lives of our children, and most likely downright harmful. But these messages yield power and profit for some and so they continue, genuine concerns about America's poor educational performance notwithstanding.

Why is there no legislation that would prevent corporations from deliberately targeting children? Why is there no collective will to generate cultural norms that would protect children from efforts to turn them into unthinking consumers? Why is it that the average middle school student in this country can correctly identify over 1,200 corporate logos, but fewer than 12 plants native to their place on earth? Part of the answer to these questions is connected to the near-exclusive control of print and broadcast media by for-profit corporations. The "media monopoly," as Benjamin Bagdikian calls it, possesses an unprecedented ability to dictate, and put parameters around, what Americans think about and discuss (Bagdikian 2004). The media in this country have been totally complicit in the effort to re-make our educational system into a societal institution subservient to Postman's god of economic utility. For more on this topic readers should consult the work of media scholars like Bagdikian, Robert McChesney, Noam Chomsky, and others. However, for a full explanation of why our educational efforts became tied to economic needs we need to start at the beginning—the very outset of the American experiment.

Our founding fathers were doing something quite extraordinary during the 1770s and 1780s. They were fashioning an alternative to feudal arrangements that had been in place for centuries. To do this, they needed to come up with answers to three perennial questions, three questions that all societies must answer, questions they cannot fail to answer, in fact. (1) How will we govern ourselves? (2) How will we meet our needs? And, (3) how will we educate our youth? The Enlightenment scholars who focused on these questions put varying emphasis on one over another, because the answer to one will necessarily affect the answer to the others.

Without delving into too much history, suffice it to say that most of America's leading Enlightenment spokespersons, like most Enlightenment scholars generally, felt that the economic question was primary—and that answers as to how to do politics and education should necessarily follow in the wake of the answer to the economic question. The supreme value driving the Enlightenment was human freedom—and when this value was inserted into the economic question, capitalism was born, or so many have argued. As an example, after Alexander Hamilton created the national bank, the epigram used on coins for a time was not "In God we trust," but "Mind your business."

When the economic question was viewed as primary, the answers to how to do politics and education became predictable. An economic arena defined by freedom meant a government that would protect economic freedom and an educational system that would promote economic wherewithal. In broad strokes, this is what has taken place in the United States. Granted, there has been resistance to this formula over the years, sometimes significant resistance, but the centrality of economics defined by freedom as the definitively American answer to the economic question has never been broken—even when that centrality led to a total economic collapse in 1929 and a near-total collapse in 2008.

The amazing staying power of the American perspective, the degree to which we cling to “free market economics” and pay homage to the god of economic utility, is tied to the eighteenth century arguments made in an attempt to undermine the power of feudal arrangements. It turns out, according to Enlightenment scholars, that freedom is the “natural” condition of humankind, and that anyone who questions a free economic market is going against the “laws of nature.” To operate in accordance with “natural law” certain political changes needed to be made, like giving all male property-owners the right to vote, separating church and state, and creating a judicial branch that might rule on conflicts that occur in the economic arena. In short, it all unfolded as planned in the English colonies on the North American seaboard.

Speaking in general terms, once again, most post-feudal nations soon identified the downside of an economic arena defined by freedom and made “adjustments” to their economic theory. In the United State those adjustments came in the form of the abolition of slavery, a treaty / reservation system that ostensibly compensated Native Americans for the acquisition of their land, the establishment of city parks, the reform of prisons and asylums, the establishment of free public schools, the extension of suffrage to all males and, eventually, all females, the establishment of police and fire forces, social security, Medicaid and Medicare, and so forth.

Still, on virtually every measure of democratic health and well-being, the U.S. lags behind the top 25 modern democracies (Dahl 2002). We have not made the adjustments that others have. For example, we are the only modern democracy that denies health care to millions of its citizens, resulting in tens of thousands of needless deaths each year. It is not the citizen’s right to life that matters in America, but the return coming to investors in health insurance corporations. We do nothing to protect American jobs from exportation—in fact, the 109th Congress actually created a tax incentive for corporations willing to export jobs—a certain strategy for raising stock prices. Yet another telling example that most Americans are unaware of is the fact that Congress passed legislation permitting the use of gas in meat packages so that red meat will stay red longer and not turn a darker color as quickly. This enables meat packaging operations to command top prices far longer than when the meat begins to turn brown after a few days. This is an instance where Congress passed a law directly benefiting corporate agribusiness by condoning the intentional deception of American citizens, and such examples abound. It should be clear at this point why economics is deemed to be the defining characteristic of the human condition and why the god of economic utility reigns supreme as the greater arbiter of educational policy and practice. As well, it should be clear why those with economic power are free to teach our youth what it means to be cool or how it is that they can make themselves liked or loved, and why no one cares much about the educational damage done in the process.

But it wasn’t always like this. There was a time in the United States when there was widespread sentiment for raising the centrality of the political question. That is, there was a democratic moment in the antebellum United States when creating a democracy, inserting a political dimension into the life of the common man, became the definitive societal project. It was during the era of "log cabin presidents" that public school systems were promoted and adopted. The goal of these systems was to prepare citizens to shoulder the intellectual burden of democracy, and it had almost nothing to do with greasing the skids of the economy or creating economic hegemony around the world. Any economic wherewithal that might redound to students in the nation's common schools was deemed to be a residual benefit, the primary goal was preparing students to shoulder their civic responsibilities. But this democratic moment didn't last long.

A biologist, of all things, helped bring the era to its end. To be fair, it wasn't the biologist so much as the sociologists who interpreted Charles Darwin's biological theories, individuals like Herbert Spencer and William Graham Sumner. For these prophets of Social Darwinism, the theory of evolution seemed to argue against a *common* educational agenda, one common to all citizens in a democracy. If by virtue of their evolutionary status all citizens possessed different intellectual capabilities, a differentiated school system was required, one that could match the curriculum to the evolutionary status of the child, or so Social Darwinists argued. Clearly minorities, who were deemed to be so obviously less evolved than whites, needed a low-grade education, one tied to occupations that required little educational background. We were so convinced of this, that not long into the twentieth century we created tech high schools for minorities, places where minority children could receive a technical, job-focused education. Many of these still exist, though the worst excesses of exclusively occupational training have been reduced.

As we noted at the outset, ask a legislator today why we go to the expense of providing free public schools and he or she will undoubtedly say "So that kids can get good jobs." Or, if not that, it will be something like this: "So America's economy can compete with the rest of the world." In other words, the view is so limited, so tied to economics as a result of a century's worth of momentum in that direction, that they lack the ability to envision an alternative and they certainly lack the knowledge of their own nation's history that could readily supply an alternative. So what is to be done? How might the link between democratic civic responsibilities and public education be re-established? How might the ends of education be re-balanced so that the educational system is a positive economic catalyst and at the same time procreative of an informed and engaged citizenry? And what is the role of science education in that re-balancing? We turn now to these questions.

Why Shift the Ends of Education?

Broaching questions related to the ends of education is difficult in a society that is at the mercy of corporate entities where shareholder value and maximizing profit is of paramount importance. We scarcely possess the vocabulary to describe the desire we feel to be part of a group, to belong to communities, and to participate in initiatives that are larger than ourselves. Practitioners and supporters of the deep ecology movement (Jensen et al. 2011; McKibben 2010) provide some help with this by pointing out that if we allow industrialization to proceed unabated, the end result is an increasingly warmer planet, one that is resource scarce and economically unequal. In our pursuit of individual freedoms we are inadvertently sacrificing the livelihood of communities and reshaping the very nature of ecosystems (*The Economist* 2012). Contemporary globalization, large-scale mechanization, increased urbanization, and hyper-consumerism has created an unprecedented demand for natural resources—for example, fossil fuel, water, precious minerals, arable land—have strained the very workings of the planetary "spheres". The grand challenge of our time is a better understanding of industrial civilization's impact on the geosphere, hydrosphere, atmosphere and biosphere, and what adaptive/changes civilization must take.

In point of fact, humans have become a geologic agent. Land erosion exceeds all natural processes by a factor of ten (National Science Foundation [NSF] 2010). Large scale farming practices, resulting in the loss of the family farm, the growth of monoculture crops for fuel and feed has created an unprecedented need for chemical fertilizers and ground water (Centner 2004). Mining practices such as the Tar Sand project in Alberta, Canada, mountain top removal for coal, and deforestation for wood products and arable land are altering the warming and cooling of the planet. What was once a 100,000 year cycle—temperature fluctuation of 5 °C—is now a small but steady increase in temperature due in large measure to the burning of fossil fuels. The result of these greenhouse gases (e.g., carbon dioxide, nitrous oxide) exceeding 350 ppm (McKibben 2010) in the atmosphere may be catastrophic if we do not alter our consumer demand and lifestyle. The incremental warming of the planet will cause global sea level rise, heat waves, droughts, and floods forcing us to rethink where and how we live in the US and across the globe (350.org 2013). Coastal cities will be directly affected by sea level rise, the current material use (e.g., concrete and steel for construction) and organization (e.g., suburban sprawl) of cities makes them heat sinks, heavily dependent on vehicles and reliant on external resources. Public transportation strategy that includes light rail, bike lanes, pedestrian walkways and public bus transportation must be part of the solution as societies reconcile the nature and use of cities. We must also consider how large metropolises are affecting the migratory patterns of wildlife. Current research and implementation of wildlife corridors has proven to be somewhat effective (National Wildlife Fund [NWF] 2012).

Too often, we think of climate change and industrial practices in terms of their affect on human population, but these shifts have a detrimental affect on many of the world's species. In fact, we are already seeing the impact of our industrial-ecological footprint on many ecosystems the world over. Because of the uneven distribution of world resources, our targeted industrial practices have decreased the capacity of environments to support certain species, reducing ecosystem biodiversity and ecosystem resilience (NSF 2009). This includes changes in migration patterns of plants and animals, and inadvertently viruses and bacteria, which may have an adverse affect on human health and other species. The removal of almost all large vertebrates from the oceans, pollution in the form of plastics and sewage run-off, and changes in ocean chemistry—coral reef die off—is altering the ocean food web (Ocean Literacy Network [OLN] 2011). One of the biggest concerns is species extinction, the loss of evolutionary history, design and pharmacopeia that may illuminate a different path from our current industrial ways. The study of biomimicry—nature's inherent design—continues to provide us with clues in how to design sustainable products and leverage ecosystems as sustainable services (Benyus 1997). In a globalized world the industrial impact of one region will impact other regions, e.g., the movement of pollutants in air and water from industrial practices. There is a need for a more integrated and holistic approach to merging economic, societal and personal needs.

Toward Civic Responsibility/Activism in Science Education

A current trend in science education is the development of critical STEM (science-technology-engineering-mathematics; see also STEAM) literacy that can serve scale-appropriate economic needs for national interest, societal needs for sustainable technological and scientific advances, and personal needs for informed and fulfilling political participation (Zolleman 2012). Environmental movements must remain aware of the corporate contributions to furthering the so-called STEM-pipeline. It is not simply a means to getting a job but an important area of study for non-STEM majors. It provides a way of understanding the material, virtual and natural world, shedding light in to lifestyle changes we need to make. It is one of many practical frameworks needed to question our consumer / material habits that contribute to the ecological challenges facing societies (Achieve 2013). It is STEM literacy for citizenship that balances higher order thinking skills—identification, understanding, interpretation, creating and communicating knowledge (Scheiler 2010; Kolsto 2001)—familiarity with the natural world (Pearson et al. 2010), reasoned decision making, the ability to ask the right questions, and think critically to ensure a more equitable and just society (Dos Sontos 2009; Krajcik and Sutherland 2010). It is not enough to learn how to develop competencies in STEM process skills, the nature of STEM practices, and STEM enterprises. Students must also leverage STEM content knowledge to learn how natural resources are shaped by markets, governments, and international treaties that govern industrial processes (National Academy of Sciences [NAS] 2001). The era of learning in silos must be replaced with an integrated-systems approach to learning. It is only through collaboration and trans-disciplinary practice that students will be able to link their personal, economic and societal needs. Human rights, land rights and the rights of species must be part of the decision making process. We have always lived in an interconnected life-web.

A critical STEM literacy necessarily will include scenarios of what it means to phase out fossil fuels. This has big implications for our energy, feedstock and products. Our current energy demands must include renewable fuels education—wind, solar, geothermal and biomass. The products generated from harnessing these energies must also be considered. For instance, the production or photovoltaics to harness the sun's energy, and batteries for hybrid cars and energy storage rely on the use of precious metals and minerals. In this discussion mining practices and policy must also be taken into account since the industrial by-product of these minerals are often toxic and carcinogenic. Ultimately, there must be a price on carbon generated from fossil fuels and an environmental tax for all natural resources used for consumer use. We must understand the true cost of harnessing nature's resources. The goal is a reinvention of materials and systems based on cradle-to-cradle principles whereby materials are selected with regard to their industrial benefit as well as their hazards and behavioral forces. Final products need to be reused continuously, eliminating the necessity for disposal and moving us towards a zero waste, zero emission society (NSF 2009; NAS 2001). Last, the chemical industry relies on fossil fuels for many of the everyday consumer products. Currently there are more than 80,000 registered chemicals with 2,000 new chemicals being created each year (NAS 2006). More research is needed in the area of green chemistry where the full lifecycle and toxicology costs are understood. This would include research in chemicals derived from biomass—plants, agricultural food and feed crops, wood waste, aquatic plants and municipal waste.

Throughout history, the best and most substantive treatises on education have focused on the individual's ability to define and defend justice in his/her particular place on earth. The great enemy of justice has been concentrated power, for the human condition, particularly absent wide-ranging study and thoughtful observation, has proven to be extremely vulnerable to the lure of power. This vulnerability is what prompted Lord Acton to assert that "power tends to corrupt, and absolute power corrupts absolutely (Henderson 2013)." Even a casual acquaintance with the history of western civilization easily demonstrates that when power is widely dispersed, educational efforts are widespread as well. When power falls into fewer and fewer hands, educational efforts are curtailed or carefully controlled. The historical connection between formal education and the equitable distribution of justice is a constant threat to concentrated power. As the United States has become more and more plutocratic, more and more subservient to the demands of too-big-to-fail corporations, those with power have fervently tried to limit any discussion of education to that which will serve the god of economic utility.

Given twenty-first century circumstances, however, this emphasis is sacrificing more than merely the kind of civic responsibility that would help re-build a middle class society, it is also sacrificing the health and well-being of the earth itself, making the long-term viability of human life a highly debatable proposition. One crucial piece of the answer to these circumstances is to re-balance the ends of education so that all Americans possess the ability to shoulder the intellectual burden of democracy. Rachel Carson's, *Silent Spring*, was metaphorically our canary in the coal mine, arguably ushering in the environmental movement. More recently, 350.org, is providing a global platform to discuss the environmental implications to irresponsible energy production. They have been very active in trying to dissuade U.S. lawmakers from completing the Keystone XL Pipeline, a TransCanada initiative originating from Alberta, Canada. 350.org is using digital media and grassroots organizing to build a global movement to solve the climate crisis. The New K-12 State-by-State initiative, *Next Generation Science Standards*, to be finalized in 2013, provides a clearer picture of the need to integrate science and engineering as practice. In order to participate in ecological-human solutions, activists must understand how science and technology is shaped, and to what ends. We must understand that all solutions require social and technical input. Finally, the global science and engineering community has posited the engineering grand challenges (The National Academies 2012), our "civilizational moment" if you will. Issues of water scarcity, food security, carbon sequestration are some of the big issues of our time. There is a K-12 component to support students and teachers interested in issue-based science. Ultimately, young people need support re-imagining community, physically and virtually, and help defining what it means to create 'resilient' communities. It is a "glocal" imperative, enacting local solutions to global issues by creating human and virtual networks of like-minds. The struggle continues…

References

350.org. (2013). *350.org*. Retrieved on March 17, 2013, from http://350.org/

Achieve. (2013). *Next generation science standards.* Washington, DC: Achieve Inc. Retrieved March 17, 2013, from http://www.nextgenscience.org/

Bagdikian, B. H. (2004). *The new media monopoly*. Boston: Houghton Mifflin.

Benyus, J. M. (1997). *Biomimicry: Innovation inspired by nature*. New York: Quill.

Carson, R. (1990). *Silent spring*. New York: Houghton Mifflin.

Centner, T. J. (2004). Enforcing environmental regulations: Concentrated animal feeding operations. *Missouri Law Review, 69*, 697–730.

Dahl, R. A. (2002). *How democratic is the American constitution?* New Haven: Yale University Press.

Dos Sontos, W. L. P. (2009). Scientific literacy: A Freirean perspective as a radical view of humanistic science education. *Science Education, 93*, 361–382.

Henderson, D. (2013). *Lord Acton on power corrupts. Library of Economics and Liberty*. Retrieved March, 2013 at www.econlog.econlib.org/archives/2013/02/lord_acton_on_p.html

Jensen, D., McBay, A., & Keith, L. (2011). *Deep green resistance: The strategy to save the planet*. New York: Seven Stories Press.

Kolsto, S. D. (2001). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education, 85*, 291–310.

Krajcik, J. S., & Sutherland, L. M. (2010). Supporting students in developing literacy in science. *Science, 328*, 456–459.

McKibben, B. (2010). *Earth: Making a life on a tough new planet*. New York: Henry Holt and Company.

National Academy of Sciences. (2001). *Grand challenges in environmental sciences*. Washington, DC: National Academy Press.

National Academy of Sciences. (2006). *Sustainability in the chemical industry: Grand challenges and research needs* (A Workshop Report). Washington, DC: National Academy Press.

National Science Foundation. (2009). *Climate literacy: The essential principles of climate sciences*. Retrieved February 14, 2013, from http://www.climatescience.gov

National Science Foundation. (2010). *Earth science literacy initiative*. Retrieved February 14, 2013, from http://www.earthscienceliteracy.org/

National Wildlife Foundation. (2012). *Wildlife corridors*. Available at http://www.nwf.org/

Ocean Literacy Network. (2011). *The essential principles of ocean science*. Retrieved February 14, 2013, from http://oceanliteracy.wp2.coexploration.org/

Pearson, P. D., Moje, E., et al. (2010). Literacy and science: Each in the service of the other. *Science, 328*, 459–463.

Postman, N. (1995). *The end of education: Redefining the value of school*. New York: Vintage Books.

Scheiler, A. (2010). Assessing literacy across a changing world. *Science, 328*, 433–434.

The Economist. (2012). A man-made world. *The Economist*, May 28, pp. 81–83.

The National Academies. (2012). *Engineering grand challenges*. Washington, DC: National Academy of Sciences. Retrieved on March 17, 2013, from http://www.grandchallengek12.org/abou

Zolleman, A. (2012). STEM literacy for learning. *School Science and Mathematics, 112*, 12–19.

Paul Theobald currently serves as dean of the School of Education at Buena Vista University in Storm Lake, Iowa. He has published widely in the area of community-based and place-based education. His most recent book, *Education Now: How Re-thinking America's Past Can Change Its Future* (Paradigm 2009), won the Critic's Choice Award from the American Educational Studies Association.

John Bedward is an assistant professor of STEM education at Buena Vista University in Storm Lake, Iowa. He has taught in a variety of K-12 settings and in formal and informal STEM settings. His current research includes integrated STEM, augmented reality, digital education, undergraduate geoscience cyberlearning and rural/urban STEM school redesign.

Chapter 21
Pursuing Youth-led Socio-scientific Activism: Conversations of Participation, Pedagogy and Power

Larry Bencze, Steve Alsop, Allison Ritchie, Michael Bowen, and Shaun Chen

Governments in many countries have increasingly mandated that teachers encourage students to learn about and explore *socioscientific issues* (SSIs).[1] In parallel, educational researchers and others have developed perspectives and practices that may assist teachers in implementing these mandates. Although considerable progress has been made in this regard, teachers' main emphasis continues to be on celebratory teaching of products (e.g., laws & theories) of fields of science and technology (Hodson 2011). Such more didactic approaches can limit students' exposure to contentious issues—often avoiding discussions that might cast negative light on fields of professional science and technology (Hodson 2008). Where there *has been* attention to SSIs, moreover, it often may be limited to asking students to negotiate issues and logically defend their positions on them (Hodson 2011; Levinson 2013). Zeidler et al. (2009), for example, who have significantly influenced the nature and progress of SSI education, suggest that the approach presents students opportunities to "reflect on issues in order to evaluate claims, analyze evidence, and

L. Bencze (✉)
Department of Curriculum, Teaching, and Learning OISE, University of Toronto, 252 Bloor St. West, Toronto, ON M5S 1V6, Canada
e-mail: larry.bencze@utoronto.ca

S. Alsop
Faculty of Education, Winters College, York University, Keele Campus, Toronto, ON, Canada
e-mail: salsop@edu.yorku.ca

A. Ritchie • S. Chen
OISE, University of Toronto, 252 Bloor St. West, Toronto, ON M5S 1V6, Canada
e-mail: allison.ritchie@gmail.com; shaun@shaunchen.com

M. Bowen
Faculty of Education, Mount Saint Vincent University, 166 Bedford Highway, Halifax, NS, Canada
e-mail: gmbowen@yahoo.com

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_21

assess multiple viewpoints regarding ethical issues on scientific topics through social interaction and discourse" (p. 75).

Although engaging students in negotiation of different perspectives, with consideration of sometimes contradictory evidence, can promote such laudable goals as knowledge and decisions about particular issues (e.g., Furberg and Ludvigsen 2008); increases in socioscientific reasoning skills (e.g., Sadler, Barab and Scott 2007); learning of science knowledge (e.g., laws and theories; e.g., Castano 2008); and, learning about the nature of science (e.g., Khishfe and Lederman 2006), there appear to be several ways to expand such engagement. Decision-making in 'real-world' contexts is more complex than cognition promoted through, for instance, prescriptive argumentation schemes. Often, it is tied to culture, identity, emotions and aesthetics, with many tacit aspects (Alsop 2005). Furthermore, each person in communities often assumes different roles/tasks, depending, in part, on interests and expertise; rather than requiring identical attitudes, skills and knowledge (Roth and Barton 2004). With such distributed expertise, outcomes are often unpredictable, situated, and resembling a *Gestalt* phenomenon—with varying interpretations about the nature and value of outcomes. We also suggest that the nature of science that students might use in decisions about SSIs should be critically scrutinized, often because fields of science and technology may be compromised through financial influences from for-profit entities (Krimsky 2003). Ironically, the metaphor of *private profit* seems to be hidden in highly individualistic SSI decision-making approaches. Emphasis may be placed on benefits for individuals (each student), such as outcomes like socioscientific reasoning mentioned above. This seems problematic in light of research suggesting that *neoliberal* economic systems, which emphasize strategic (non)intervention in markets to maximize private profit, promote *possessive individualism*—an orientation that many persuasively argue contribute to problems for the wellbeing of individuals, societies and environments (Bakan 2004; McMurtry 1999; McQuaig and Brooks 2010).

Partly in light of the contention that each of us is in dynamic relationship with most (if not all) entities on earth (Latour 2005), many scholars are now urging educators to encourage and enable students to accept more *collectivist* (rather than *egoist*) epistemological stances and, accordingly, take socio-political actions[2] that may contribute to improvements in the wellbeing of individuals, societies and environments (Hodson 2011). They are, in other words, recommending a tack contrary to that promoted by many capitalists; that is, to urge individuals to 'spend' some of their capital (e.g., cultural & social) (Bourdieu 1986) on positive systemic change. Such actions may not be fully altruistic, given that positive action for networks may also benefit those initiating the actions. Acting on—instead of just developing one's personal positions about—SSIs can help learners to develop deeper, more personalized, understanding of and commitments to issues. According to Wenger (1998), for example, deep and personal commitments to ideas, skills, etc. may best arise when learners are personally involved in reciprocal relationships between phenomena and their representations—such as when students, for example, develop representations (conclusions) from their personalized science inquiries into SSIs and, then, use their findings and conclusions to implement actions to improve situations (phenomena) associated with those SSIs. Apart from such personal gains, however, student-led actions for common benefits seem necessary because potential problems like global warming seem so serious that immediate development of activist citizens may be essential (Hodson 2011). Moreover, given the immense adverse influence that neoliberal capitalists appear to be having over individuals, societies and environments, there may be needs for pedagogies that strongly prioritize social justice and environmental sustainability (McLaren 2000). Such foci place much more emphasis on efforts to affect change through interactions with those in power positions (Hodson 2011).

There have been some successes in encouraging and enabling students to take actions to address socioscientific issues. In the context of secondary schools, McNeil and Houle Vaughn (2012), for example, report that mentored teachers were able to encourage students to take on more personal actions regarding climate change. Meanwhile, some educators, such as Ponder and Cox-Peterson (2010), report successes in engaging students in community-based service learning projects. An emphasis we have been pursuing is to encourage students to base their decisions about issues, including actions to address them, at least partly on self-directed primary research. Encouraging young people to undertake social actions to promote causes may require that they develop deep and personal attachments to issues (Hodson 2011). Such affective engagements with SSIs seem to develop if students self-direct *primary* (e.g., surveys), along with secondary (e.g., internet searches), investigations into issues. Findings can motivate and direct actions they might take to address SSIs. This tack is premised on the prediction, based on knowledge duality theory (Wenger 1998), that students should develop deep commitments to action if they are personally engaged in reciprocal relations between *phenomena* (e.g., citizens' views of consumer products) and *representations* of them (e.g., survey data). Along these lines, we report some successes with encouraging and enabling students (Bencze et al. 2012) and student-teachers (Bencze and Sperling 2012) to conduct research-informed actions to address SSIs.

Although reports like those above suggest successes, in various contexts, it is apparent that, perhaps largely because of the aforementioned over-emphasis in schools on instruction in products of science and technology, socio-political activism is still rare in educational contexts for young people (Hodson 2011; Santos 2009). We also have found that promotion of student-led research-informed actions to address socioscientific issues in formal school contexts has been difficult (Bencze and Carter 2011). Consequently, there appears to be a great need for further exploration of contexts that might enable and encourage student actions on socioscientific issues.

Towards Youth-Driven Altruistic Social Actions

In light of difficulties that educators, generally, and our research group, more specifically, have had in enlisting teachers for encouraging and enabling students in formal educational contexts to implement research-informed action projects to address socioscientific issues, we decided to explore such activism in the context of after-school youth activist clubs. Given that students' performance in such optional clubs is not evaluated, we felt that young people may more freely implement research-informed actions—a tack recommended by Hodson (2011). However, because we found that encouraging student-led research-informed actions within another group's youth club quite difficult, largely because of that group's emphasis on didactic instructional approaches (Sperling and Bencze 2011), we decided to establish our own youth group—one in which self-directness was prioritized. Accordingly, in September 2011, we established an after-school activist club for teenagers, called Science (in) Action (SinA),[3] with a mandate to encourage and enable youth to self-direct research-informed action projects to address personal, social and/or environmental issues associated with fields of science and technology. Underlying this mandate is actor network theory (Latour 2005), which suggests that each person is dynamically associated with a web of actants—all of which may affect us and that we may affect, both to varying degrees. Consequently, we may have responsibilities to actants in our network that may have contributed, to some extent, to strengths, accomplishments, etc.—such as our material wealth and public speaking abilities—that we might, otherwise, consider completely attributable to ourselves (Alperovitz and Daly 2008).

With the above ethic in mind, we met for 90 min once per week (except holidays) between September 2011 and June 2012 with about 10 teenagers from various schools in the Toronto, Canada, area who expressed interest in 'taking actions, based on their own research, to improve the wellbeing of individuals, societies and environments.' As elaborated later in this chapter (under 'Factors Affecting Youth Actions'), we mostly worked with youth in a very *reflexive* mode—continually inviting them to: express their positions on various SSIs; conduct primary and secondary research to learn more about them; and, develop and implement plans of actions to address issues of their interest/concern. Throughout such activities, we acted as sources of ideas, approaches and material resources *they* requested. At the same time, we conducted educational research to document and explain youths' decisions—particularly in terms of the nature and extent of their pro-social actions and factors that may have contributed to such actions. To achieve our research agenda, we conducted data-collection and analyses having *rationalistic* and *naturalistic* characteristics (Guba and Lincoln 1988). Rationalistically, we focused, for example, on teenagers' ongoing conceptions of knowledge, knowledge building and uses of knowledge. Naturalistically, we collected data that enabled emergence of unexpected situational outcomes. Data collected from ten youth (ages 14–18) include project work artefacts (e.g., videos and electronic slideshows), instructional materials, field notes and semi-structured and *in-situ* interviews. For analyses, each of us coded data for categories and then developed encompassing themes—using constant comparative methods based on constructivist grounded theory (Charmaz 2006). Categories and themes were negotiated between us to achieve consensus (Wasser and Bresler 1996). Member checks with participants were conducted to help ensure claims' trustworthiness, each of which reported here was based on at least three supporting data sources.

Youths' Social Actions

Most youth involved in Science (in) Action were able to complete research-informed action projects to address socioscientific issues of their choice. A representative sample of their project topics is given in Table 21.1. There were, however, some qualitative differences between the after-school projects and those in formal educational contexts. Below, we provide highlights of SinA projects—with special focus on one participant, whose project illustrated many features of the others, in addition to some unique features we felt worth sharing.

Many of those who volunteered for SinA were quite savvy with computers, Internet and other forms of information technology. Perhaps as a consequence, many chose either to focus their research on some aspect of technology (refer to Table 21.1). Dan, a student in grade 8 who was particularly technologically-capable, decided to explore the effectiveness of Annie Leonard's video, *The Story of Electronics* (SoE),[4] in educating peers about issues associated with electronics waste (eWaste). Unlike all other groups, which conducted studies, Dan chose to conduct an experimental investigation prior to action. After analyzing the SoE for content, he developed a survey to determine youths' (n = 15) knowledge and practices regarding electronics technologies prior to and after their viewing the SoE. To his surprise, most of the youth who viewed the video retained relatively little information he included in his survey—such as implications of Moore's Law[5] and promotion of extended producer responsibility.[6] This conclusion seemed supported by post-survey discussions he had with participants, with findings like: "One of the big things I found in my tests is that people weren't paying as much attention to the video. … I think they kinda got bored by it. To me, it is kind-of interesting. But, whenever I would ask them why they aren't listening, they'd say 'because we don't like documentaries.' Their view of these kinds of videos is [that they would ask themselves,] 'Why should we do anything about these? We're just kids'" (March 22, 2012). To overcome this apparent educational shortcoming, Dan produced a multimedia presentation about eWaste issues and actions—including a movie and

Table 21.1 Youth participants and their project topics

Name	Grade	Project title(s)
Andrea	12	Video Game Use
Aaron	8	Internet Censorship
Bill	12	Cigarette Smoking
Dan	8	Electronic Waste
Lucy	10	Facebook™ Uses; Cafeteria Foods
Millie	12	Facebook™ Uses; Cafeteria Foods
Nathalie	11	Acquired Immunodeficiency Syndrome (AIDS)
Randi	11	Cigarette Smoking
Sacha	11	Cigarette Smoking
Shawn	8	Internet Censorship

slide series. About his presentation, he said, "[W]hen we present [our findings] to all the teachers, hopefully they will take it all away and teach about it" (May 22, 2012).

Through their self-led research and development of action plans, participants learned what they considered interesting facts, ideas, perspectives, etc.—including those pertaining to various S-T-S-E relationships—dealing with their chosen issue. With regards to eWaste, for instance, Dan learned some significant facts about chemicals in electronics:

> I don't think people are aware enough of what kind of chemicals and what kind of impacts throwing away your electronics … People know about batteries, because they are all chemicals; but, they don't know that if you throw away certain electrical products—almost all electrical products—it really is a hazard to the environment, because these electronics are built with chemicals like PVC and other highly toxic chemicals. (March 22, 2012)

Similarly, with regards to issues surrounding smoking, 'Sacha' said: "[I]t costs a lot, a lot of money for people who get lung cancer from smoking. They have to pay huge amounts of money, in order to get their lungs repaired. And also, it costs the government lots of, lots of money in health care" (May 15, 2012).

In learning about such facts and relationships, however, all youth club members seemed to realize that many of the STSE issues about which they and peers were dealing involved decisions made by powerful people and/or groups. Generally, they saw governments and (capitalist) companies—often in collusion—as the main decision-makers. When asked by a research assistant (SC) who would oppose eWaste regulation, for instance, Dan answered: "The big companies who don't want their products to be portrayed as non-environmentally friendly products that are terrible for the environment. Also the companies [oppose eWaste regulation] because product take-back laws are [being introduced] and people are really registering with them [the laws]" (May 22, 2012). About smoking, meanwhile, Sacha said: [Cigarette companies] are advertising that [smoking] is good for you. They'll make you strong. They'll make you attractive. They'll make you like Superman or something like that. And they're actually turning you into something that's like a rotten, mouldy piece of cheese. So yeah, I think that they definitely play a big part in mold that fantasy world [about] smoking" (May 15, 2012). Similarly, when discussing internet control, 'Shawn' said:

> These companies are what make governments run. They give money. The money goes in from these companies. It's like bribery in a way, but not really, cause they're giving money. They're like, 'hey, we're giving you all this money, you guys got to give us something in return here.' They give them money, and they get what they want. (May 22, 2012)

Critically considering STSE relationships, as indicated above, seemed to motivate students to make personal decisions about issues. About potential loss of openness of the internet, for example, 'Aaron' said: "[O]ur topic is mainly about how the government and big companies are taking over the Internet, which most of us think of as something everybody is supposed to use" (April 17, 2012). Meanwhile, Lucy criticized recent government regulations mandating healthy foods in local school cafeterias:

> Maybe it's a negative factor to your health and stuff, but at the same time, since we're older now, we can control ourselves better. I wouldn't go and just get 10 slices of pizza … And I

> think it's kind of good for the students, too, because since they've been denied their rights to have Skittles[™] as a snack, they're going out during lunch to buy big party boxes of pizza, and they do that every day … . (April 11, 2012)

Having formed personal opinions about issues, many of the teenagers in SinA expressed an *interest/desire* to 'speak truth to power'[7]; to take actions aimed at decision-makers. Dan said, for instance, "[m]aybe we could talk to the big [consumer electronics] companies and tell them that people do not know about the toxics" (March 22, 2012). In imagining possible kinds of actions, 'Randi' said: "If I was doing that [protesting], I would hope to annoy those people [average workers] so much that it would somehow go up and up the chain. If you were [saying something] like, 'This sucks. I can't handle these people any more. I have to take the week off.' Then, if a hundred people do that, what's it going to do?" (Jan. 24, 2012). Similarly, 'Andrea' said:

> We would direct [the petition] to the Ministry of Education, the person who's in charge of this whole food protocol; someone who deals with the public representation … in charge of making the rules and who has the ability to change them. We can't just get someone who's involved in the process, but has no power or authority over this whole new change or program. It has to be someone with some, like, power; right? (Feb. 23, 2012)

'Millie,' who posted a cafeteria-food survey on Facebook™, added this note: "Do you know whats truly fantastic? The new survey has received 79 results since yesterday! [… and …] Exemplar[y] responses include: 'Like: Cookies Dislike: all healthy' and 'they are now putting apples in our breakfast sandwiches[; I]t's gross'" (Feb. 18, 2012). She and her team used this as motivation to suggest that they could write a letter to corporations and/or principals about their findings, and what they want them to do.

Despite the promising nature of teenagers' apparent intention to 'speak truth to power,' most of their actual actions seemed to be either *local* or *remote*. They mainly aimed their actions at friends, peers, family members and members of their school communities (albeit some of them, like teachers, having power positions). There was very little in the way of letters to politicians or corporations, for example; and, there were no public protests. Dan, for example, talked about spreading the word about his eWaste survey results by talking to parents at his sister's school, because "those parents could spread the word [about electronics environmentalism]" (Feb. 21, 2012). Most youth were quite comfortable placing essentially anonymous posters, such as that in Fig. 21.1, throughout their school buildings. When they did aim messages at powerful entities (governments and companies), they preferred to do so anonymously and at-a-distance. Although such approaches may seem timid, it seemed to make sense to them to use the power of mass communication for development of mass concerns. A typical recommendation in this regard was strongly voiced by Aaron, who said:

> You could do an internet protest. You could literally get people from all over the world. … Anyone who knows their way around social networks can produce an online protest rather easily. … We are against SOPA, right? So, if we make a really well-made and really putting our point across video, and post it on YouTube™ and create multiple links for it and, if possible, get into other people's [online] descriptions and put the link to your video, then you could literally cause a whole ruckus! (January 24, 2012)

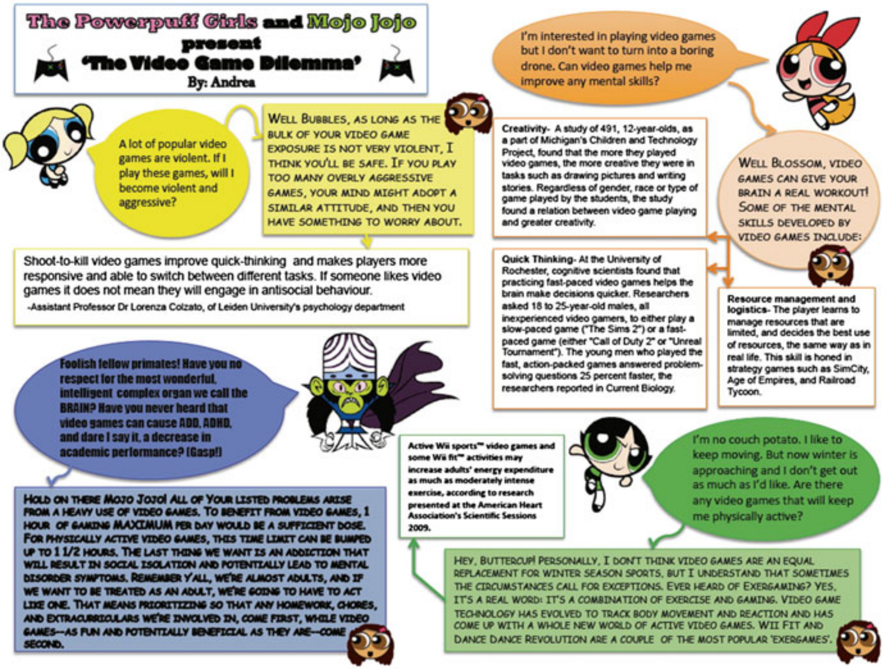


Fig. 21.1 A typical youth action poster

In support, Dan succinctly added: "One person can't change the world, but one person inspiring a lot of other people can [change the world]. … I think kids can do this [affect change on something like eWaste], but I don't think kids can do this alone" (March 22, 2012).

Not only did teenagers' research-informed actions appear somewhat 'timid' (local and/or remote), they also seemed quite *slow/tentative*. In comparing their progress with that reported in our projects involving students enrolled in formal schooling (Bencze et al. 2012; Krstovic and Bencze 2012), we concluded that teenagers in school contexts seemed to complete projects more quickly than those in our informal contexts over a similar time period (about 36 h of contact time). Nevertheless, youth in SinA also appeared to develop some deep commitments to the pursuit of research-informed action projects in future. For example, Aaran said:

> [Research-informed action] has changed me in learning how to get an issue, think about it, research it, and execute your plan. … I'll do it whenever I think something is a little bit messed up, and I think I need to deal with the issue. … I never tried to make a difference. I never really thought like that. I was more like a person, 'Here's a problem. It may affect me. But I don't think I can make a difference. I'm just one person.' I didn't think about how one person could get another person, and then five more people, then 'til you get a whole army. That's pretty cool. (May 22, 2012)

Randi seemed to concur, saying:

> It has made me more comfortable with asking for people to help me. … Asking people interviews, I realized people were willing and wanting to do it. And I think I feel passionately about a lot of different topics, like sexism, religion, etc. … I think [Science (in) Action changed] how I went about researching, and how I made my point, and made me comfortable being outspoken about things that made me upset. (May 29, 2012)

Factors Affecting Youth Actions

Reflexive Apprenticeship

As we soon realized, we could not work with youth in an optional after-school context in ways we witnessed and used in formal instructional situations since at least 2006. In working with (student-)teachers to promote research-informed actions (RiA) on SSIs, some successes were achieved by first implementing an *apprenticeship* that featured relatively teacher-directed activities aimed at helping students to develop expertise and confidence for conducting student-led projects (Bencze and Carter 2011). Assuming youth had little experience with RiA projects in schools, we began our club activities with an apprenticeship that involved—after showing participants a video from YouTube™, in which a fitness enthusiast alerted his viewers to potential misinformation regarding labeling of 'trans-fats'[8] in manufactured foods—a field-trip to a local grocery store to conduct a study of product labeling. It became readily apparent, however, that youth participants wanted the club to be less like formal schooling and more like a 'hobby'—an activity of personal choice one conducts during leisure time. Accordingly, we quickly adopted and used throughout the year an approach we are calling a *reflexive apprenticeship*—a quasi-Socratic approach, in which, after broadly-stating the overall purpose of the club, we asked youth questions to encourage thought and action and, when they requested it, we provided them with ideas and approaches they might use. On the one hand, for example, we stated that we wanted them to conduct primary and secondary research to investigate STSE issues of their choice and then develop actions to address them. Once underway with their projects, we also asked them questions that may be useful—such as: [Regarding issues,] 'What are possible positive and negative relationships between fields of science and technology and societies and environments?' and 'What people or groups may have the most influence on decisions about science and technology?'; [Regarding research,] 'Should you use experiments or correlational studies?[9]; [Regarding actions,] 'What kinds of actions might you take?' and 'At what people or groups will you aim your actions?' If they requested assistance, such as an explanation about how to distinguish an experiment from a correlational study, we provided it. On the other hand, choices for issues, research and actions were mostly left to the youth.

Perhaps because of the somewhat limited guidance from us, youth projects in SinA were relatively slow compared to those conducted by students in formal science education contexts we have studied (as noted above). Nevertheless, perhaps their projects were *relatively deep* compared to many conducted by students in schools. Again, drawing on *knowledge duality theory* (refer above), because youth in SinA had considerable personal choice regarding representations of phenomena (e.g., graphs from their studies) and applications of them (e.g., actions), they may have developed deep commitments to their projects. Their choices of topics were, to a great extent, self-determined. When asked what they would like to investigate, for instance, they avoided suggestions made by us, like fast foods, nuclear energy and climate change, in favor of topics of their interest, including: internet stalking, child pornography and video-game playing (Oct. 27, 2011). In that regard, we noticed that their topics often reflected their personal interests and/or those of parents/guardians. Dan, for instance, said his project focusing on eWaste likely stemmed from the fact that his mother "is an environmentalist" (March 22, 2012). Teenagers' choices were not, however, highly individualized—as we earlier suggested is sometimes promoted in school science and in societies, more generally. Most students chose to work in collaborative teams; but, also, members often learned from experiences of peers in other teams. When one of the youth mentioned the possibility of a group protest, another ('Bill') suggested that perhaps a better tack was to draw on suggestions made by Malcolm Gladwell (2002), in his book *The Tipping Point*, that their ideas could be made to 'go viral' on the internet if they focused on three kinds of people; that is, 'connectors' (those with many social connections), 'mavens' (intelligent people with ideas) and 'sales[persons]' (promoters of ideas). This was an idea Bill gleaned from his parents, who owned an internet services company. Among peers taking up this idea, Andrea said: "When I think of connectors, I think of people in the student council. They know people who … work on the parent council, and they know the Principal as well" (Feb 9, 2012). With such collective youth ownership, therefore, apparent slow progress may enable deep commitments.

Teenagers' Spheres of Agency

We were intrigued by teenagers' unanimous choice, despite our suggestions that they may consider direct actions (like letters to leaders or group protests), to limit their advocacy to local and friendly contexts (e.g., schools) or remote and anonymous ones (e.g., via YouTube™). We wondered about the apparent reticence in 'speaking truth to power,' despite their suggestions of the possible need for such a tack (refer above). In reviewing statements made by them, largely in the context of their project work, their apparent timidity towards direct actions may be explained, in part, because of a sense of relative *powerlessness*. They were, generally, aware that many decisions for many people often are made by few powerful individuals and/or groups. Randi stated such a stance very well in the context of discussing the nature of science in relation to fields of technology and society:

> Corporations can get people to slant their science [via media] or the way that the scientists word things so that they confuse society. People who aren't scientists just won't understand it or will ignore it. There's so many companies that have that issue of putting things out and they just don't work, they do harmful things to people, and that company finds some loophole way of wording around it, or slants information so that people don't know (Mar. 6, 2012).

Such awareness also was evident in their statements to explain their action choices. Regarding his suggestion, for example, that companies might be encouraged to voluntarily add information about toxins to their product labels (regarding electronics), Dan said he suspected that companies would say, "'He's just a school boy[, We needn't listen to him.']. … I am not old enough to get people's support. People will think that I am just a kid and won't be serious" (March 22, 2012). He preferred the anonymity of the internet to implement actions. About the possibility of taking action via a website he could produce, Dan said: "[In that context,] I wouldn't have to mention my age. I could act like I am about 40 … so that people would trust me more" (March 22, 2012).

Youth members of Science (in) Action were not only aware of powerful societal actants, but many of them seemed to have a sense of *fear* of leaders' unseen power. In her particularly eloquent way of speaking on behalf of other youth in the group, Randi, when asked if they would join a large, public, protest, said "[I would do so] if I was anonymous. If there were six of us, and I was just standing there, people could see me. … Even if it's a hundred people, that's not very anonymous. [If people see me,] then I am never going to get hired for a job, ever!" (Jan. 24, 2012). This suggested to us that, perhaps, most of these youth preferred local and remote contexts for action because, in part, they sensed they live in a veritable *panopticon* (Foucault, 1977)—a detention structure, in which prisoners self-regulate their behavior and are inhibited from protest largely because of their belief in the ever-presence of all-seeing guards (hidden in a centrally-located guard house). On the other hand, although we had no sense that participant youth were aware of the concept, their actions aimed at local and familiar and/or distant and unfamiliar actants may be appropriate. According to Gramsci (cited in Cohn 2005), direct actions against the elite may not be effective if they have managed to exercise control over the general society, through processes of cultural hegemony. In such cases, it may be more effective to engage in counter-hegemonic activities, such as those launched by SinA youth, aimed at 'average' citizens who may not, otherwise, support actions against the elite.

Concluding Thoughts

For those who believe our current capitalist system—including its emphasis on consumerism, often at the expense of the wellbeing of individuals, societies and environments—needs reform, if not replacement, this study provides a few potentially-useful findings. Here, we took a pedagogical stance akin toRanciére's (1991/1987) conception of an 'ignorant schoolmaster'—a teacher who, mostly by question-asking regarding a subject about which s/he may knows little, enables learners to largely self-determine answers to their questions and, in this case, also implement pro-social actions based on their learning. This tack opened up a space to remind us that, when youth are given freedom of choice and support, they may take considerable amounts of time to perhaps more deeply and personally explore and build relationships with socioscientific issues and, through attachments derived from such inquiries, take actions to address the issues in ways meaningful to them. Their actions, moreover, may reflect their sense of agency in societies dominated by a logic of capitalism, that may, however, be gradually challenged by counter-hegemonic, electronic media-based educational messages.

Notes

1. This term is one of several used to describe controversies regarding potential problems associated with fields of science and technology. In Canada, the site of this research, such issues are addressed in terms of 'STSE' (Science, Technology, Society & Environment) relationships.
2. Forms of action students might take include: *educating others* (e.g., via posters and pamphlets), *lobbying power-brokers* (e.g., via petitions and letters), developing potentially-improved products and systems (e.g., an electronics item with recyclable components) and/or *making personal improvements* (e.g., using a travel mug) (Bencze et al. 2012).
3. You can learn more about Science (in) Action at: http://webspace.oise.utoronto.ca/~benczela/science_in_action.html
4. http://www.storyofstuff.org/movies-all/story-of-electronics/
5. This is the idea that the number of transistors in electronics should double every 18 months—perhaps leading consumers to discard and replace them then. This is an expectation of legislation that encourages companies to assume financial responsibility for materials, etc. in their products after sale and after they are discarded.
6. This is an expectation of legislation that encourages companies to assume financial responsibility for materials, etc. in their products after sale and after they are discarded.

7. http://www.urbandictionary.com/define.php?term=speak%20truth%20to%20power
8. The term 'trans-fat' is a short-form for trans fatty acid—which is a fatty substance often manufactured from vegetable oils (by adding hydrogen atoms to them) so that they will exist in solid form at room temperatures. They are linked to cardio-vascular diseases like heart attacks and strokes. Manufacturers often use perhaps more benign names for them on packaging, such as: *hydrogenated vegetable oils* and *vegetable oil shortening*.
9. We have had some success in school contexts encouraging students to use correlational studies, rather than experiments, as sources of evidence for actions on STSE issues (Krstovic and Bencze 2012)—particularly because of potential harm to living things in experimentation.

Acknowledgements We acknowledge financial support from the *Social Sciences and Humanities Research Council* (Canada) for this and related projects.

References

Alperovitz, G., & Daly, L. (2008). *Unjust deserts: How the rich are taking our common inheritance*. New York: New Press.

Alsop, S. (Ed.). (2005). *Beyond Cartesian dualism: Encountering affect in teaching and learning of science*. Dordrecht: Springer.

Bakan, J. (2004). *The corporation: The pathological pursuit of profit and power*. Toronto: Viking.

Bencze, L., & Carter, L. (2011). Globalizing students acting for the common good. *Journal of Research in Science Teaching, 48*, 648–669.

Bencze, J. L., & Sperling, E. R. (2012). Student-teachers as advocates for student-led research-informed socioscientific activism. *Canadian Journal of Science, Mathematics and Technology Education, 12*, 62–85.

Bencze, L., Sperling, E., & Carter, L. (2012). Students' research-informed socioscientific activism: Re/Visions for a sustainable future. *Research in Science Education, 42*, 129–148.

Bourdieu, P. (1986). The forms of capital. In J. G. Richardson (Ed.), *The handbook of theory: Research for the sociology of education* (pp. 241–258). New York: Greenwood Press.

Castano, C. (2008). Socio-scientific discussions as a way to improve the comprehension of science and the understanding of the interrelation between species and the environment. *Research in Science Education, 38*, 565–587.

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. New York: Sage.

Cohn, T. H. (2005). *Global political economy: Theory and practice*. New York: Pearson Education.

Foucault, M. (1977). *Discipline and punish: The birth of the prison*. New York: Pantheon Books.

Furberg, A., & Ludvigsen, S. (2008). Students' meaning-making of socioscientific issues in computer mediated settings: Exploring learning through interaction trajectories. *International Journal of Science Education, 30*, 1775–1799.

Gladwell, M. (2002). *The tipping point: How little things can make a big difference*. Boston: Little, Brown and Company.

Guba, E. G., & Lincoln, Y. S. (1988). Naturalistic and rationalistic enquiry. In J. P. Keeves (Ed.), *Educational research, methodology and measurement: An international handbook* (pp. 81–85). London: Pergamon Press.

Hodson, D. (2008). *Towards scientific literacy: A teachers' guide to the history, philosophy and sociology of science*. Rotterdam: Sense.
Hodson, D. (2011). *Looking to the future: Building a curriculum for social activism*. Rotterdam: Sense.
Khishfe, R., & Lederman, N. G. (2006). Teaching nature of science within a controversial topic: Integrated versus nonintegrated. *Journal of Research in Science Teaching, 43*, 395–418.
Krimsky, S. (2003). *Science in the private interest: Has the lure of profits corrupted biomedical research?* Lanham: Rowman & Littlefield.
Krstovic, M., & Bencze, J. L. (2012). The use of correlational studies to encourage activism in science. *Crucible*, *43*. Online at: http://www.stao.ca
Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. Oxford: Oxford University Press.
Levinson, R. (2013). Practice and theory of socio-scientific issues: An authentic model? *Studies in Science Education, 49*, 99–116.
McLaren, P. (2000). *Che Guevara, Paulo Freire, and the pedagogy of the revolution*. Lanham: Rowman & Littlefield.
McMurtry, J. (1999). *The cancer stage of capitalism*. London: Pluto.
McNeill, K. L., & Houle Vaughn, M. (2012). Urban high school students' critical science agency: Conceptual understandings and environmental actions around climate change. *Research in Science Education, 42*, 373–399.
McQuaig, L., & Brooks, N. (2010). *The trouble with billionaires*. Toronto: Viking.
Ponder, J., & Cox-Peterson, A. (2010). Action-based science instruction: Service-learning, stewardship, and civic involvement. In D. J. Tippins, M. P. Mueller, M. van Eijck, & J. D. Adams (Eds.), *Cultural studies and environmentalism: The confluence of ecojustice, place-based (science) education, and indigenous knowledge systems* (pp. 137–149). Dordrecht: Springer.
Rancière, J. (1987). *The ignorant schoolmaster: Five lessons in intellectual emancipation* (K. Ross, Trans., 1991). Stanford: Stanford University Press.
Roth, W.-M., & Barton, A. (2004). *Rethinking scientific literacy*. London: RoutledgeFalmer.
Sadler, T. D., Barab, S. A., & Scott, B. (2007). What do students gain by engaging in socioscientific inquiry? *Research in Science Education, 37*, 371–391.
Santos, dos, W. L. P. (2009). Scientific literacy: A Freirean perspective as a radical view of humanistic science education. Science Education, 93, 361–382.
Sperling, E., & Bencze, J. L. (2011). *Are we teaching girls to fish? Community-university collaboration for youth food justice education*. A presentation at the annual conference of the Australasian Science Education Research Association, June 29–July 2, Adelaide, Australia.
Wasser, J. D., & Bresler, L. (1996). Working in the interpretive zone: Conceptualizing collaboration in qualitative research teams. *Educational Researcher, 25*, 5–15.
Wenger, E. (1998). *Communities of practice*. Cambridge: Cambridge University Press.
Zeidler, D. L., Sadler, T. D., Applebaum, S., & Callahan, B. E. (2009). Advancing reflective judgement through socioscientific issues. *Journal of Research in Science Teaching, 46*, 74–101.

Larry Bencze is an associate professor in Science Education at OISE, University of Toronto. He teaches in the graduate studies and teacher education programmes and conducts research associated with efforts to actively promote social justice and environmental wellbeing in and through science and technology education.

Steve Alsop is a professor in the Faculty of Education and Department of Science and Technologies Studies at York University, Canada. Steve's teaching and research explores the social and political organisation of scientific and technological knowledge, pedagogies of science and technology, and environmental sustainability.

Allison Ritchie is a doctoral student at the department of Curriculum, Teaching, and Learning at OISE/University of Toronto. Her research interest is in participatory action research within Science Education that focuses on re-imagining students as researchers and knowledge generators on social justice issues as defined by them, and how they might take action on these issues.

Michael Bowen is an associate professor in the Faculty of Education at Mount Saint Vicent University with research interests in sociology/ethnography of science, informal science, online collaborative communities, graphing/inscriptions learning and use, writing-to-use science, gender issues, and science teacher education.

Shaun Chen Named by Maclean's Magazine as one of "100 young Canadians to watch," Shaun Chen is a community activist, educator and researcher. In 2006, Shaun was elected to the Toronto District School Board as Trustee representing Scarborough-Rouge River. A recipient of the Queen Elizabeth II Diamond Jubilee Medal, Shaun holds his MA from OISE/University of Toronto.

Chapter 22
Harnessing Youth Activism with/in Undergraduate Education: A Case Study of *Change Lab*

Audrey Desjardins, Sabrina Hauser, Jennifer A. McRae, Carlos G.A. Ormond, Deanna Rogers, and David B. Zandvliet

This report captures stories told by key stakeholders involved in the development and current offering of the *Change Lab* program. It attempts to honor the voices of many (but not all) of those involved in its inception including former and current students who conceived of this form of undergraduate education in the first place. These players (co-authors on this chapter) act either as leaders in the design of our experience-based, dialogue-driven project *or* as active participants, steering the development of future forms the program might take. Through their innovation, passion, and commitment, they provide insight into the power of dialogue and sustainability education that (in this case) is focused on the improvement of the university campus as a living lab for sustainability.

By weaving together each of our own personal accounts, we hope to capture the energy and enthusiasm that we as individuals have shared with each other during class meetings and research visits during *Change Lab*. We also share the many design lessons we have learned while working together over a period of many months. Our narrative is phenomenological and ethnographic (Maggs-Rapport 2000). In other words, while each of our stories are unique, it is our intention that they may reveal certain qualities or conditions found in other university communities when it comes to the development of interdisciplinary, environmental and experiential forms of undergraduate education.

Finally, three distinct, but overlapping narratives compose this work: the first a *theoretical* narrative (lead by Carlos and David) explores the many forms that activism *might* take in undergraduate education; the second, a *course designer* narrative (lead by Jennifer and Deanna) recounts events and actions inspiring us to

A. Desjardins • S. Hauser • J.A. McRae • C.G.A. Ormond • D. Rogers
Simon Fraser University, Burnaby, BC, Canada

D.B. Zandvliet (✉)
Institute for Environmental Learning, Simon Fraser University, Burnaby, Canada
e-mail: dbz@sfu.ca; http://eco-learning.org; http://www.eecom.org

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_22

conceptualize and develop this project; and lastly, a *participant* narrative (lead by Audrey and Sabrina) recounts the experiences of students enrolled in *Change Lab*. Each of these are written in the first person present and tell the story of an ongoing, evolving *activism* occurring at the undergraduate level at a major comprehensive university in Canada.

Activism and Education

Activism, taken from the Latin root *actus*: "a doing, a driving force, or an impulse," refers to taking direct action to achieve or impede social, environmental, economical and political change. Activism presents itself in many forms: "from ordinary people writing letters to newspapers, or holding local meetings, through to the activities of international organizations like Amnesty International or Greenpeace, which are well-funded groups that conduct international campaigns" (Ricketts 2012, p. 19).

There is a range of issues that could initiative activism from the general public. For the past 30 years or so, environmental causes have been the focus of public attention, however, issues such as human and animal rights, fair trade, gender issues, heritage protection and world debt, have become strong issues of contention. Activism is not limited to just high profile causes either, other examples include: action surrounding disabled people; abandoned animals; seniors; or advocating for increased funding for cancer research (Ricketts 2012). The actions of the public to advocate on behalf of a cause have played an important role in shaping society: *It is the work of activists and social movements which pushes society along, prompts it to deal with its own failings and inequalities and helps to manifest a vision of a better world* (Ricketts 2012, p. 6).

Activism and education however, are a controversial pairing. For many, education is seen as impartial and should focus solely on preparing children or young adults with the skills to participate positively in society. Still, while our collective and globalized consciousness appears headed (slowly) towards a paradigm shift for sustainability (see Zoller 2012), little has changed in education to facilitate this shift (Stevenson 2007; Wals and Jickling 2002). Sustainability education then (viewed by those seeking the status quo) has been described as being "at best a distraction from the core curriculum and at worst a platform for the promulgation of radically subversive messages" (McClaren and Hammond 2005, p. 267). The challenge lies in developing educational programming that reflects a shift towards sustainability, with a process that "accurately [reflects] current debates and the state of knowledge about human-environment interactions" (McClaren and Hammond 2005, p. 267).

For sustainability to take a serious hold within the education system it will "demand [a] serious didactical re-orientation" (Wals and Jickling 2002, p. 228). Unfortunately, research continues to report that in both K-12 and post-secondary education, there is a persistence of a traditional *teaching to know* approach characterized by teacher-led lectures and an emphasis on low-level processes such as rote memorization (Barak et al. 2007; Boddy et al. 2003; Zoller and Nahum 2011). This approach develops only lower-order cognitive skills (LOCS) in students, and sadly, teachers are often the only ones in a classroom engaged in higher order processes (Stevenson 2007). LOCS are associated with recall of information, comprehension and application; while higher order cognitive skills (HOCS) are representative of the capabilities to analyze, synthesize and evaluate the world, or in short, *learning to think* (Zoller 2011, 2012; Zoller and Nahum 2011). In our opinion, the development of higher-order skills should be a primary goal for undergraduate education within any discipline.

Activism *and* Action Competence

In this research, we view activism though a lens of 'action competence' in order to resolve some of our own dissonance about the role of undergraduate education and how this conception of 'competence' is a possible ideal for sustainability education. *Action competence* (defined here provisionally) can be seen as "a capability, based on critical thinking and incomplete knowledge, to involve yourself as a person with other persons in responsible actions and counter-actions for a more humane world" (Schnack 1994). In this sense, action competence may indeed be understood as an essential component supporting the development of activism in students. We elaborate on this theme here, while also providing some thoughts as to how this may be connected to our own views of student activism with/in undergraduate education.

The concept of action competence, Jensen and Schnack argue, should occupy a central position in the theory of environmental or sustainability education as many of the crucial educational problems concerning a traditional liberal education are united and activated by this concept (Jensen and Schnack 1997). Our interests in beginning with action competence as a potential outcome for undergraduate education are based both on skepticism about a dominant educational paradigm which manifests itself in a tendency towards individualization – and that often regards the educational process as simply a question of behaviour modification (Jensen and Schnack 1997). At the same time, action competence can be seen as an alternative to more traditional and largely science-oriented approaches to sustainability education.

Bishop and Scott (1998) argue that (sustainability) education can be characterized by a 'rhetoric' of action-taking and that the call for the development of personal action competence is only one example of this. Their work critically examines the concept of action competence which they define as (paraphrasing): a set of capabilities which equip people with the ability to take purposive and focused action, and which embodies a democratic commitment to be participants in the continuing shaping of society. They note that action competence is seen by some as a crucial outcome in education, since it brings together its processes and practices with an urgent need to develop democratic citizenship skills (and values) in students. However, deconstructing this notion, Bishop and Scott also note a tendency for action competence to undervalue the place of science in the construction of knowledge and to a holistic understanding of environmental issues.

While noting this tension in our own work, the development of *Change Lab* is predicated on an assumption that the process of students taking action with/in their undergraduate education potentially develops *within them* a form of action competence. Action competence (for us) means students have the ability and willingness to take action on issues of campus sustainability that interest and engage them. In practice, it is developed as students learn about sustainability issues, then plan and take informed action on those issues. Further, many factors can potentially support the development of students' action competence, including: experiential learning, personal reflection, knowledge construction, future visioning, action-taking, and community building. All of these tools assist us when learning about campus and sustainability related issues.

What follows is a narrative focusing on the design features of Change Lab and how these are intended to facilitate or foster student activism within it. It includes perspectives on why the course was developed, its assignment structures, workshop delivery models and the content and processes that inform our work. The overarching story (as recounted by Jennifer and Deanna) also describes how the course evolved and how we envisioned it encourages and facilitates activism on campus, and action competence within students.

How Education Became Our Activism

What happens when two engaged students' education transforms them? *They then try and transform their education*. This is our story of how education became our personal activism. In 2009, we found ourselves in the *Semester in Dialogue* program, a unique full-time, interdisciplinary program offered at our university. It would turn out to be one of the very few opportunities in our formal education where we were not just told about the problems of the world: we were expected to be actively engaged in addressing them. This program not only invited solutions-oriented thinking, it gave us space to realize our full potential, access outstanding mentorship opportunities, and build a community of support. The *Dialogue* program exposed us not only to the expanse of what was happening in our local community but also integrated us (and our peers) within it. For us, the experience was nothing short of transformative.

Returning to regular classrooms in the fall after *Dialogue* provoked deep cognitive dissonance for us both. Our expectations of what the university could and should be – a place for civic engagement and action on the pressing issues of the twenty-first century (as we now believed) had been radically transformed by our experiences. Still, we returned to find the institution just as we had left it: (for the undergraduate) focused on getting a theoretical grounding and writing papers seemingly destined only for the recycling bin. Where we were once top students, happily going to lectures and engaging with our course materials, the contrast between our earlier dialogue experience and the reality of the lecture hall was so stark, we were now debating dropping out.

After many long conversations with peers and mentors, instead of leaving the university, we decided to make education the next focus of our social change work. We wanted to help create situations for other students to receive the same opportunity that we were given. Even more so, we wanted to create spaces that would empower students with skills and abilities needed to act and create positive change in this time that we face so many interrelated challenges as a global society. This space became the *Change Lab*.

Our program is designed to foster and facilitate a specific set of action competencies in students to enable them to mobilize their capacity on issues of personal and social importance. It focuses on the study and intersections of sustainability, social change, and education. If we consider activism in its broadest definition to be "efforts to create positive social change," then *Change Lab* is designed to incubate and foster the skill set needed to effect and bring about that change, through both direct experience and purposeful curricular intervention. When we designed this experience, it was with the intention to try to equip students with the skills and abilities they would need to be effective change agents both at the university and in their communities after graduation.

The overarching objectives of *Change Lab* then are: to empower students to move ideas to action; to provide social change skills training; to increase campus sustainability; and to allow students to experiment/ take risks while critically reflecting on their actions: all of this within a curricular context. The program spans two semesters. The fall term coalesces around themes of personal development, sustainability, skills-oriented workshops and place-based curriculum. During this time, students propose and design sustainability projects with a view to their implementation in the following term. The spring term focuses exclusively on these emergent projects. In short, through the *Change Lab* design we attempt to develop students' action competence in the following ways.

Student Empowerment

Students (as individuals) can often experience a sense of social isolation and disconnection from their community, which can be one of the largest barriers to young people getting involved in civic life and in their community. We intend to foster student empowerment through the facilitation model used to run *Change Lab*: actively challenging the 'sit back and be told' culture most students have experienced through the entirety of their formal education. Self-direction is paramount in this facilitated experience and students are encouraged to be active partners in co-constructing the curriculum. When the syllabus is handed out, a *DRAFT* watermark runs across it and students are invited from the first day to contribute to the design and details of their experiences. The instructors are not "instructors" per se but facilitators and every effort, starting with the syllabus, is made to demonstrate and create a horizontal power dynamic that requires students to take ownership of their own course experiences.

Assignments themselves are also aimed to foster empowerment. *Power In* (adapted from the *Dialogue* program) is one such assignment. Its purpose is to understand the decision making processes that effect sustainability at the university, and in particular, key stakeholders and interest groups related to campus sustainability. It is meant to engage students with the complexity of multi-stakeholder decision making processes and the intricate power dynamics of the institution they are attempting to change. During this assignment the requirement is that students interview five key decision makers.

Social Change Skills

Effecting social change at the university also requires a unique skill set gained through both direct experience and training. In the conception of *Change Lab*, it was important to us to find ways to both explicitly and implicitly provide students a platform for garnering and experimenting with this skill set. There are three key ingredients we provide students to work with in this regard:

Mentorship Students have access to a network of mentors and project advisors for personal growth and to help them complete their projects. We feel that strong mentorship fuels growth. Throughout the course, we offer individual meetings with students and encourage them to consult with these community members.

Training from Community Allies Community professionals are invited to the class in order to provide valuable skills training workshops for our students. This also fosters dialogue and connections between community practitioners who are actively engaged in social change work and diffuses their wisdom and skills amongst the students. The workshops are diverse with topics ranging from strategic planning to narratives-based communication.

Focus on Collaborative Structures Addressing complex social problems through activism also requires a capacity to work collaboratively across disciplines, sectors, cultures and perspectives. Designing *Change Lab* as an interdisciplinary experience with an emphasis on team projects allows students to develop confidence and capacity working within a collaborative structure.

Increasing Campus Sustainability

The central assignment for the course is the design of sustainability projects using the campus as a living lab. The goals of the projects are simply to increase sustainability on campus and students design and execute these projects as part of their coursework. This gets students to practice moving 'ideas to action.' In the first few weeks of the course, key sustainability stakeholders are brought into the class. They engage with the students on the strategic direction of the sustainability agenda at the university and also pitch potential projects. We encourage students to work with different campus and community partners so that their projects can live on beyond our 8 months spent together.

Critical Reflection

Through bi-weekly reflections throughout the year and a final portfolio assessment at the end of the fall term, we also give students ample space to explore their critical voice. Mandating reflection throughout the course experience is intended to foster deeper thinking on their activism, while also developing in them greater metacognitive capacity. Throughout this process, students demonstrate personal, professional and philosophical growth – necessitating a need to think about their learning both inside and outside of the classroom. The assignment formats are also not restricted to a written medium and so, students are encouraged to explore diverse and creative forms of communicating their ideas, thoughts and aspirations to one another.

Following this account of the curriculum and course design perspective, is a continuation of the Change Lab story from the unique perspective of our current students who experience this learning environment first hand. The following participant narrative (recounted by Audrey and Sabrina) discusses the types and instances of activism that are seen as arising spontaneously out of student participation in course meetings and workshops. It includes a description of some examples of planned activism and action competence outcomes, while also discussing factors that may be strengthening or constraining their occurrence. Lastly, it considers which social factors or skills are required to facilitate activism with/in an undergraduate education.

Change Lab Through the Eyes of Students

Last September, we decided to take this course to further our own investigations on personal development and sustainability, and to explore how to create social change around us. As graduate students, we were invited by the facilitators to become *participant-observers* in this class. This implied that we would fully engage in the class workshops and projects, but that we would keep track of our observations within the class. In addition to class projects, we agreed to take part in the research side of *Change Lab*. In the past few months, we have observed what our cohort is experiencing in this new and engaging learning process. We watch them creating projects, as well as describe how we ourselves are growing within this unique environment. From a participant's point of view, we see three general types of activism being suggested in *Change Lab*, which we classify as *infrastructure*, *education*, and *events*.

Infrastructure encompasses projects that consider permanently using physical space, infrastructure and/or materials. Ideas that came up in the classroom include: a concept for a rooftop-garden; a design for a gazebo as a social space to connect people, and plans for reducing toxic and other waste within the university campus environment.

Education entails projects that envision work on curricular changes within the university education system. Classroom ideas here include: working on models for experiential education and promoting its spread across the curriculum; as well as adding an 'E' (for environment) criteria for courses that would be a graduation requirement.

Short-time public *events* include projects that reach out to people to make them think or act in a more sustainable way. Ideas here include: an exhibition on a future vision of a sustainable University campus; an art piece made out of waste materials; a presentation of many sustainability ideas at a public event such as Pecha Kucha Night [http://www.pecha-kucha.org]; and a student summit to promote experiential learning.

We acknowledge that there are overlaps between these categories. For example, encouraging and promoting experiential learning inspired a team to create an event called the *Student Summit* that could showcase course opportunities and learning opportunities available within the university. The underlying principles (or meanings) for all of the types of activism we described are *social* sustainability and *environmental* sustainability. All of the ideas were proposed by students and presented to the group as potential group projects.

Factors Supporting Activism

We witness the ideation and suggestion of many activist projects by guests, facilitators, and our peers, and can identify different factors that help provoke, inspire, and foster the development of ideas.

First, key sustainability stakeholders and sponsors of *Change Lab* are invited to present potential projects or areas that require work with regards to sustainability on the campus. Even when these ideas are presented by people outside of our group, we can recall instances where activism grew from this. When, for example, the new director of the university's sustainability office explained that they were in the process of creating a narrative to articulate a vision for the future of the campus, students with a creative background immediately imagined a project in which they would create a futuristic and sustainable vision of the campus. Students imagined this project to be presented as an exhibition of photographs, objects and prototypes, with short video presentations. While this is not exactly what the director had in mind, his description of the idea was a starting point for generating ideas within a given realm. Eventually, students elected to pursue this project; discussing their ideas with the stakeholder of the sustainability office and developing a new collaboration.

Second, as part of a process for creating project proposals, our class was invited to an event hosted by the *Vancouver Design Nerds*. In this 3-hour *design jam*, students 'pitch' ideas of potential projects, ideas are grouped by themes, teams of four work on a specific theme, and present the results of their brainstorm and discussion. This method – part of an accelerated design process that allows everyone to suggest ideas without the fear of being judged (since in a brainstorm, there are no bad ideas!) also develops our ideas to a fuller extent. We think that the openness of the process encourages students to take on activism related initiatives. Many students pitched ideas even if felt they were not ready. This might be partly due to the fact that our group had already been developing a small strong community 'feel' to it.

Third, at the aforementioned design jam, the course facilitators (Deanna and Jennifer) proposed an idea they first called *Education Ninja* aimed at provoking change in the curriculum, and including more experiential learning opportunities but also supporting sustainability initiatives. This idea was adopted with passion by one of our classmates who rallied a team to implement a variation on this idea.

Fourth, a strong sense of community in the classroom has encouraged us, extroverts and introverts, to propose ideas for discussion, while feeling safe and being sure that others will listen and not judge. We observed this in several self-directed in-class proposal sessions for project ideas. We also experience this feeling of openness through the online activities and exchanges we pursue. As a group, we use a Facebook group to propose ideas, post links, images, and videos to share our intentions and ideas. This bond between us is initiated during the first weekend of the semester, when all students attend a 2-day retreat to discuss their ideas on sustainability, create a community agreement, and get to know each other. In summary, we see that the ideas proposed, the design process, and our group's community feeling are all factors that support students in the development of project proposals.

Lastly, we witness how the individual development and personal growth of students supports and empowers us for future activism within and beyond Change Lab. In the last in-class session of the first term, we present our individual personal, professional, and philosophical growth through portfolios, which take different formats (paintings, stop motion animations, essays, timelines). It was obvious to us how each of our peers grow through this unique experience and how we are all able to see this affect our perspective on education and future careers.

Factors Constraining Activism

As participants in the course we also observe several barriers and constraints that can hinder the development of activist ideas within *Change Lab*.

The aim of the program is to get us working on projects that promote and foster sustainability on campus. All participants go through an application process and prove their interest in sustainability, which demonstrates their motivation. However, sustainability is a broad and flexible term that can hold multiple definitions and areas of interest and application such as social, environmental, and economical sustainability. We observe that students often have different interests, passions and opinions when it comes to work on sustainability and that many diverging directions are proposed for the potential projects. Differing directions and definitions can create feelings of misunderstanding among students, and eventually create barriers to activism. For example, a project focusing on environmental sustainability might also explicitly exclude social sustainability because it supports the regeneration of an ecological space on campus but does not account for how students might use it.

Further, *Change Lab* invites students from many different faculties to apply. Bringing together people with different backgrounds studying different disciplines can be an advantage when tackling complex issues like sustainability but also a drawback in the process of finding and collaborating on a shared topic of interest. It is known that interdisciplinary groups can be complementary and work well together, however we often observe difficulties around finding and defining a shared project to work on. It is also difficult discussing projects with different disciplinary assumptions. Jargon, basic theories and key concepts within each discipline can be misunderstood among the students. For example, students in health, geography, international studies, sociology and design don't understand the term 'narrative' in the same way. If a project is using this term to describe what the students intend to work on, it can be hard for others to understand exactly what a project might entail.

When it comes to the final phase of our decision-making on project ideas, differing areas of interest and skills can have major influences. Some people want to work on social sustainability, while others want to create solutions for growing food, yet others want to work on the education system and/or get people engaged. Lastly the focus points may vary among students within a project group, which creates tension in the group and can have an effect on team building and in the selection of a project to work on. More specifically, we observe that some people have great motivation for a certain project and become leaders for the moment, installing a certain sense of competition between students who want to find teammates for their own projects, creating an environment where the ability of communicating ideas clearly and engagingly is quite important for successfully moving a project forward. When, for example, a student has an idea but does not communicate it well, it may not catch the attention and interest of other students. However, we see that the sense of community and as a workshop the design jam's pitch and brainstorming sessions really help us to listen to everyone. The dynamics of creating project teams is a process that can potentially eliminate good activist ideas because of group dynamics, people's personalities and interests, communication skills, or how well and clear ideas are formed in the first place.

A missing skill can also be a barrier, especially when actually developing a project. We interviewed students from past *Change Labs* who told us that in the project development phase it was sometimes a drawback that students were missing certain skills such as project management, dialogue, emotional intelligence, critical reflection, public speaking, or specific software skills. In addition, past students told us that personal values such as: possessing an honest commitment, genuine investment, and clarity of vision are sometimes lacking in project teams, creating another potential barrier to completion of a project. We clearly see how certain skills are useful and why workshops focusing on skills such as collaboration, the use of narrative, and the design process are coordinated for us. Currently, in the first term of this year's *Change Lab* students have diverse reactions to each workshop and it is not clear yet if they have helped us gain the needed skills or competences in these areas. Finally, we have also (sometimes) observed frustration, anxiety or stress due to the new experience of self-direction that this class encourages. For some students that much freedom can become numbing and can potentially prevent us from proposing ideas, choosing a project or leading a team.

A Developing Model for *Change Lab*

Through a combination of narrative, ethnographic and auto-ethnographic methods we have attempted to describe how *Change Lab* is developing into a new model for environmental, experiential and self-directed learning and an important part of the undergraduate university experience. This chapter tells the story of its conception, development and implementation through three lenses: a *theoretical* lens exploring the many forms that activism may take and referencing the notion of 'action competence' as an ideal for sustainability education; a *course design* lens recounting events and actions that inspired the conceptualization and development of our project; and a *participant* lens recounting the experiences of students enrolled in *Change Lab* as they struggle to develop action competence while also realizing their individual and collective goals.

Is the model perfect? No. But it is new and being continually refined. While it provides a container for students to engage, we realize that not all students leave this experience activated, however, we do think that many will have more confidence in pursuing their passion. The *Change Lab* program gives students an opportunity to think deeply about what they really care about and about how (and why) they can make a difference.

Today's university graduates are inheriting an increasingly complex and uncertain world—and will take jobs in fields that did not exist even a decade ago. They will be expected to respond in *real-time* to challenges that the conventional university curriculum has (arguably) failed to prepare them for. When we look at the university campus, we see latent and un-activated potential for sustainable actions all around us. Yet, students spend countless hours a week sitting in lecture halls; grappling with issues from climate change to social decay, but are never afforded the space and time, nor equipped with the skills, to act. As a member of Change Lab's inaugural cohort put it, we want to create classrooms that "*recognize the artificiality of their four walls,*" and provide opportunities for students to "*get real about values, connect with others … and build visions and projects that are aligned with what they really want for themselves, their place of learning, their community and the world.*"

We think university educators need to ask themselves: What is their role in these times of uncertainty? What kind of graduates do they want to help create? By asking these questions and by changing the way we educate, we may eventually see a radical shift in the type of society we shape.

References

Barak, M., Ben-Chaim, D., & Zoller, U. (2007). Purposefully teaching for the promotion of higher-order thinking skill: A case of critical thinking. *Research in Science Education, 37*, 353–369.

Bishop, K. N., & Scott, W. (1998). Deconstructing action competence: Developing a case for a more scientifically-attentive environmental education. *Public Understanding of Science, 7*, 225–236.

Boddy, N., Watson, K., & Aubusson, P. (2003). A trial of the five Es: A referent model for constructivist teaching and learning. *Research in Science Education, 33*, 27–42.

Jensen, B. B., & Schnack, K. (1997). The action competence approach in environmental education. *Environmental Education Research, 3*, 162–178.

Maggs-Rapport, F. (2000). Combining methodological approaches in research: Ethnography and interpretive phenomenology. *Journal of Advanced Nursing, 31*, 219–225.

McClaren, M., & Hammond, B. (2005). Integrating education and action in environmental education. In E. Johnson & M. Mappin (Eds.), *Environmental education and advocacy: Changing perspectives of ecology and education* (pp. 1–28). Cambridge: Cambridge University Press.

Ricketts, A. (2012). *The activists' handbook: A step-by-step guide to participatory democracy*. London: Zed Books.

Schnack, K. (1994). Some further comments on the action competence debate. In B. B. Jensen & K. Schnack (Eds.), *Action and action comments as key concepts in critical pedagogy* (Studies in educational theory and curriculum, Vol. 12, p. 190). Copenhagen: Royal Danish School of Educational Studies.

Stevenson, R. B. (2007). Schooling and environmental education: Contradictions in purpose and practice. *Environmental Education Research, 13*, 139–153.

Wals, E. J., & Jickling, B. (2002). "Sustainability" in higher education: From doublethink and newspeak to critical thinking and meaning learning. *International Journal of Sustainability in Higher Education, 3*, 221–232.

Zoller, U. (2011). From teaching-to-know-to-learning-to-think for sustainability: What should it take? And how to do it? *Journal of Modern Education Review, 1*, 34–40.

Zoller, U. (2012). Science education for global sustainability: What is necessary for teaching, learning, and assessment strategies? *Journal of Chemical Education, 89*, 297–300.

Zoller, U., & Nahum, T. L. (2011). From teaching to KNOW to learning to THINK in science education. In B. J. Fraser, K. G. Tobin, & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 209–229). Dordrecht: Springer.

Audrey Desjardins is an industrial designer, interaction designer and design researcher. She studied and worked in Montreal and Vancouver, Canada, as well as Valencia, Spain. Her research interests are in sustainable interaction design, how non-expert designers design, and how to democratize technology. She is passionate about making things herself and is always amazed by the creative human nature.

Sabrina Hauser is an information scientist, interaction designer and design researcher. She studied and worked in Germany before moving to Vancouver, BC to pursue her Ph.D. Her research interests include sustainable interaction design, and practices of everyday design. Driven by her

research, environmental issues and her own lifestyle, Sabrina is really passionate about promoting changes towards a more sustainable future.

Jennifer A. McRae is the co-project coordinator of Simon Fraser University's Experiential Education Project and a co-founder and facilitator of The Change Lab, a 2-semester program at SFU that focuses on the intersections of social change, sustainability, leadership and innovation.

Carlos G.A. Ormond besides his involvement with Change Lab, teaches environmental education at SFU, in addition to acting as: research coordinator for the Institute for Environmental Learning/UNU RCE on ESD; program coordinator with the Canadian Network for Environmental Education and Communication; and project manager with the Critical Thinking Consortium.

Deanna Rogers is currently the co-project coordinator of Simon Fraser University's Experiential Education Project & SFU's ChangeLab. She has also facilitated many dialogues, has founded regional government projects and is keen on intergenerational organizing. Her work seeks to spark moments of potential for connection, purpose and change.

David B. Zandvliet is an associate professor at Simon Fraser University (Vancouver, Canada) and director of the Institute for Environmental Learning. His interests lie at the intersection of science and environmental education and learning environments research. He is the Faculty sponsor for the Change Lab program within the Faculty of Environment.

Chapter 23
Science and Democracy in Youth Environmental Action – Learning "Good" Thinking

Tania M. Schusler and Marianne E. Krasny

> *…thinking is a process of inquiry, of looking into things, of investigating. … It is seeking, a quest, for something that is not at hand. We sometimes talk as if 'original research' were a peculiar prerogative of scientists or at least of advanced students. But all thinking is research, and all research is native, original, with him who carries it out.*
>
> (John Dewey, Democracy and Education, 1916)

> *Science is in my opinion just a very general word that describes everything we know, and everything we seek to learn.*
>
> (Teen participant in local environmental research and action, 2003)

As evidenced by public debates about environmental controversies ranging from regulation of genetically modified organisms (GMOs) to global climate change, the media and citizens often lack ability to evaluate critically the quality of scientific evidence. Furthermore, politicians may either intentionally distort research results or are themselves unable to assess scientific evidence critically and evaluate the implications of disagreement among scientists. This leads to further confusion among the general populace. For example, as evidence of global warming continues to mount, some U.S. politicians draw on the testimony of the small minority of dissenting scientists to support their stance against controls on greenhouse gasses. At the other end of the spectrum are citizens who uncritically support the positions of environmental organizations without evaluating larger consequences, such as

T.M. Schusler (✉)
Institute of Environmental Sustainability, Loyola University Chicago,
1032 W. Sheridan Road, 425 BVM Hall, Chicago, IL 60660, USA
e-mail: tschusler@luc.edu

M.E. Krasny
Department of Natural Resources, Cornell University, Fernow Hall, Ithaca, NY 14853, USA
e-mail: mek2@cornell.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_23

being categorically opposed to GMOs without considering potential positive impacts of some new GMO technologies. As educators, how can we develop citizens' capabilities to think critically about environmental and other complex socioscientific issues?

Grappling with local environmental issues – which occur at the intersection of ecological, economic, social, and political systems – has the potential to provide opportunity for young people to develop dispositions, understandings, and skills related to what Hodson (2011) calls "critical scientific literacy." In this chapter, we explore whether and how local environmental action can function as an avenue through which young people increase their capabilities for democratic participation as scientifically literate citizens. Specifically, we seek to understand the interplay of science and civic engagement by examining young people's reflections on their experiences in several cases of youth environmental action in New York State.

Environmental Action, Science and Democracy

"Scientific literacy" has a long history of use with many and at times disparate interpretations (c.f., Hodson 2011, Chapter 1 for a review). For the purposes of this analysis, we adopt Hodson's (2011) notion of critical scientific literacy, as follows: "…the fundamental purpose of critical scientific literacy is to help people think for themselves and reach their own conclusions about a range of issues that have a scientific, technological and/or environmental dimension" (p. 28). Critical scientific literacy equips learners with the capacity "…to take appropriate, responsible and effective action on matters of social, economic, environmental and moral-ethical concern" (Hodson 2011, p. 28). This concept of critical scientific literacy parallels ideas discussed by other scholars as well. It involves not only understanding scientific concepts and processes, but also being able to recognize "…the power and utility of scientific work … *and* … its limitations in dealing with the kinds of problems for which its techniques are ill suited" (*emphasis in original*) (Scott 1998, p. 290). It entails the abilities to assess the value of knowledge in a particular context and to participate in the social negotiations that produce knowledge (Roth and Désautels 2004). Critical scientific literacy increases a citizen's capacity to make choices rather than accept the prescriptions of others, to hold experts accountable, and to insert one's own knowledge into the public discourse. As such, the educational goal of developing learners' critical scientific literacy reflects a fundamentally democratic aim, which leads us to conclude that democratic pedagogy is particularly suitable to achieving this goal. Youth environmental action, a democratic approach to environmental education, offers one potential avenue for developing young people's critical scientific literacy. Below we first describe youth environmental action and then discuss how it might increase learners' critical scientific literacy through the integration of science and civic education.

Examples of youth environmental action include persuading local government officials to implement erosion control along a stream bank in response to water quality testing revealing high levels of sediment (Tompkins 2005), or reclaiming a city lot for a vegetable garden and growing produce for a local community kitchen in response to a neighborhood survey documenting limited local access to fresh produce (Figueroa 2003). As an educational approach, environmental action aims not to modify specific behaviors like recycling or saving water, but rather engages youth in planning and taking action on environmental issues they find relevant. It involves shared decision-making, which occurs when adults and youth collaborate in planning, implementing, and evaluating a project, whether the project is initiated by youth or adults.[1]

Emmons (1997) defines environmental action as a deliberate strategy involving decisions, planning, implementation, and reflection by an individual or group that intends to achieve a specific environmental outcome. Jensen and Schnack (1997) distinguish environmental action from habits, activities, and behaviors, because action is intentional (i.e., consciously undertaken with reference to motives and reasons) and, ideally, targeted at solutions to the root causes of a problem (whether directly contributing to solving the problem or indirectly influencing others to do so). At least five forms of youth environmental action have been documented in educational practice in the United States:

- physical environmental improvements (e.g., planting trees to stabilize streambanks; transforming vacant lots into community gardens);
- community education (e.g., organizing community information fairs; producing educational media like newsletters or videos);
- inquiry (e.g., community assessments, surveys, and mapping; scientific experiments designed to inform or evaluate action);
- public issue analysis and advocacy for policy change (e.g., researching and analyzing the environmental impacts of on-site wastewater treatment regulations and presenting policy recommendations to a state legislative committee); and
- products or services contributing to community development (e.g., sustainably growing food for sale at a neighborhood farmers market).

Youth environmental action projects facilitated by teachers, non-formal educators, and community organizers in the U.S. typically include at least two and often three or more of the above forms of action (Schusler 2007).

While environmental action projects are not always successful and these experiences are more meaningful for some participating youth than others (Schusler and Krasny 2007), several benefits have been associated with youth participation in local environmental action, including positive youth development (Schusler and Krasny 2010); relevant science learning (e.g., Fusco and Barton 2001; Roth and Lee 2004); and improved environmental management, neighborhood planning, and community development (Hart 1997). In addition to improving natural and built environments, environmental action experiences can help youth grow as citizens as they participate authentically in community issues. Jensen and Schnack (1997) provide justification for this latter aim:

> The fundamental assumption is that environmental problems are structurally anchored in society and our ways of living. For this reason it is necessary to find solutions to these problems through changes at both the societal and individual level. This is why the aim of environmental education must be to make present and future citizens capable of acting on a societal as well as a personal level. (p. 164)

Consistent with scholars' contention, after school program managers, community organizers, community-based science educators, and teachers facilitating youth participation in local environmental action also describe developing citizens – and, in the words of some, change agents – as a central educational aim (Schusler et al. 2009). Recognizing this democratic aim of environmental action, another way to define "youth environmental action" is as a *process* in which youth and adults co-create environmental and social change, which in turn builds young people's capabilities for further participation in personal and community transformation whether in environmental or other realms (Schusler et al. 2009).

Bishop and Scott (1998) argue for the importance of science within environmental action. For example, to target action at the root causes of an environmental problem requires the understanding of cause and effect, which often necessitates scientific investigation. McClaren and Hammond (2005) describe a process for learning through action that includes research both to inform and evaluate action in an iterative, cyclical process. Similarly, Stapp et al. (1996) describe a spiral of planning, implementing, and evaluating environmental action in which research plays an essential role to understand situations, assess the results of prior action, and decide desirable future steps. As noted above, educators facilitating youth environmental action in the United States often involve youth in inquiry through which youth produce knowledge that in turn guides other forms of action.

The potential for developing critical scientific literacy through educational experiences that integrate science and action depends in large part on how one conceptualizes these. Misconceptions of science as a body of declarative knowledge to be acquired cognitively, of the scientific method as a rote sequence of procedures to follow, and of civic participation limited to voting in elections leave little room for their integration in educational settings. Furthermore, science is often misleadingly portrayed as value-free and apolitical, characteristics counter to civic participation. However, the *processes* of doing science and engaging in participatory democracy share several characteristics, such as questioning assumptions, understanding systems, considering alternative explanations, and debating critically within a community. Thus, as a pedagogical approach, environmental action can be conceptualized as the intersection of science education and civic education in the forms of inquiry-based science education and youth civic engagement (Fig. 23.1), as we further explain below.

Civic education is a complex enterprise involving a variety of cognitive, conceptual, and attitudinal strands (Torney-Purta et al. 2001). One approach to civic education – "youth civic engagement" – aptly describes young people's involvement in environmental action. Camino and Zeldin (2002) define civic engagement as "being able to influence choices in collective action" (p. 214) and recognize that, as a bedrock value of democracy, citizen engagement is the purview of every citizen, not only officials and professionals. Skelton et al. (2002) define *youth* civic engagement as "young citizens developing civic skills and habits as they actively shape democratic society in collaboration with others" (p. 9). Pathways to youth civic engagement (e.g., public policy consultation, youth organizing, and service learning) seek to promote concurrently both youth development and community change. Typically,

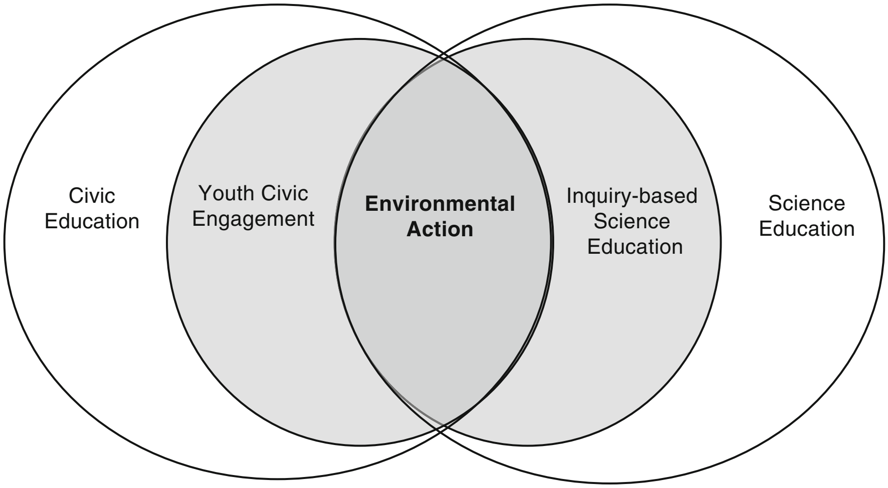


Fig. 23.1 Environmental action occurs at the intersection of youth civic engagement and inquiry-based science education

youth civic engagement is characterized by partnerships in which adults serve as allies and advisors to young people (Camino and Zeldin 2002).

Like civic education, approaches to science education vary with different ideas about the relationship of science to society and correspondingly the purpose of science education. Jenkins (1994) argues for science education that views science in the context of specific social purposes (e.g., related to employment, health, or environment) and values knowledge for action rather than for its own sake. In this view:

> … scientific knowledge becomes as much a resource for helping students … make sense of their role as actors in a social world as a powerful, external set of procedures for comprehending and shaping the material world. Moreover, scientific knowledge is but one resource called in aid of this purpose, albeit often one of impressive scope and predictive power. (p. 604)

Environmental action provides context for learners to engage in scientific inquiry toward specific social purposes. "When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations" (National Research Council [NRC] 1996, p. 2). In inquiry-based science education the teacher is a coach and facilitator rather than dispenser of knowledge, students are self-directed learners rather than passive receivers, and student work takes the form of student-directed learning rather than teacher-prescribed activities (Anderson 2002). The term "inquiry" has been critiqued as too broad to be meaningful for the purpose of designing science education standards (NRC 2012). Nonetheless, opportunities to engage in inquiry-based learning focused on specific questions to understand and take action within socio-ecological systems can develop learners' understanding of scientific practices (e.g., engaging in arguments from evidence) and cross-cutting concepts (e.g., cause and effect, systems, energy and matter), as called for in the *Framework for K-12 Science Education* in the United States (NRC 2012). Furthermore, although this framework does not include the social sciences despite the authors' acknowledgement of their importance, inquiry within environmental action provides opportunity for scientific inquiry into not only ecological but also social, economic, political, and cultural dimensions of socio-ecological systems.

Young people's participation in local environmental action can involve a range of different inquiries, including descriptive, correlational, and experimental research to answer questions about social-ecological systems. Through participation in community action, learners can become co-producers of scientific knowledge. For example, Fusco and Calabrese Barton (2001) describe how teens in an after-school science education program are producers of knowledge in the transformation of an inner-city vacant lot into a community garden. They conclude that science and action become inextricable when the aim of science education is not mentally isolated changes in individuals' knowledge, but a "nexus of interrelated and situated shifts in learning and development" that occur as learners participate in the social negotiations that produce knowledge relevant to community problems (p. 872).

Young People's Experiences of Environmental Action

Recognizing the potential for young people to develop and exercise critical scientific literacy through participation in environmental action, how do youth themselves perceive science and civic engagement in the context of environmental action experiences? We explore this question as part of a larger study (c.f., Schusler 2007 for more information) investigating the practices of educators and experiences of young people participating in environmental action projects in the U.S.

Interviews of the Participants

Of 28 programs across the U.S. included in the full study, we had the opportunity to interact directly with youth participants in 10 programs located in New York State. Thus, our investigation of young people's perceptions of science and civic engagement in the context of their environmental action experiences draws on these 10 programs[2] (Table 23.1). Six programs take place in community-based educational settings (non-profit organizations with missions related to community and/or youth development) and four programs in school settings (connected to science classes). It is important to note that educators' goals in these programs are multi-faceted and do not include necessarily the integration of science education and civic engagement as a primary aim. Nonetheless, these programs provide useful contexts to explore this intersection because they engage youth in local environmental action.

Table 23.1 Programs through which youth interviewed participated in environmental action (54 youth, 10 programs)

Program description[a]	# Youth interviewed	Educational setting	Location	Focus of action
Program A – Community program in which youth maintained a community garden plot and contributed data to a citizen science program on urban weed management	7	Non-formal	Urban	Community gardening
East New York farms! – Community program in which youth employed as interns participated in agricultural learning and leadership training, growing food for the community, managing a neighborhood farmers' market, and educating residents about healthy food	3	Non-formal	Urban	Food systems
Growing green – Community program in which youth employed during the growing season built, planted, maintained, and harvested gardens and marketed and sold their produce. Youth were also involved in business planning and community outreach	3	Non-formal	Urban	Food systems
TRUCE nutrition and fitness center – Community program in which youth participated in developing fitness and nutrition related programming. After conducting a neighborhood survey that documented lack of availability of fresh fruits and vegetables, youth employed by the program reclaimed an abandoned, city-owned lot, where they developed a vegetable garden and donated produce they grew to a community kitchen	4	Non-formal	Urban	Community gardening, open space preservation
Caroline youth services – Community program in which high school students employed through the program guided middle school students in organizing community events and service projects. In a community beautification project, youth designed and installed raised bed gardens in front of the town hall	3	Non-formal	Rural	Community beautification, community building
Lansing youth services – Community program in which middle school students produced a "Green Homes" documentary featuring local residents	5	Non-formal	Rural	Green building, media
Pine Bush project, Farnsworth middle school – Middle school science class in which students conducted scientific inquiry in conjunction with action to restore a local, globally rare ecosystem. After-school and summer program in which students managed a butterfly house (where butterflies were reared for introduction to the wild), gardens for native plant propagation, and public outreach programs, including tours and day camps for younger children	5	Formal	Suburban	Habitat restoration, wildlife conservation

(continued)

Table 23.1 (continued)

Program description[a]	# Youth interviewed	Educational setting	Location	Focus of action
Sustainability initiatives, Lehman alternative community school – High school ecology class in which students conducted individual and collective action projects in conjunction with their course work. Among many projects undertaken were advocating for the school district to install a solar electric system; designing and building a raised garden bed at a home for adults with disabilities; assessing the quality of woods adjacent to the school for wildlife habitat; and developing and teaching a sustainability curriculum to elementary school students	10[b]	Formal	Small city	Multiple
Roof garden project, school of the future – High school science class and after school club that designed and built a wheelchair accessible roof garden. At the time of this study, students were engaged in re-design of the space and scientific experiments around the effectiveness of green roof modules with varying design parameters (e.g., plant types, soil medium and depths) for controlling the building's temperature and reducing its stormwater runoff	6	Formal	Urban	Roof garden, green roofs, sustainability
Landfill project, Mynderse academy – High school biology class in which students researched the impacts of a nearby landfill on their community, organized a panel discussion to educate others about diverse points of view on the landfill's proposed expansion, and surveyed peers to inform community groups about young people's opinions on the issue	8	Formal	Rural	Solid waste management

[a]Based on program materials and interviews with teacher or program leader

[b]Two groups of five youth each were interviewed at this site

Table 23.2 Demographics of youth interviewed

Sex	28 girls and 26 boys
Age	9 to 18 years
Race/ethnicity	4 Asian, 9 African-American, 11 Latino, 30 white
Location	5 suburban, 16 rural, 10 small city, 23 urban (large city)
Educational setting	29 formal and 25 non-formal

Guided by a phenomenological stance, we assume that through dialogue and reflection we can understand the meaning of an experience – environmental action – for those experiencing it – participating youth. To gain insights into the meaning that young people construct of their environmental action experiences with respect to science and civic engagement, the first author conducts ten group interviews (Patton 2002) with a total of 46 young people participating in nine of the programs. In addition to these group interviews, an outside evaluator conducts individual interviews with eight students participating in the "Landfill Project" co-facilitated by their teacher and the primary author of this chapter. In all, group and individual interviews include 54 youth (Table 23.2).

Each group interview includes three to seven youth selected by the teacher or program leader. The young people interviewed are often those most actively engaged with the program; thus, the data do not reflect the full diversity of experiences among participating youth. Each group interview begins with general questions about young people's experiences and then moves to more focused questions encouraging their reflections on what and how they learn, how their participation influences their perceptions of themselves in relation to their community, and what connections they see between their environmental action experience and science (Schusler 2007). Throughout, the interviewer probes for specific examples. Group interviews range from 18 to 65 min with most lasting about a half hour. Similar to group interview questions, the outside evaluator inquires about students' roles and experiences in the Landfill Project, how the project differs from their other science classes, what they learn through their participation, and how the project influences their perceptions of science and scientists. Interviews are digitally recorded (with the exception of one where detailed notes are taken) and transcribed verbatim.

Analysis of interview data is conducted thematically across sites using HyperResearch software to aid in data management. The primary author initially codes the data from each program using codes that reflect the interview questions (e.g., "what we do," "describe experience," "what learned," "how learned," "science," "community"). She also creates a matrix of specific learning reported by youth across the 10 programs. She then examines data within each code as well as the matrix to identify emergent themes and patterns. The primary unit of analysis is the program. While the group interviews produce rich data through the exchanges between youth as they build upon and respond to each other's comments, they are not designed to assess comprehensively each individual's learning. Results reported within include reflections from individual youth; however, our conclusions regarding the overlap of science and civic learning are based on learning evident among the group of youth interviewed within each program rather than each youth participant.

Reflections Based on These Youths' Actions

It is important to reiterate that the data collected often reflect the experiences of youth most engaged in the environmental action projects. Because we did not interview a representative sample of youth, we cannot ascertain the extent to which science and/or civic learning occurred for other participants, if it did at all. Our intent is not to generalize but rather to share insights based on these young people's reflections on their environmental action experiences in a diverse range of educational settings to illuminate opportunities, possibilities, and potential contradictions with respect to the integration of science education and civic engagement.

Science and Civic Learning

To understand how environmental action can provide opportunity for both science and civic learning, we first present findings related to science learning and then to civic learning. We next share evidence that youth learned dispositions and skills relevant to both endeavors. Finally we note discrepant evidence illustrating that not all youth experience environmental action projects positively.

Science Learning

Young people's reflections on the connections between science and their experiences of environmental action demonstrate varied dimensions of science learning as illustrated in Table 23.3. Young people's descriptions of their experiences suggest that participation in environmental action contributes to science learning by enhancing their motivation and increasing their scientific content knowledge, understanding of the inquiry process, recognition of science as a complex endeavor, and/or appreciation of the relevance of science to their lives. Youth speak knowledgably about scientific concepts (e.g., plant science, soils, butterfly metamorphosis, nutrition, energy efficiency) related to their projects in all but one program. Youth in one program (included in this study because they design and build a raised garden bed for community beautification) demonstrate limited environmental science knowledge. This is not surprising, however, because the environmental action project aforementioned is one of many community service projects organized by these youth, most of which are not environmentally focused. In two programs, both school science classes, students' descriptions of their activities also demonstrate solid understanding of scientific inquiry in terms of designing and conducting scientific experiments, in one case, and posing questions, developing hypotheses, collecting data, and debating possible interpretations of those data in a social science survey, in the other case. Among students in science classes, a common sentiment is that actually doing rather than simulating science, conducting research with the goal of making a difference in their community, and engaging in hands-on activities make science more meaningful and relevant.

Table 23.3 Evidence of science learning in young people's reflections on their environmental action experiences

Young people's reflections	Science learning
I'll say the garden could influence the community because if we have, because you know how people in the world have asthma and how they like have asthma attacks by breathing in smokes but then how plants give off oxygen when you give them like carbon dioxide. If we had like more plants, we could have like there would be more oxygen for kids with asthma to breathe because then they won't be, because some kids [with] asthma be dying in the world and that's because there's a lot of trucks and cars that be giving off smoke and it's bad for them to breathe it in but if we had, when the plants give off the oxygen, it will be easier for them to breathe… (Community and youth development program participant (TRUCE))	*Understanding scientific content (e.g., relationship of environmental pollution and human health)*
I feel like [the Roof Garden] ties in with science because when you have to come up with a hypothesis, you have to set up experiments, 'Okay what's going to be good?' You have to do observations. And it's not like when you do like a little mini lab you're doing it for a week. This is like a really big lab, you're doing it for months and months and months. And even after years it still can't be perfect but so it's like it ties into science just perfectly. (Science student (Roof Garden))	*Understanding science process and the Nature of Science (e.g., science is empirical, tentative)*
… it really [put] the class in context and made it so relevant. Our homework was enacting change in our community … it really makes it part of active life, not just tasks like studying meticulous vocabulary sheets. It made me think about the issues deeper than I would have in a typical 40- min class. (Science student (Sustainability Initiatives))	*Feeling that science is relevant*
… my dad's a chemist … and I always think he does too much work. He's spending night after night. And now that I've done this project, I sort of understand how it can get so unraveled. … now I understand what they go through. Every day is like an adventure. I'm amazed at how much information you find out. (Science student (Landfill Project))	*Recognizing science as a complex endeavor*
It made me more aware of what people do and how important people's jobs in the scientific aspect are. When we talked to those engineers, like, that whole landfill depends on them and how they can design it and use their background like they need to know a lot, they need to know math as well as science. And they need to put like their names on sheets of paper that say this is safe for people. And if they don't design it the right way they can't do that, and so it really made me appreciate all the things that science can do for you in a job in the community in all kinds of settings. (Science student (Landfill Project))	*Appreciating role of science in society*

Civic Learning

Youth also share reflections on their environmental action experiences related to civic engagement. For example:

> You spend a lot of time helping too. You have to spend a lot of time learning, you have to spend a lot of time trying to teach other people. And that made me feel really good, that I could do something to help.
> – Science student and summer program participant (Pine Bush)

> I'm happy every time I walk down the street and I see like one of Growing Green's gardens, I feel happy that I helped.
> – Community and youth development program participant (Growing Green)

Like the two youth quoted above, young people in every program express positive feelings about doing something good for their community. In seven programs, young people also describe sentiments similar to those articulated in the following quotes:

> Well for me it was like before being a good community member meant like not doing bad things, you know, not getting into trouble, or just basically being a good kid, but now it's like actually doing something to help.
> – Youth development program participant (Caroline Youth Services)

> Now I feel like I'm one of the very few trying to bring back something positive to East New York. And it's helping, a lot of people come out to our farmers market, which we have every Saturday, it opens June 28. And like it's developing our community, it's slow but we're making change, we're making progress.
> – Community and youth development program participant (East New York Farms!)

This shift in young people's perceptions of themselves as community members is especially striking; youth speak of their activities in the context of a larger public purpose and of themselves having become producers and contributors to their communities. In addition, some youth describe how their experiences lead to the development of specific dispositions and skills that enhance one's capability to participate in civic life as illustrated by the examples in Table 23.4.

Dispositions and Skills Common to Scientific Inquiry and Civic Engagement

Table 23.5 summarizes the learning evident in youths' descriptions of their environmental action experiences, including some skills valuable to both scientific inquiry and civic engagement. Whether in the process of inquiry or engaging in other forms of action, youth often encounter challenges that lead to learning valuable dispositions (e.g., persistence) and skills (e.g., planning), as the following examples illustrate.

Table 23.4 Evidence of civic learning in young people's reflections on their environmental action experiences

Young people's reflections	Civic learning
I think the most important thing I have learned is to try and stay calm and be patient with people. (Youth development program participant (Lansing Youth Services))	*Learning to work with others*
… and it was interesting to hear a lot of people's point of views on [the landfill]. We didn't know they were so diverse. Like we thought pretty much everyone hated it, didn't want it there. A lot of people actually want it because it gives us [funds for] our rec center. It was good hearing everyone's opinion, and making it more like finding out facts instead of just a general statement in the beginning, like, 'We don't want it, we're going to fight it.' So it was good that we were open … cuz a lot of us were kind of biased in the beginning. (Science student (Landfill Project))	*Valuing diverse points of view*
It can be frustrating having to work with this person and that person and you realize the layers that you have to work through. You realize that someone doesn't install solar panels just because they're lazy, but because they're a single mother and have other priorities. Like when I started my project, I wanted to put in a garden NOW but you have to work with people … (Science student (Sustainability Initiatives))	*Recognizing that others' priorities differ from one's own*
Like what exactly do you want this roof garden to be? Like okay yeah it's going to be part of the environment but how do you want it to feel? When people come and see your roof garden do you want it to be a place where people just relax? A place where it can be a learning center? A place where you know books or a lounge? Have a set plan and then do all the stuff that needs to come after that. (Science student (Roof Garden))	*Developing a vision and planning to reach it*
Like before we made any move we were in the classroom for a good couple weeks trying to decide the best possible solution and trouble shooting any issues that we thought might arise and we were just constantly like rethinking everything. Trying to figure out every angle before making a set decision just to make sure that nothing, no corner was left untouched. (Science student (Roof Garden))	*Considering alternative options*
… the real thing to be successful is like to try to do your best, be motivated and all of that because if you don't really have that then it's like you're just going to give up on one little thing that, one little obstacle, one little bad thing that gets in your way, you're just going to give up and if you keep getting motivated and keep trying … you're going to succeed in what you have to do. (Community and youth development program participant (TRUCE))	*Being persistent and staying motivated when obstacles arise*
I spent a lot of time going to the right people and asking for things and they would send me to someone else and then I'd be sent back to the first person who could help me after they were told by somebody else to do so. I spent a lot of time on administrative and feasibility … I learned about how something might actually get done in bureaucracy … and how to have a vision and stick with it. (Science student (Sustainability Initiatives))	*Learning how existing power structures work*

Table 23.5 Summary of science and civic learning evident in youths' reflections on their experiences participating in local environmental action

In describing their experiences participating in environmental action, youth demonstrated …	Related to scientific inquiry	Related to civic engagement
Content knowledge (e.g., soils, plant science, air quality)	X	
Understanding of research design (e.g., for a social science survey or ecological experiment)	X	
Understanding nature of science (e.g., empirical, tentative)	X	
Understanding relevance of science to young person's life or community (i.e., science became meaningful)	X	X
Positive feelings from doing something good for community		X
View of self as producer/contributor to community	X	X
Teamwork, ability to work with others	X	X
Recognition of diverse viewpoints, differing priorities	X	X
Capabilities in planning, thinking "big picture"	X	X
Capabilities in weighing alternative options	X	X
Persistence despite obstacles	X	X
Understanding systems (e.g., relationships between environmental pollution and health, power within social structures)	X	X
Good judgment, critical thinking	X	X

Here science students at the School of the Future discuss the most important things they learned from their involvement in the roof garden project:

Jacqueline[3]: Well for me I know like [how to] plan and carry through with an experiment, especially when you have to build a lot of it. We, like we could order a lot of materials but also we had to build a fair amount. So just like following through with experiments and planning.

Maureen: And actually knowing what the experiment is for. Like what's the reason for this. What's the reason for probes. …Yeah the infrared, like what's the reason for that? Like it measures the temperature. Why do you need to know the temperature of the soil? Why do you need to know the air above the soil? Why do you need to know the soil temperature?

Emily: …I didn't know about green roofs really until the class but I mean they are really interesting … they have so many fantastic facts, and so I guess everything we do does have a bigger picture to it. And you know I also agree with Jacqueline with all the planning ahead thing, it's a real project that's alive and it's growing up there, which is really fun.

Chris: …it goes beyond just the green roofs. It's also … learning about how the impact we're making on the environment and the culture that we're living in and how to change it so we can make the world better.

Below science students at Lehman Alternative Community School describe their experience designing and implementing a sustainability initiative:

Grace: The group experience has been the hardest part for me because we like suck in the communicating.

Meghan: Yeah, we were figuring out how to get to the school [to teach younger students a lesson about composting as part of a project to design a classroom composting system] like 10 min before we had to be there.

Grace: So it's been a really good learning experience for me in that, one really I'd say good thing about having this be a class project with my peers, is that if I'm doing something on my own, I'm just doing it on my own. And here I learned that to make a big change, or any change, you really have to work with others and working with others is so more, much more like unexpected surprises. So that's been kind of my experience with it.

Becky: But at the same time I don't think it's a project that one person could have pulled off. Yeah, like each of us is responsible for one lesson plan except Grace did two. And I think everybody brings something different, that sounds really corny but like everybody has their own like way of getting to the kids and that's really good because, like I think, like, every lesson it seems like a different group of kids, like respond to a different way of communicating and we all have different things. … I think in some ways the group thing has worked really well.

Grace: Oh yeah. I agree. It's just been also the hardest part for me too.

Finally, youth exhibited critical thinking in their descriptions of their environmental action experiences, which reflected both scientific and civic dimensions, as illustrated by the examples in Table 23.6.

Discrepant Evidence

While the results of this study are overwhelming positive, it is important to recall that interviews occur with youth most actively engaged in environmental action projects with the exception of the Landfill Project for which the outside evaluator interviews a cross-section of students. Results from the Landfill Project show that participants' learning can vary widely, as illustrated by a selection of student responses to the question: "What did you learn by participating in this project?"

During this project I learned many new things! I learned about how to research people's opinions and thoughts. Sometimes it was frustrating, but in the end I was very proud of what our class stuck through and accomplished.

This year, I've learned about the real scientific method. It takes a lot of work to be educated, but it's worth it. Now, I'm glad I know more about the environment and people of our community. I also learned that science is everything: social, biochemical, etc. This year was a great learning experience!

Not much. The reason why was because this project was boring.

I didn't learn anything.

Table 23.6 Evidence of critical thinking in young people's reflections on their environmental action experiences

Interview excerpt	Critical thinking
Youth: [Our work in the gardens and farmers market] basically goes around … to many people … because we help people with their obesity, sometimes they have high cholesterol, and sometimes when they go to the grocery store, they pay a lot for fruits and vegetables which have a high amount of pesticide in them	*This youth recognized the public value of her work in articulating connections between nutrition, food security, environment, and health. She demonstrated preciseness in understanding the meaning of "organic" and critical thinking in explaining this so that the interviewer understood correctly*
Interviewer: So everything you grow here is organic?	
Youth: Well, we're not certified organic, we don't put nothing on it, but we're not certified organic because they haven't come and checked or nothing like that	
Interviewer: What's something that you have not liked about your experience [in the program]? Something that you would change?	*Several youth, like this one, when asked what they disliked about their experience spoke of barriers to the success of their projects. Here, this youth exhibited critical thinking in his understanding of the implications of relying on grant funding for the long-term sustainability of the project*
Youth: We don't get like an annual budget like, 'Alright the school gives us $10,000 every year.' It's not like that. We had to write grants and stuff. So like everything is dependent on the budget, so if for a year we don't have any budget, all the plants … might die because we can't afford like the tools or like fertilizers and stuff. And that's one thing that I really don't like is this messes up like the project	
Youth A: I think also the events we have sort of let people know that you don't have to do really big things to make a difference. Like just by having a program, we're probably making differences in kids lives I'm sure	*With conviction that their work was worthwhile, the comments of these two youth also demonstrated critical thinking in questioning and wanting to understand better the magnitude and nature of that impact*
Youth B: … maybe asking people what they consider the magnitude of [the] impact to be. Like … you know thinking and considering how many people we've actually helped. You know is it two or three people that we've really strongly impacted? Or maybe it's a dozen people we've you know changed the lives of. So making people think about that could be interesting	

What causes some students to view the project as a valuable learning experience, while others claim to have learned little through the process? One explanation might lie in students' motivation for participation. Some students are genuinely interested in the Landfill Project, while others participate reluctantly because it is a required part of their coursework.

Critical Scientific Literacy Embedded in Environmental Action

Young people's reflections on their experiences in ten environmental action programs in New York State illustrate the compatibility of science and civic education. Youth in all but one program articulate connections between environmental action and science. Young people's scientific understanding often takes the form of practical knowledge about the social-ecological systems within which their action takes place. Science occurs in the context of broader social purposes (Jenkins 1994) and youth participate in the social negotiations that produce knowledge relevant to these purposes (Fusco and Calabrese Barton 2001). Youth in all programs speak positively about contributing to their community, and some describe a shift from viewing themselves as passive recipients to active producers. Sherrod et al. (2002) report that youth commonly define citizenship as simply doing what is expected and obeying laws. We find that participating in environmental action influences some youths' concepts of themselves as community members from passively "staying out of trouble" to actively producing, contributing, and doing something good for the community. But can we claim that this science and civic learning comes together in the development of young people's critical scientific literacy? Our evidence, although limited, suggests the answer is yes. Critical scientific literacy is reflected in young people's use of science and production of knowledge in collective action to improve their local environments. Furthermore, we observe critical scientific literacy in some youths' demonstration of critical thinking.

Critical thinking is often viewed as a higher-order cognitive skill involving certain mental processes or procedural moves; however, young people in this study exhibit critical thinking that also involves normative dispositions and good judgment. Bailin (2002) describes a conception of critical thinking for which the pedagogical focus shifts from application of processes and acquisition of skills to "the question of what one needs to understand in order to meet the criteria of good thinking in particular contexts" (p. 368). ten Dam and Volman (2004) define critical thinking as "acquiring the competence to *participate* critically in the communities and social practices to which a person belongs (italics in original)" (p. 372). These views recognize that the thinker must possess a constellation of resources (Bailin 2002), which includes sources of evidence or forms of verification (e.g., experience, cares, and commitments) beyond the rationalistic epistemology typically associated with critical thinking (ten Dam and Volman 2004).

We witness this form of critical or, in Bailin's words, "good" thinking as young people demonstrate understanding, judgment, and competence to participate in the specific contexts of their action experiences. For example, the young woman who clarifies the definition of "organic" recognizes the distinction between organic farming practices and formal organic certification *and* exercises good judgment in the context of the situation by clarifying this for the interviewer. The student concerned about his project's budget exhibits critical thinking about threats to the project's long-term sustainability, a familiar challenge for many organizations in the environmental and social services fields. The young people curious about the magnitude of their program's impact demonstrate critical reflection in their desire to evaluate their project in order to measure its outcomes. Each of these examples illustrates the young person's ability to apply critical thinking for specific individual and social purposes. The words of a practitioner facilitating one of the environmental action programs capture well the aim of providing opportunity for youth to develop and exercise good thinking:

> [We're] … providing [youth] with the resources to critically analyze their own lives within their community and be able to understand that they can have the potential to make real change in their lives and their community. Because I think a lot of times people become very disempowered and don't really acknowledge their abilities in life so I think it's really important to encourage people to understand their capabilities.

The cases of environmental action that we examine offer evidence counter to common perceptions that good science and activism are mutually exclusive. Science is often misleadingly portrayed as value-free and apolitical, characteristics counter to civic participation. Yet, scientific practice and civic engagement share several characteristics, including questioning assumptions, understanding systems, considering alternative explanations, and debating critically within a community. Indeed, youth in this study report learning knowledge, dispositions, and skills characteristic of both scientific inquiry and civic engagement. Whether in discovering factors that affect a stream's water quality or developing a strategy to influence local watershed management policy, *the habit of asking critical questions about social-ecological systems is an essential dimension of both scientific practice and civic engagement*. Fundamentally, inquiry-based science education and youth civic engagement both involve thinking critically about systems (e.g., ecological, economic, social, political). We propose that environmental action involves a civic-science synergy because it concurrently engages youth in civic and scientific processes through which they can develop critical dispositions and skills characteristic of both endeavors (Fig. 23.2).

We suggest three lines of future research to understand further this civic-science synergy within environmental action. First, because this study's sample is limited to young people often most actively engaged with an environmental action project, we cannot claim that environmental action experiences have positive learning outcomes for all participants. One would expect that a young person's learning increases with the extent of her or his participation in an action project. Further research is needed to assess whether science and civic learning occur across a representative sample of participants and what factors influence their learning.

In addition to investigating the scientific and civic dimensions of young people's environmental action experiences in greater depth, a second avenue for research is the relationship of different pedagogical approaches to participants' learning. For example, Westheimer and Kahne (2004) find that participatory and justice-oriented approaches to civic education, while both successful, contribute to distinct learning outcomes. Programs emphasizing participation do not necessarily develop students' abilities to critique root causes of social problems and vice versa. Also of interest are the "dilemmas" (technical, political, cultural) of educational practice involving scientific inquiry (Anderson 2002) and community action and how educators navigate tensions

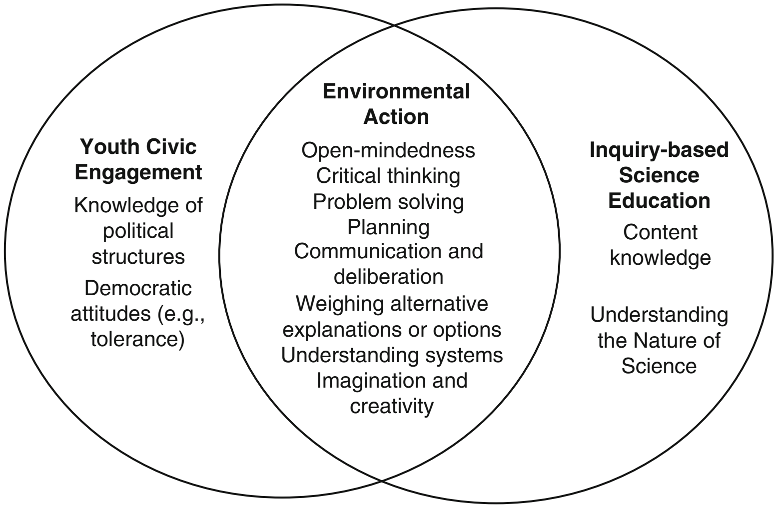


Fig. 23.2 The integration of youth civic engagement and science education in environmental action occurs in the development of dispositions and skills characteristic of both civic participation and scientific inquiry

that arise, for example, in structuring youth participation, sharing decision-making power, and feeling comfortable with uncertainty as a project evolves.

Finally, an essential question needing further research is what learning theory(ies) best explain the development of critical scientific literacy through environmental action. Boyer and Roth (2006) use activity theory to explain learning among participants (adults and youth) in an eel-grass habitat stewardship project. From this lens, learning is understood as an increase in opportunities for action and an outcome of the "mutually presupposing relation between social and material resources within the activity as a whole" (p. 1046). Krasny and Tidball (2009) discuss learning theories relevant to community gardens as contexts for science and civic action learning. These include individualist theories that describe learning as an internal activity characterized by acquisition of knowledge and skills that may be transferred across contexts; sociocultural learning theories that emphasize learning as interaction with other individuals and the environment and as increasingly skilled levels of participation in a community of practice; and social learning theory as discussed in the literature on adaptive co-management of social-ecological systems in which the focus shifts from individual learning to group or organizational learning in concerted action to enhance natural resources (Krasny and Tidball 2009). Each of these theories might have relevance to the ten cases considered in this study; however, programs varied in specific educational aims and educators' own theories and pedagogical approaches (e.g., place-based education, experiential learning, Freirean pedagogy). Increasing the body of empirically rich case studies of youth environmental action and their analysis with respect to relevant learning theories will enhance understanding of how learning occurs through environmental action. Furthermore, such analyses can help ground and refine learning theories based on learners' and educators' life experiences.

"Good" Thinking Citizens

Society increasingly faces scientifically and politically complex problems (e.g., climate change, biodiversity loss, environmental injustice) that require citizens have the capability to participate in public processes incorporating scientific analysis with deliberation about societal goals (Fischer 2000). Environmental action offers one pedagogical approach for developing young people's capabilities to participate in democracy as scientifically literate citizens. We explored young people's reflections on the connections between science and civic engagement in the context of their participation in local environmental action in ten programs in New York State. We found that youth developed knowledge, dispositions, and skills related to both science and civic participation, many of which (e.g., understanding systems, considering alternative explanations, debating critically within a community) are characteristic of both endeavors. Furthermore, some youth demonstrated critical thinking in the context of specific situations. Such "good" thinking can enable individuals not only to reach their own conclusions about a range of issues with scientific, technological, and/or environmental dimensions but also to negotiate with others in democratic processes on matters of social, economic, environmental and moral-ethical concern.

Notes

1. For excellent discussions of different forms of youth participation, see Roger Hart's (1997) *Children's Participation: the Theory and Practice of Involving Young Citizens in Community Development and Environmental Care* and David Driskell's (2002) *Creating Better Cities with Children and Youth: A Manual for Participation*.
2. We identified eight of these programs through peer referral, one by its receipt of a national environmental excellence award, and one through the primary author's involvement as a co-facilitator of the action project.
3. Pseudonyms are used to protect participants' identities.

Acknowledgments We are grateful to each of the youth and practitioners who shared with us their experiences participating in or facilitating environmental action programs. We also thank the following individuals for their contributions to this research: Carol Cook, Dan Decker, Gretchen Ferenz, Stephen Hamilton, Kerri Mullen, Scott Peters, Jamila Simon, Michael Simsik, Linda Tompkins, and Nancy Trautmann. Funding for this research was provided by the Cornell University Agricultural Experiment Station federal formula funds, Project No. NYC-147459, received from the Cooperative State Research, Education and Extension Service, U.S. Department of Agriculture. Support for the primary author's involvement with the Landfill Project was provided by the National Science Foundation's Graduate Teaching Fellows in K-12 Education Program.

References

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*, 1–12.

Bailin, S. (2002). Critical thinking and science education. *Science & Education, 11*, 361–375.

Bishop, K., & Scott, W. (1998). Deconstructing action competence: Developing a case for a more scientifically-attentive environmental education. *Public Understanding of Science, 7*, 225–236.

Boyer, L., & Roth, W. M. (2006). Learning and teaching as emergent features of informal settings: An ethnographic study in an environmental action group. *Science Education, 90*, 1028–1049.

Camino, L., & Zeldin, S. (2002). From periphery to center: Pathways for youth civic engagement in the day-to-day life of communities. *Applied Developmental Science, 6*, 213–220.

Driskell, D. (2002). *Creating better cities with children and youth: A manual for participation*. London: Earthscan.

Emmons, K. M. (1997). Perspectives on environmental action: Reflection and revision through practical experience. *The Journal of Environmental Education, 29*, 34–44.

Figueroa, R., Jr. (2003). TRUCE Carrie McCracken Community Garden Action Project: Garden Mosaics. Retrieved November 11, 2006, from http://www.gardenmosaics.cornell.edu/pgs/data/actionread.aspx?garden=107

Fischer, F. (2000). *Citizens, experts, and the environment: The politics of local knowledge*. Durham: Duke University Press.

Fusco, D., & Calabrese Barton, A. (2001). Creating relevant science through urban planning and gardening. *Journal of Research in Science Teaching, 38*, 860–877.

Hart, R. A. (1997). *Children's participation: The theory and practice of involving young citizens in community development and environmental care*. London: Earthscan.

Hodson, D. (2011). *Looking to the future: Building a curriculum for social activism*. Rotterdam: Sense.

Jenkins, E. W. (1994). Public understanding of science and science education for action. *Journal of Curriculum Studies, 26*, 601–611.

Jensen, B. B., & Schnack, K. (1997). The action competence approach in environmental education. *Environmental Education Research, 3*, 163–178.

Krasny, M. E., & Tidball, K. G. (2009). Community gardens as contexts for science, stewardship, and civic action learning. *Cities and the Environment, 2*, 1–18.

McClaren, M., & Hammond, B. (2005). Integrating education and action in environmental education. In E. A. Johnson & M. J. Mappin (Eds.), *Environmental education and advocacy: Changing perspectives of ecology and education* (pp. 267–291). Cambridge: Cambridge University Press.

National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academies Press.

National Research Council. (2012). *Framework for K-12 Science Education*. Washington, DC: National Academies Press.

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. Thousand Oaks: Sage.

Roth, W. M., & Désautels, J. (2004). Educating for citizenship: Reappraising the role of science education. *Canadian Journal for Science, Mathematics and Technology Education, 4*, 149–168.

Roth, W. M., & Lee, S. (2004). Science education as/for participation in the community. *Science Education, 88*, 263–291.

Schusler, T. M. (2007). *Youth-adult partnerships creating positive environmental change*. Doctoral dissertation, Cornell University, Ithaca, NY.

Schusler, T. M., & Krasny, M. E. (2007). Youth participation in local environmental action: An avenue for science and civic learning? In A. Reid, B. B. Jensen, J. Nikel, & V. Simovska (Eds.), *Participation and learning: Perspectives on education and the environment, health and sustainability* (pp. 268–284). Dordrecht: Springer.

Schusler, T. M., & Krasny, M. E. (2010). Youth environmental action as context for youth development. *Journal of Environmental Education, 41*, 208–223.

Schusler, T. M., Krasny, M. E., Peters, S. P., & Decker, D. J. (2009). Developing citizens and communities through youth environmental action. *Environmental Education Research, 15*, 111–127.
Scott, J. C. (1998). *Seeing like a state: How certain schemes to improve the human condition have failed*. New Haven: Yale University Press.
Sherrod, L. R., Flanagan, C., & Youniss, J. (2002). Dimensions of citizenship and opportunities for youth development: The what, why, when, where, and who of citizenship development. *Applied Developmental Science, 6*, 264–272.
Skelton, N., Boyte, H. C., & Leonard, L. S. (2002). *Youth civic engagement: Reflections on an emerging public idea*. Minneapolis: University of Minnesota.
Stapp, W. B., Wals, A., & Stankorb, S. L. (1996). *Environmental education for empowerment: Action research and community problem solving*. Dubuque: Kendall Hunt.
ten Dam, G., & Volman, M. (2004). Critical thinking as a citizenship competence: Teaching strategies. *Learning and Instruction, 14*, 359–379.
Tompkins, L. (2005). A case for community-based education: Students form partnerships to tackle local environmental issues. *The Science Teacher, 72*, 34–36.
Torney-Purta, J., Lehmann, R., Oswald, H., & Schulz, W. (2001). *Citizenship and education in twenty-eight countries: Civic knowledge and engagement at age fourteen*. Amsterdam: International Association for the Evaluation of Educational Achievement.
Westheimer, J., & Kahne, J. (2004). What kind of citizen? The politics of educating for democracy. *American Educational Research Journal, 41*, 237–269.

Tania M. Schusler is a social scientist and faculty member in the Institute of Environmental Sustainability at Loyola University Chicago. Her research focuses on understanding the dynamics of participation and learning in creating more sustainable, resilient, and just communities at a local/regional scale.

Marianne E. Krasny is a professor and chair in the Department of Natural Resources and Director of the Civic Ecology Lab at Cornell University. Through her research and outreach, she works with community-based organizations to examine how self-organized, environmental stewardship practices in cities contribute to ecosystem services, civic renewal, and social-ecological systems resilience. She also directs EPA's national environmental education training program EECapacity.

Chapter 24
Hitting the Big Screen – Urban Youth Activism Through Documentary Film

Stephanie J. Hathcock and Daniel L. Dickerson

> *Never doubt that a small group of thoughtful, committed people can change the world. Indeed, it is the only thing that ever has.*
> *(Margaret Mead)*

When people get involved in community issues, change can occur. Even small strides can make huge differences in the long run. This type of involvement is encouraged in youth because they are quickly developing into adults that can and should be involved in advocating for their local communities and beyond. Unfortunately, research shows that youth activism has been decreasing over the past few decades (Giroux 2002). Many factors could be contributing to this decline, including the increased amount of time being spent on digital technologies such as the Internet, television, and gaming. This chapter focuses on our efforts to tap into the potential of digital technologies as a means of promoting youth activism in science through student-created documentary film.

Our chapter begins with a discussion of the background of youth activism, including place-based education and the importance of building a sense of ownership. We review existing studies involving the creation of documentary films in science education. We provide the background for River Quest, which is the residential camp we created to address the needs of one of our school partners. We discuss the River Quest experience, including camp activities and the documentary film that tie the camp together. To conclude, we end with a discussion of what is learned from the initial year of River Quest and what has been modified.

S.J. Hathcock (✉)
School of Teaching and Curriculum Leadership, Oklahoma State University,
224 Willard Hall, Stillwater, OK 74078, USA
e-mail: stephanie.hathcock@okstate.edu

D.L. Dickerson
STEM Education and Professional Studies, Old Dominion University,
256 Education Bldg, Norfolk, VA 23529, USA

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_24

Activism, Place and Documentary Film

Activism and active engagement with the community and society remain desirable characteristics among today's youth (National Research Council [NRC] 1996). These characteristics are difficult to achieve among any group, however, studies have shown that African American, Hispanic, and urban youth are less likely to participate in activism or actively engage with their communities when compared to Caucasian and middle class youth (Hart and Atkins 2002).

Our definition of activism comes from Martin et al. (2007), who write that activism occurs when, "Some person or group recognizes a problem and takes some action(s) to address it in order to create change" (p. 78). They consider activism to be an issue involving geographic scale. This means that the problems are scaled (personal, community, state), the action is scaled (discussion, creation of materials, demonstrations), and the change that is created is scaled (money donated, change in attitude). This scaling supports activism as a place-based activity that is dependent on the social relationships and networking that interact with it (Martin et al. 2007). We also adhere to the theoretical principles that activism can be used to solve societal problems (Lester et al. 2006), and that it involves personal responsibility as well as attempts to influence others, both through actions and advocacy (Bouillion and Gomez 2001).

Activism is beneficial for youth development. Youth who participate in activist activities are also less likely to use drugs and alcohol (Barber et al. 2001), engage in criminal activity (Mahoney 2000), or have problems with truancy or school dropout (Flanagan and Van Horn 2003). Activism promotes self-esteem (Pancer et al. 2007), improves school performance (Davila and Mora 2007), and increases the ability to relate socially (Maton 1990). Youth activism has also been shown to be beneficial to participants' communities and institutions (Youniss and Levine 2009). For example, studies show positive effects from youth activism for neighborhoods and corporations (Guessous et al. 2006). Youth participation also strengthens community spirit and increases respect in youth / adult communication (Flanagan and Van Horn 2003).

Place-Based Activism and Building a Sense of Ownership

An understanding of local issues in the environment can contribute to the development of activism attitudes (O'Neill and Calabrese Barton 2005). However, minority youth may see themselves as outsiders to science, which may influence whether they engage with local issues (Brickhouse 1994).

Creating the right conditions for urban students to learn about their local community is key. Constructing this environment involves the science being connected to students' lives (O'Neill and Calabrese Barton 2005). Developing science connections that help engage students involves crafting learning communities whereby students develop ownership of scientific ideas, processes, and understand where science fits in their lives. One way to facilitate ownership development is to encourage students to see themselves as producers of science rather than just consumers of knowledge (Moll et al. 1992). When students see themselves only as consumers of knowledge, they may not express their critical thinking and creativity as they seek answers from people who are considered producers of knowledge (Furman and Calabrese Barton 2006). When students see themselves as producers of knowledge, their opportunities for critical thinking and creativity are increased (Moll et al. 1992), as is their sense of ownership of science – due to the ideas they are producing.

O'Neill and Calabrese Barton (2005) argue that this sense of ownership can be nurtured when students use their personal resources (e.g. knowledge, interests, awareness) in science. The current generation of youth has different personal resources than past generations. They interact with the world in very different and highly technological ways. They are continuously trying out new ways to express themselves, and that communication may not look like that of past generations (Youniss and Levine 2009). With this information in mind, we developed River Quest, which affords students the opportunity to be the producers of knowledge through student-created documentary film.

Documentary Film

Research suggests that technology use positively contributes to students' learning by increasing their motivation and interest (Blumenfeld et al. 1991). Student-created videos contribute to a sense of ownership because students make the decisions and they select and collect footage, cut, edit, create voice-overs, and choose songs. They create the storyline of the film and select the footage based on what is meaningful, which we will show, promotes a sense of ownership in both the science and the film.

Giroux (2001) discusses the power film can have in positioning ideologies and values into public conversation. In fact, art in general has the power to promote social and environmental justice (Lawrence 2005). Unfortunately, documentary film with youth remains largely unexplored. Within the realm of science education, O'Neill and Calabrese Barton (2005) study 'sense of ownership' as it relates to student-created documentaries with urban sixth-grade students. Elmesky (2005) looks at how the creation of a science digital video allows urban high school students to build personal connections with science. Furman and Calabrese Barton (2006) find how student voice can be captured through digital video, and can be used to assess learning as their voice changes over the course of science learning. With these studies in mind, we set out to create an environment in which students can be in charge of creating a documentary about pollution issues in their local environment.

The Need for River Quest

The Hampton Roads area of Virginia encompasses a group of coastal communities situated near the Chesapeake Bay. Many of the daily activities of life involve the local waterways, which include the Bay and the Atlantic Ocean. River Quest focuses on an urban city that sits on a heavily polluted waterway. The majority of the students in the city's public schools are African American as well as economically disadvantaged. Research shows that minority and low-socioeconomic status populations are more vulnerable to exposure to substandard environmental conditions (Evans and Kantrowitz 2002). River Quest helps these students identify areas of environmental concern within their community and develop stewardship and advocacy strategies. Specifically, the creation of River Quest is guided by four goals:

1. Offer students an opportunity to explore and understand the environment within their own community;
2. Encourage students to learn about STEM college and career opportunities in the region;
3. Present students with opportunities for environmental advocacy through the use of documentary film;
4. Encourage intergenerational learning about environmental issues facing the community.

Goal 1: Offer students an opportunity to explore and understand the environment within their own community The Chesapeake Bay stretches from Maryland to Virginia, and its watershed includes roughly 17 million people (Chesapeake Bay Program 2012). Some of the major issues the Bay is facing come from: pollution from agriculture, storm water runoff, and wastewater treatment plants; development and population growth; and low numbers of many fish and shellfish species (Chesapeake Bay Program 2012). The Elizabeth River is a tributary of the Chesapeake Bay, and together, these two bodies of water make up the majority of the recreational and industrial water usage in the local communities. Since these bodies of water surround our communities, the condition of the bay and the river is a growing concern for local environmental entities as well as all of the citizens (Elizabeth River Project 2012). We believe that by exploring some of the local environmental issues, students will access a better sense of their community and perhaps increase their sense of ownership and thoughts of activism within themselves.

Goal 2: Encourage students to learn about STEM college and career opportunities in the region STEM is a major trend in education and one associated issue is the continued lack of minorities and women in STEM fields (Museus et al. 2011). We select this issue through River Quest, and intend to showcase some of the STEM occupations in our local community. We make a point of connecting students with minority and women scientists and STEM professionals, including the military and non-governmental organizations. A recent study by Maltese and Tai (2011) finds that sparking an interest in science is one of the most important factors to perseverance through the STEM pipeline. They argue that sparking interest does not need to be a sustained process, but rather, can be done during a one-shot opportunity such as a summer camp (Maltese and Tai 2011). By giving students the opportunity to have personal experiences with STEM professionals and associated fields, we hope to spark an interest in the STEM pipeline and contribute to the public understanding of science.

Goal 3: Present students with opportunities for environmental advocacy through the use of documentary film Encouraging and promoting environmental advocacy and activism does not come easily. We believe that presenting students with opportunities to use their personal resources to create film clips that are important to them will create personal relationships with them and the science, and promote ownership of the problems facing the local environment. This can lead to advocacy and activism on their part as they begin to understand that there is a place for their voice in the community, and they have important information to share (Moll et al. 1992).

Goal 4: Encourage intergenerational learning about environmental issues facing the community This goal is closely related to Goal 3, and deals with students gaining an understanding of their local environmental issues, which can lead to activism in helping solve community problems. Students viewing themselves as the producers of knowledge, in this case, the documentary film, places them in the role of advocate and promotes how they can effectively teach others, including their family members. Students can also use their family members as resources. Many students have family members who grew up in the area. They can also serve as sources of local wisdom for students as they create their documentaries.

The River Quest Experience

River Quest participation is voluntary and competitive. Selections are made based on current enrollment in the school system: B average or higher in coursework; strong desire to learn; ability to work independently and with groups; interest in the outdoors, including water; and availability for the 4 day camp. Students are required to submit a one-page essay describing how they meet the criteria, as well as provide two teacher recommendations. Students participate in one of 3 weeks of the camp, each of which consists of 4 days and 3 nights. We limit each week of the camp to 12 students, so we see a total of 36 students over the course of 3 weeks. The vast majority of students are African American, however Caucasian, Hispanic, and Filipino students also participate.

The curriculum is implemented by two of the school division's science teachers (8th grade and high school oceanography), one doctoral level science education student, and faculty from Old Dominion University. There are three major themes for the camp: (1) types and sources of pollution, (2) environmental stewardship, and (3) career development. Each of the discussions, activities, and field trips, centers on the themes. The themes are addressed using the local community waterways, which include the Chesapeake Bay and the Elizabeth River. Major components of the curriculum are discussed below.

Student-Directed Conversations with Scientists

To promote a better understanding of the role and image of scientists, we schedule a dinner with scientists on the first night of each camp week. We meet at a local pizza parlor, sitting in small groups that promote discussion among individuals and between small groups. Both practicing scientists and graduate students attend these dinners. Most of the attendees are from the University's oceanography department, and many of them are minorities and women. The students come with questions about their documentary footage (discussed later on) and the scientists do their best to answer these questions and also discuss some of the highlights of their jobs. According to the student evaluations, this is one of their favorite activities, mainly because they are able to get to know the scientists on a more personal level. Many students are surprised to see that there are women and young people among the scientists. Eating with scientists in a casual setting humanizes them, and lets the students see that they are common people who have very interesting jobs (Fig. 24.1).

Fig. 24.1 Small-group discussions during dinner with scientists

Fig. 24.2 Water quality sampling at the Learning Barge

Elizabeth River Project

The Elizabeth River Project is a local non-profit organization with the mission of restoring the Elizabeth River to environmental health. They work with local governments, businesses, and communities to educate people about the state of the river, with the goal of making it fishable and swimmable by 2020. They operate a Learning Barge that is designed for K-12 students to learn about ecology and sustainability (Elizabeth River Project 2012). When our students visit the Learning Barge, they have discussions about the state of the river, the effects of fertilizers and pet waste, and sustainable practices such as solar panels (Fig. 24.2).

Coast Guard Ship Tour

The local community is home to several military bases, including Navy, Marines, and Coast Guard. Although they know of its existence, most of the students are unaware of the Coast Guard's role in marine environmental protection (United States Coast Guard [USCG] 2012). Our students tour the U.S. Coast Guard Cutter, Legare, to learn about waste processing and disposal, recycling, and HazMat procedures. They also visit with the base's Environmental Specialist to learn more about how the Coast Guard manages their environmental footprint. This includes touring the vegetable garden that is watered by treated wastewater and fertilized by base composting.

Fig. 24.3 Checking soil samples collected from the Elizabeth River

Research Vessel Cruise

Students meet with some of the University's oceanography researchers and get a tour of portions of the Elizabeth River on the R/V Riptide. While underway, they take water and soil samples and conduct a plankton net tow. They work with the scientists to conduct tests on their samples, make meaning of how that type of sampling contributes to our knowledge of the state of the river, and discuss ways to promote the environmental health of the river (Fig. 24.3).

STEM Activities

The students participate in several STEM activities throughout the week. One of the major activities highlights the Port of Virginia, which borders the Hampton Roads area. They learn about port logistics, including the environmental quality procedures that the ports follow to reduce their footprint. Students participate in a port logistics simulation led by one of the University's STEM faculty members. They also learn about the various career opportunities within the port system, especially those that deal with environmental quality.

Canoe Exploration of the Elizabeth River

To learn more about the Elizabeth River, students spend part of a day exploring it on canoes. From their vantage point, they can see the Port of Virginia, waterfront communities, Norfolk Naval Base, and a local golf course. Each of these provides opportunities for observations, discussions, and advocacy solutions (Fig. 24.4).

Fig. 24.4 Learning to use a Niskin bottle to collect water samples

The Documentary Film

The documentary film serves as the connecting thread for each of the River Quest activities. The film is created from student video clips that are joined together to tell a story about pollution in the community and how citizens can address pollution through positive environmental stewardship behaviors. Students receive a Flip camera for their use during the camp. They are allowed to film any part of an activity of their choice during the day. They film themselves and others, including the scientists and other adults they come into contact with, and the action is authentic or staged. Most of their evening time is spent downloading and selecting from video clips on laptops. For safety reasons, the cameras are collected at the end of each day prior to bedtime.

On the first day of camp we show students portions of a kid-friendly documentary film called, *What's On Your Plate?* (Gund 2009). The film chronicles two 11-year-old girls as they try to figure out where their food comes from, including how it is cultivated, where it is shipped from, and how it is prepared for consumption. The film is chosen because it shows the girls asking important questions but also goofing off and having fun while they tell the story of their food. After watching portions of the film, students decide whom they will work with (individual, partners, or small groups), and discuss ideas for film clips involving pollution in their community. Each film group selects a specific topic related to pollution, which includes water, air, noise, and land pollution, as well as more specific topics such as biomagnifications.

Once students decide on topics, they create storyboard ideas for each of the activities they are about to experience at camp. They develop questions for the scientists and activity leaders that offer information needed for their film clips, and as the week progresses, they begin amassing video footage (Fig. 24.5).

Fig. 24.5 Using flip cameras to film a field trip on the Elizabeth River

Flip cameras are handheld cameras roughly the size of cell phones that are inexpensive and easy to use. While these characteristics make Flip cameras perfect for student-created documentaries, they can also lead to challenges with the quality of the videos. During the first week of River Quest, participants receive only technical instruction regarding the camera's operation. Upon viewing portions of the footage, it becomes clear that additional instruction would be necessary in order to obtain usable footage. The initial footage is extremely shaky, seldom centered, and contains very poor audio. The program leaders may alter the schedule for the remaining 2 weeks to include additional instruction regarding techniques and strategies for how to shoot video with the Flip cameras. The subsequent videos are usually better, but much of the footage is still unusable. This is an area for improvement in future efforts.

The students spend their evenings determining which clips they wish to submit for the documentary and provide an explanation for the footage and how it should be used. Due to time constraints, students do not participate in combining the footage or producing the documentary. We work with the School of Communication at Elon University to combine the footage into the final film. The film incorporates elements of the components of River Quest, and showcases the students' experiences, questions, and suggestions. The film also includes additional stock video, audio, and an introduction by the Elizabeth River Project. It has a run time of 6 min 58 s. A screening of the film occurred in April 2012, during which students, their families, and members of the local community were present. Students exhibit pride in their contributions toward the documentary, and are very excited to share the film with their families and the community. They also start conversations about the current state of the Chesapeake Bay and Elizabeth River, which leads their parents and community members to want more information regarding our local pollution issues.

Community Environmental Awareness and Advocacy

River Quest is designed to fill a need for creating community environmental awareness, STEM college and career exploration, intergenerational learning, and most important to this chapter, present opportunities for urban students to participate in environmental advocacy by becoming knowledge producers. Students come away from River Quest with a documentary that educates others about pollution and encourages environmental stewardship behaviors that will address some of their pollution problems. They are able to show the film to their families and members of the local community, and have a foot in the door for becoming activists for their local community.

Based on the lessons learned from the first year of River Quest, the 2012 version contains more direction on how to properly film documentaries. Students worked with our local public broadcasting system to develop a better understanding of camera usage, storyline development, and the overall impact possible with documentary film. We are in the process of producing the 2012 film – excited to see the results!

References

Barber, B. L., Eccles, J. S., & Stone, M. R. (2001). Whatever happened to the jock, the brain, and the princess? Young adult pathways linked to adolescent activity involvement and social identity. *Journal of Adolescent Research, 16*, 429–455.

Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., & Palinesar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist, 26*, 369–398.

Bouillion, L. M., & Gomez, L. M. (2001). Connecting school and community with science learning: Real world problems and school-community partnerships as contextual scaffolds. *Journal of Research in Science Teaching, 38*, 878–898.

Brickhouse, N. (1994). Bringing in the outsiders: Reshaping the sciences of the future. *Curriculum Studies, 26*, 401–416.

Chesapeake Bay Program. (2012). *Learn the issues*. Retrieved January 8, 2013, from http://www.chesapeakebay.net/

Davila, A., & Mora, M. T. (2007). *An assessment of civic engagement and educational attainment*. Retrieved January 8, 2013, on http://www.civicyouth.org/PopUps/FactSheets/FS_Mora.Davila.pdf

Elizabeth River Project. (2012). *State of the river*. Retrieved January 8, 2013, on http://www.elizabethriver.org/

Elmesky, R. (2005). "I am science and the world is mine": Embodied practices as resources for empowerment. *School Science and Mathematics, 105*, 335–342.

Evans, G. W., & Kantrowitz, E. (2002). Socioeconomic status and health: The potential role of environmental risk exposure. *Annual Review of Public Health, 23*, 303–331.

Flanagan, C. A., & Van Horn, B. (2003). Youth civic development: A logical next step in community youth development. In F. Villarruel, D. Perkins, L. Borden, & J. Keith (Eds.), *Community youth development: Practice, policy, and research* (pp. 273–279). Thousand Oaks: Sage.

Furman, M., & Calabrese Barton, A. (2006). Capturing urban student voices in the creation of a science mini-documentary. *Journal of Research in Science Teaching, 43*, 667–694.

Giroux, H. (2001). Breaking into the movies: Pedagogy and the politics of film. *Journal of Advanced Composition, 21*, 583–598.

Giroux, H. (2002). Democracy, freedom, and justice after September 11th: Rethinking the role of educators and the politics of schooling. *The Teachers College Record, 104*, 1138–1162.
Guessous, O., Armstrong, M. N., House, D., & Prescott-Adams, F. (2006). *Evaluation results of the Summer Youth Fellows Program*. Atlanta: Hands on Atlanta.
Gund, C. (2009). *What's on your plate?* Retrieved January 8, 2013, from http://www.whatsonyourplateproject.org/
Hart, D., & Atkins, R. (2002). Civic competence and urban youth. *Applied Developmental Science, 6*, 227–236.
Lawrence, R. L. (Ed.). (2005). *Artistic ways of knowing: Expanding opportunities for teaching and learning.* (New directions in adult and continuing education series, 107). San Francisco: Jossey-Bass.
Lester, B. T., Ma, L., Lee, O., & Lambert, J. (2006). Social activism in elementary science education: A science, technology, and society approach to teach global warming. *International Journal of Science Education, 28*, 315–339.
Mahoney, J. L. (2000). School extracurricular activity participation as a moderator in the development of antisocial patters. *Child Development, 71*, 502–516.
Maltese, A. V., & Tai, R. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education, 95*, 877–907.
Martin, D. G., Hanson, S., & Fontaine, D. (2007). What counts as activism? The role of individuals in creating change. *Women's Studies Quarterly, 35*, 78–94.
Maton, K. (1990). Meaningful involvement in instrumental activity and well-being: Studies of older adolescents and at risk urban teenagers. *American Journal of Community Psychology, 18*, 297–320.
Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory Into Practice, 31*, 132–141.
Museus, S. D., Palmer, R. T., Davis, R. J., & Marambe, D. C. (2011). *Racial and ethnic minority students' success in STEM education*. Hoboken: Jossey-Bass.
National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.
O'Neill, T., & Calabrese Barton, A. (2005). Uncovering student ownership in science learning: The making of a student created mini-documentary. *School Science and Mathematics, 105*, 292–301.
Pancer, S. M., Pratt, M., Hunsberger, B., & Alisar, S. (2007). Community and political involvement in adolescence: What distinguishes the activists from the uninvolved? *Journal of Community Psychology, 35*, 741–759.
United States Coast Guard. (2012). *USCG Missions.* Retrieved on January 8, 2013, from http://www.uscg.mil/top/missions/
Youniss, J., & Levine, P. (Eds.). (2009). *Engaging young people in civic life*. Nashville: Vanderbilt University Press.

Stephanie J. Hathcock is an assistant professor of science education in the College of Education at Oklahoma State University. Her research focuses on environmental science, science professional development, and creativity within science teaching and learning.

Daniel L. Dickerson is associate professor of science education in the Department of STEM Education and Professional Studies at Old Dominion University. His research focuses on the teaching and learning of earth and environmental science content, environmental education, and socio-scientific issues in science education. He is a former high school earth science teacher who has served as PI, Co-PI, or Evaluator on NOAA, NSF, US Department of Education, IMLS, state, and foundation funded projects.

Chapter 25
Citizen Diplomacy to Youth Activism: The Story of the Global Thinking Project

Jack Hassard

> *We must be scholars and activists. It is simply not enough to be scientists—that is to measure and calculate, but rather we must be willing to dedicate ourselves to causes—to be activists who are willing to commit to environmental and humanitarian issues. (Dr. Jennie Springer, Principal, Dunwoody High School, From an address given at GTP Environmental Summit, Simpsonwood Conference Center, Norcross, October 2, 1996)*

Thirty years ago, a Russian train left Helsinki for Moscow carrying psychologists and educators from North America who were participants in the first citizen diplomacy project sponsored by the Association for Humanistic Psychology (AHP). That train trip was the start of a 20-year Track-II[1] Diplomacy Project, and evolved into a global teacher and student environmental activist project that brought together hundreds of teachers and students not only from the United States and the former Soviet Union, but colleagues and students in many other countries including Australia, the Czech Republic, and Spain.

That train trip changed my life, and the lives of countless science and social science teachers, school principals, researchers, students (ages 12–18) and their parents.

Citizen diplomacy, citizen science, and youth activism are not new ideas, but the forces that shape contemporary education around the globe are based on issues related to work and economics. In our capitalist system, conservative and neoliberal policies are making it more and more difficult for educators to create environments that foster the kind of inquiry and freedom needed to engage in activist projects. Put to the side in the words of Henry Giroux (2011), "are questions of justice, social freedom, and the capacity for democratic agency, action, and change as well as the related issues of power."

I will describe here that, although difficult, it is possible to overcome neoliberal and conservative policies and engage colleagues whose cultural and political

J. Hassard (✉)
Department of Middle and Secondary Education,
Georgia State University, P.O. Box 264, Marietta, GA 30061, USA
e-mail: jhassard@mac.com

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_25

context is much more authoritarian than we generally consider in the West. When ordinary people are brought together to discuss common interests and concerns, actions can emerge that would be surprising even to the most progressive among us. The citizen diplomacy activity that emerged between American and Russian students, and between students in other countries as mentioned above, integrates Vladimir Vernadsky's (1926) conception of the Biosphere and environmental education, the humanistic psychology and philosophy of Carl Rogers (1961), John Dewey's conception of experiential learning (1938), and Track II Diplomacy (Davidson and Montville 1981).

The notion of citizen-to-citizen exchanges with North Americans and Soviets was unknown until 1958 when Eisenhower and Khrushchev signed a 2-year agreement spelling out exchanges in culture, science, technology, and other fields. According to Richmond and Hawkins, "the early years were marked by strict reciprocity, suspicion, and close control, but they established contacts that were to flourish and expand when bilateral relations improved in the era of détente" (Richmond and Hawkins 1988, p. 8). This first initiative was followed by exchanges among private section organizations, which led to "people-to-people" exchanges.

In the field of psychology and education, the AHP led the way in establishing people-to-people contact beginning in 1972 when U.S. psychologist Stanley Krippner (AHP President, 1974–1975) gave lectures in Moscow on humanistic psychology. Researchers Michael Murphy and James Hickman from the Esalen Institute traveled to the Soviet Union and met with researchers, scientists, medical practitioners, healers, and psychologists who were involved in the human potential movement of their own. Then in 1980, Murphy and Hickman invited members of the Soviet Embassy in Washington to Esalen, to participate in discussions on human potential and extraordinary performances of humans (Hassard 1990). They established the Esalen Soviet-American Exchange Project, and continued inviting people at higher and higher levels eventually reaching ambassadors, senators and Soviet officials. Think about this: Soviet and American policymakers sitting in Esalen hot tubs looking out on the Pacific!

But they also had other notable achievements including the first astronaut-cosmonaut meetings, the first Space-Bridge (two-way rock concert via satellite), a nongovernmental agreement with the Soviet Writers Union, and joint book fairs (Leonard 1988).

The roots of citizen diplomacy and people-to-people exchanges had been established. The AHP, having close relationships with Esalen, embarked on a program that would enable North American psychologists and educators to participate in a Track II diplomacy project with citizens in the Soviet Union.

In the present age, as reflected in the chapters of this book, there are science educators who are paving the way for students to be critical citizens and for school's to consider this kind of work as a primary aim of education.

Bencze, Alsop, and Ritchie (Chap. 21, this volume) make the important point that "many scholars are now urging educators to encourage and enable students to accept more collectivist (rather than egoist) epistemological stances and, accordingly, take socio-political actions that may be in the wellbeing of individuals, societies and environments." They also point out that these actions are contrary to the capitalist policies whereby citizens are mere consumers and spenders of their own capital.

From 1983 to 2001, a project rooted in citizen science, youth activism, and global collaboration emerged and developed into the Global Thinking Project, a kind of hands-across-the-globe program. It became an environmental education program based on "education for the environment," a model that embodies the principles of Deep Ecology (Devall and Sessions 1985). Deep Ecology, coined by Arne Naess, is a deeper approach to the study of nature exemplified in the work of Aldo Leopold and Rachel Carson (Devall and Sessions 1985). In this sense, teachers encourage their students to engage in projects that help them experience the connections between themselves and nature as well as advocating a holistic approach to looking at environmental topics.

Engaging students in ways that enable them to take actions and experience environmental science as *education for the environment* (Michel 1996) is what Aikenhead (2005) and Dos Santos (2008) define as humanistic science. This definition of humanistic science was the core of the approach to teaching science that was discussed and argued among American and Russian science teachers.[2]

The story that follows is an historical account of a citizen diplomacy project that integrated citizen science, ecojustice and youth activism, involving hundreds of teachers, researchers and students who believed it was important to work together with people in other cultures to try and take action on important environmental questions that are both local and global in nature.[3]

Inauguration: Initial Days of the AHP Soviet/American Exchange Project

On September 1, 1983 a Soviet interceptor Su-15 shot down Korean Air Lines flight 007, killing all 269 passengers and crew aboard, including Lawrence McDonald, a sitting member of the United States Congress.

On September 7, 1983, I was on a Russian train from Helsinki bound for Moscow, marking the beginning of my second trip the Soviet Union. In an atmosphere of rhetoric and tension, I was a member of a group of 30 educators, psychologists, and psychotherapists traveling to the Soviet Union, unsure until the last minute whether we would be admitted, or whether any of our planned meetings would be held. Yet, on the Soviet train, the Tolstoy, the group held small group meetings to prepare for encounters we hoped to have with Soviet psychologists and educators.

Thirty-five hours after leaving New York's Kennedy airport, looking ragged yet excited, we entered a meeting room at the Soviet Institute for Psychology with a prominent picture and bust of Lenin. After a few minutes, ten Soviet researchers walked in and sat down. Then the director, Dr. Boris Lomov, a large white-haired man in his late fifties, made his appearance. The atmosphere was tense. Lomov appeared to be a bit put-off that we were there. He made a few introductory comments, referring briefly to the tension that existed between our two countries and the fact that our meeting had nearly been cancelled by the U.S.S.R. Academy of Sciences.

Francis Macy,[4] director of the AHP delegation, broke the ice and saved the day. Speaking in Russian, he introduced the AHP delegation, thanked the Institute of Psychology for receiving us, and said he hoped this would be the first of many professional meetings between the AHP and the Institute of Psychology. This helped establish a friendly atmosphere in the room, and when the formal part of the meeting—a lecture by Lomov (who died in 1989) about psychology in the Soviet Union—was over, Americans and Canadians, and Soviets formed small groups to talk, exchange books, and papers, and arrange for informal meetings. Now we were ready to go to our hotel, to rest and begin getting used to being in what Ronald Reagan called "the evil empire."[5]

We were from different parts of North America, but all were motivated to invest themselves and their resources to open channels of communication with colleagues in the Soviet Union. Some were eager to make contact with refuseniks, Soviet citizens who were denied exit visas to emigrate abroad. Others sought connections with Soviet psychologists. Many were interested in contacting schools and educators. We never would have believed that this first trip to the U.S.S.R. would result in lasting relationships, not to mention the types of activist projects that emerged from this first trip, highlighted by a large-scale youth activist program known as the Global Thinking Project (Hassard and Kolb 1996; Hassard and Weisberg 1999b).

The fundamental goal of the exchange project was to bring together North American and Soviet professional psychologists, therapists, and educators to collaborate on mutual problems, to learn about others' practice and theory, and, by knowing each other, to contribute to the reduction of tension that existed between the superpowers. Specifically the project sought to:

- Sponsor delegations to the Soviet Union on an annual basis to share values, theories and practices of humanistic psychology and education.[6]
- Develop agreements with Soviet institutions and individuals to carry out collaborative activities.[7]
- Facilitate the publication of joint and individual articles, papers, and reports.[8]
- Facilitate and support informal relationships between AHP delegates and their Soviet counterparts.
- Invite and sponsor Russian colleagues and delegations to the United States.[9]
- Contact Soviet refuseniks and dissidents, especially during the early years of the project.[10]

The AHP exchange project had a powerful beginning, and continued for nearly two decades, but has had lasting affects, even to today.[11]

Formal and Informal Meetings in Moscow, Leningrad and Tbilisi, 1984–1986

The AHP-Exchange project, without official invitations, sought ways to establish relationships with individuals, schools, institutes and universities. With each new encounter was the hope that this might lead to more lasting and satisfying and in-depth relations.

Before entering the Soviet Union, a 2-day seminar was held in Helsinki to discuss professional topics, and enable delegates to deal with anxieties about traveling to the Soviet Union. A resource book was created, and delegates were encouraged to read articles and books related to history, culture, psychology and education of the Soviet Union. The Helsinki seminars were conducted in collaboration with Finnish psychologists and educators.

The delegates explored Soviet psychology and education in three cities: Moscow, Leningrad (now St. Petersburg), and Tbilisi (Georgia). Later in our collaborations we would work with schools not only in Moscow and St. Petersburg, but Pushchino, a research center of the Russian Academy of Sciences, located south of Moscow along the Oka River, Yaroslavl, an ancient town at the confluence of the Volga and Kotorosl Rivers, and Chelyabinsk, located just east of the Ural Mountains on the Miass River.

The planned program for delegates was impressive and grueling. It consisted of professional meetings (at psychology and educational institutions and universities), and cultural visits (Red Square, the Kremlin, the Pushkin Museum, the Hermitage, the Circus, the Bolshoi). Professional meetings were quite unpredictable. Usually meetings started as large group sessions learning about the structure of the institution and finding out about the curriculum or the staff's lines of research.

The real breakthroughs took place in small groups. From the very beginning, delegates were insistent that time be devoted to small group interaction. In fact, when this was first suggested at the Institute for the U.S. and Canadian Studies,[12] our host Yuri Zamoshkin was not sure that it was a good idea. Why couldn't we be simply in one group? The intense small group discussions must have had a positive impact on him, because when we returned the next year, he suggested that we immediately break into small groups and go off into individual's offices for further discussion.

The small group discussions in each institute drove the exchange project, and humanized the context. It was in the small group discussions that important decisions were made as well as future planning. We listened to each to each other, and it was obvious that everyone wanted to make connections that would lead to meaningful dialogue and future projects.

Another feature that originated from these early trips was visits to Russian homes, for discussions, food and drink. Although not a formal part of the schedule at this time, the leadership team made sure that each delegate was invited to someone's home during the trip. In most cases, each delegate visited several Russian homes. As one delegate reported, "In each case I was struck with the relative lavishness of even the most modest of American homes by comparison. However, the lavish hospitality and generosity of the Georgians exceeded any I experienced elsewhere."

During this period of time, four AHP delegations participated in conferences, meetings, coffees and dinners with counter-parts in schools, universities and research institutes in Moscow, Leningrad and Tbilisi. A network among North American and Soviet colleagues was established. Using phone,[13] fax, and snail mail, they reached out to each other to plan future events. On the American side, the only organization officially involved was the Association for Humanistic Psychology, while on the Soviet-side, strong connections and unofficial agreements were made with research institutes in psychology and education including the Institute for Psychology, the Institute for General and Educational Psychology, the USA-Canada Institute, the Uznadze Institute for Psychology, the Institute for Adult Education, the University of Leningrad, and the Academy of Pedagogical Sciences (now the Russian Academy of Education). Formal agreements were also made with schools in five Russian cities.

We began to learn about and trust each other, and to realize that we had common interests and the desire to work together. We were entering a new phase of work.

Conferences and Teaching: Avenues of Collaboration 1987–1989

A new stage of work with each other emerged during this period. It included experiences where Americans and Soviets held conferences that focused on humanistic education and environmental education, taught in each other's schools, and the drafted agreements for collaborative work.

The new stage is best exemplified when the foreign affairs officers of the Academy of Pedagogical Sciences, roses in hand, met a 12-member delegation from Georgia at the Sheremetyevo Airport in Moscow in October 1978. The American delegation was composed of three teachers, a principal, two education consultants, an educational psychologist, and five professors. In Moscow a 5-day program featured a seminar at the Institute for General and Educational Psychology on creative and cooperative teaching, and a cross-cultural study of beginning teachers. There was also demonstration teaching at School 710, and two small group seminars in the laboratory of Dr. Alexander Orlov at the Institute for General and Educational Psychology.

After an overnight train trip to Leningrad, we met with colleagues at the Institute for Adult Education, located on the banks of the Neva River. A conference was held with the education researchers in the Institute for Adult education, headed by Professor Yuvenali Koulytkin. Small group sessions were held on teacher preparation, humanistic teaching environments, and the development of humanistic teaching materials. Two sessions were held, and then reports were presented to the whole conference.

One of the Soviets who organized one of the small groups and spoke eloquently at these meetings was Professor Galina Soukhobskaya, director of the Laboratory of Psychology in the institute. She and her colleagues have investigated classroom teacher behavior, which they used to describe three topologies of classroom interaction. She developed a theoretical model, which she called the "child-oriented model," that is very similar to the person-centered model developed by Carl Rogers (1969). Soukhobskaya pointed out that teachers in these environments created an atmosphere that recognized the right of the child to have a different value system, with the teacher serving as the facilitator of learning. This was an important report because it signaled that Soviet researchers understood that students can be independent thinkers, and indeed could be activists.

Researchers from the Institute for Adult Education arrived in Atlanta later that year for a grinding 10-day schedule of visits to schools, seminars, and conference at Georgia State University. For the Soviets, one of the highlights of their trip was the visit we made to Martin Luther King Center for Social Change. There was a very strong connection between our Soviet colleagues and the civil rights movement led by Dr. Martin Luther King.

During the visit, our Russian colleagues visited schools in the Atlanta, DeKalb and Fulton County schools. The Soviets were just as anxious to discover and ask questions about American education just as much as we were to learn about their schools. In one classroom discussion with American students, Yulia Siroyezhina said she liked what she perceived as a sense of freedom in the classroom, something that she said most Soviet students do not typically experience. Simeone Vershlovsky observed that American elementary and middle school education was very different than Soviet education, in the sense that American classrooms were more personalized, and the students experienced a greater sense of decision-making. Soviet and American secondary education appeared, in his opinion, to be rather similar in the sense that instruction was generally didactic and that students had other interests in mind than school.

A conference was held at Georgia State University in which over a 100 local teachers and administrators attended, which featured speeches by Yuvenali Koulytkin on the nature of Soviet education, Galina Soukhobskaya on humanizing the classroom, and Natasha Shoumakova on gifted education and creativity. Concurrent afternoon sessions were planned on several topics: teaching in each other's schools, the psychology of the humanistic and creative teacher, and comparing the preparation of teachers in the U.S. and the U.S.S.R.

Humanistic science, creative thinking and inquiry were important areas of collaboration. But more importantly, it was agreed that the center of collaboration had to be in the classrooms in Soviet and American schools, not university centers or research institutes. We worked together on this goal, and through it we pushed through the prejudices that had long separated researchers and classroom teachers. Indeed, some of the teachers in Russia that we worked with were also members of the Academy of Pedagogical Sciences, and thus held joint-appointments (Table 25.1).

Table 25.1 Dates, location, events between American and Soviet teachers and professors, 1987–1989

Dates	Location	Event	Comments
October 1987	Moscow, Tbilisi, Leningrad	AHP delegation to U.S.S.R.	Taught lessons in schools in each city
November 1988	Moscow, Leningrad	12 Member U.S. Education Delegation to U.S.S.R. Academy of Pedagogical Sciences	Teaching in schools, conferences on environmental education and humanistic education
December 1988	Atlanta	Soviet delegation to U.S.	First Conference on Global Thinking at Georgia State University; Wrote draft of agreement between GSU & Soviet Academy
May, 1989	Moscow, Leningrad	Small delegation to U.S.S.R.	Signing of Research Agreement; visits to schools
November 1989	Moscow, Leningrad	12 Teachers and professors to Russian Academy	Conference in Leningrad; Drafts of environmental education lessons

Teaching in Each Other's Classrooms

By 1987, American teachers were invited to demonstrate humanistic science pedagogies in Moscow and Tbilisi (Georgia). It marked the first time that we were invited to teach Soviet students.

In the fall of 1987, we began demonstration teaching in School 710, a school in Moscow with about 800 students, pre-school through high school. We had visited the school the previous year, and at that time, an agreement was reached with the teachers and school's head, Mr. Vadim Zhudov, that the demonstration lessons would:

- Establish classroom environments where students would become active science learners;
- Enable students to explore science topics in earth science and physical science;
- Create learning situations where students would work in collaborative and cooperative learning teams

We didn't realize how significant it was for us to teach lessons in Moscow School 710. Those that taught lessons were naturally nervous and hoped that things would go well. Each room was packed with observers, teachers, the Director, and researchers. The lessons involved hands on activities and demonstrations, and small group discussion, artwork, and a take home packet of materials and a booklet in Russian for the students to share with their parents.

Our goal in these demonstration lessons was to present an approach to teaching that involved inquiry, cooperative learning and hands-on experiences in order to create dialogue among American and Russian teachers. In this case, we wanted the students to participate actively in learning, a practice that was not common in Russian schools (or in American schools, for that matter).

We also visited Russian teachers' classrooms, and observed lessons in mathematics and science. We observed Nadezda Plaskonova, a talented young woman who had clear command of her mathematics class and subject. She used no textbook. Instead students kept detailed notebooks, which in the end became their texts. In a chemistry class, we observed a teacher use the Socratic method very effectively. With great vibrancy, she asked questions, using humor and surprise as well. Many of her interactions with students became extended dialogues, and the students were spontaneous with their remarks.

The Leningrad Agreement

The proposal that was signed in Moscow in May 1989 committed both sides to work together on mutually agreed upon areas for 3 years. The question that surfaced was, what specific project can we create that will result in a truly collaborative effort? Phil Gang of the Institute for Educational Studies, Alan Hoffman, a professor of social studies education at Georgia State University, Julie Weisberg,[14] professor of education at Agnes Scott College and I prepared a paper that proposed that American and Soviet teachers and scholars plan, write, field-test, and disseminate in the United States and the Soviet Union secondary school curriculum materials that focus on the following conceptual themes:

- The identification of and alternative solutions to global environmental problems;
- Prevention of nuclear war
- Ways to improve relationships between the Soviet Union and the United States.

The paper was presented during the May visit to researchers at the Institute of Adult Education in two separate seminars. The paper was also presented at School 157 and School 91 in Leningrad, and it was also presented at School 710 and the Institute of General and Educational Psychology in Moscow.

In a way so typical of our work with Soviets, these teachers and researchers embraced, after long discussions, these ideas, and paved the way for a collaborative 3-year curriculum project. And the Soviets suggested that in preparation for our next meeting in September 1989, that both sides survey teachers and students concerning the relevance and interest in our proposed curriculum topics. Are American and Soviet teachers and students interested in teaching and learning about the global problems that we think are important? We prepared two surveys. The student version asked secondary students to rate their level of interest on ten topics that we proposed as curriculum themes. The teacher version asked educators to rate their interest in the topic, and how easily the topics could be infused into the contemporary secondary curriculum in each country.

Americans and Soviets in a Leningrad conference, used the results of the survey as a basis for presentations and discussions. The Soviets developed an instrument, World, Profession and Me: Assessing Teachers' Ideas and Attitudes on World Ecology and Global Relations that was designed to measure teacher attitudes and concepts about world ecology, war and peace issues, and U.S.-Soviet relations (Vershlovsky and Kulyutkin 1989).

We agreed to develop cross-cultural teaching materials that would address the problem of helping students think globally, and saw it as a shift in thinking from the mechanized and individualistic model of thinking that dominates teaching around the world. It's an industrial model, and as Bencze, Alsop and Ritchie (Chap. 21, this volume) point out, the overemphasis on the products of science and technology, pushes to the side alternative approaches to thinking.

Global Thinking

Global thinking is an alternative pattern of thinking. Global thinking takes direction from societal concerns rather than from the inward structure of traditional education. Global thinking means looking at the process of schooling differently, considering what it means to be well educated in a global society.

A number of themes emerge as organizing principles for global thinking. Springer (1993) presents a model of global thinking that emphasizes four themes:

- Interdependence—helping students understand the idea of mutually reliant and connections.
- Right-to-choose—the demand to participate in all aspects of one's life.
- Anticipation—ability to deal with the future, to predict coming events, and understand the consequences of current and future actions.
- Participation—the complimentary side of anticipation. The ability to participate directly in projects and activities.

In *No Limits to Learning*, thinking in terms of large systems requires a new kind of participation. Botkin et al. (1979) writes:

> Participation in relation to global issues necessarily implies several simultaneous levels. On the one hand, the battleground of global issues is local. It is in the rice fields and irrigation ditches, in the shortages of over-abundance of food, in the school on the corner and the initiation rites to adulthood. It is in the totality of personal and social life-patterns. Thus participation is necessarily anchored in the local setting. Yet it cannot be confined to localities. Preservation of the ecological and cultural heritage of humanity, resolution of energy and food problems, and national and international decisions about other great world issues all necessitate an understanding of the behaviour of large systems whose complexity requires far greater competence than we now possess. The need to develop greater competence and to take new initiatives is pressing. For example, during times of danger or after a natural catastrophe, nearly everyone participates. Can we not learn to participate constructively when animated by a vision of the common good rather than a vision of the common danger?

Springer (1993) sees global thinking as a means of helping students accommodate to the rapid globalization of the world by becoming aware of and acting on the themes of interdependence and right-to-choose. Interdependence requires action on the part of the student. Understanding interdependence must go beyond the definition, and be based on real work by the students. Providing experiences in which students learn about interconnections among global problems is essential. Collaborating on cooperative projects with students in other cultures is one example of how to "teach" interdependence.

As Springer (1993) points out, "the right-to-choose" metaphor has emerged around the world as people have demanded the right to participate in all aspects of their lives. Of importance here is the fact that grassroots movements have had powerful impacts on how people think about change. As people have realized how powerful their images of reality are, they have demanded the right-to-choose. This notion has a profound affect on the decisions that are made about how and what to teach. Providing students opportunities to enact their ideas to solve problems, indeed to select the problems they wish to investigate, is in sync with global thinking.

Cross-Cultural Partnerships

Although Georgia State University emerged as the focal point for collaboration, curriculum development and research, the work has been a partnership among schools, universities, and research institutions of each side. Because this work began without external funding, initial support for the project came from individual educators who persisted in visiting the USSR every year. Chief among these connections was the relationship established with the USSR Academy of Pedagogical Sciences and schools in three Russian cities. Three years before we received funding from the Eisenhower Higher Education Program, the Environmental Protection Agency and the United State Information Agency, the Soviets supported the financial cost of receiving Americans in Moscow and Leningrad, and provided airfare for Russian educators to visit Georgia between 1988 and 1993.

The collaboration among the constituencies has been varied. As shown in Table 25.2 seven types of activities have characterized collaboration in the GTP Project. These have included 18 teacher exchanges involving 325 educators, 17 teacher leadership conferences held in each country involving nearly 1,000 educators, summer institutes in the U.S. involving educators from the U.S. (70), Russia (35), Australia (5), the Czech Republic (2) and Spain (3), student summits and exchanges involving 396 students and their families, individual visits of professors from G.S.U., and more than a decade of online collaboration using the resources of the Internet.

Table 25.2 Types of collaboration, instances, participants and focus of the collaboration 1983–2000

Types of collaboration	Instances	Participants	Focus	Time period
Teacher exchanges	18	American: 250	Demonstration teaching; class observations. Discussion of humanistic education and science teaching; cultural experiences: family experiences. Exchanges included 12–30 educators for 10–21 days	1983–2000
		Russian: 75		
Teacher conferences	17	Atlanta: 275	Open to all educators; Sessions on American and Russian educators' experiences; Curriculum reports, Global Thinking Project	1988–2000
		Moscow: 250		
		St. Petersburg: 200		
		Yaroslavl: 175		
		Chelyabinsk: 75		
Summer institutes	4	American: 70	One to two week institutes at The Simpsonwood Conference Center in Norcross, GA. Hands-on experiences with the curriculum and the technology; discussions of social responsibility and student activism	1993–1995
		Russian: 35		
		Spain: 3		
		Australia: 5		
		Czech Republic: 2		
Student summits	7	American: 166	Held at the end of each student exchange in the U.S. and Russia. Organized by students to engage others in the results of their citizen science activity.	1993
		Russian: 166		1995–1998
		Australian: 3		
Student exchanges	12	American: 198	Students were hosted for 21 days and lived in a host country home; engaged in GTP activities; attending school; family/cultural experiences	1990–1998
		Russian: 198		
		Families: 396		
Online collaboration	10 years	75 schools and approximately 3,000 students from Argentina, Australia, Brazil, Canada, Czech Republic, New Zealand, Russia, Scotland, Spain, Ukraine, USA	Teachers used the GTP curriculum in an online environment starting in 1990. Tools included e-mail, bulletin boards, GTP website, video conferencing	1990–2000
Individual visits	3	Professors and researchers	Project directors and professors from each side visited Atlanta or Moscow for planning and small group meetings to set agendas	1989–2000

Fighters for the Environment: 1990–1995

Agreements were in place by 1989. Now we were ready to move forward to develop a global environmental science curriculum, and build a network of schools connected by a fairly primitive Internet.

This was the period during which the Global Thinking Project was co-created. Our goal during this period of time was to create a global environmental curriculum that was based on deep ecology and student activism. Another goal was to create a program in which students could collaborate with each other utilizing the emerging technology of the Internet. We were interested in fostering global collaboration though telecommunications communities of practice. We designed an environmental science curriculum and telecommunications network and field-tested the program in schools in the U.S., the Soviet Union, Australia, Czech Republic, Catalonia (Spain), and other countries. The Global Thinking Teachers Resource Guide was translated in Catalan, Czech, and Russian.

The ideals of humanistic psychology and education were put into practice by involving teachers and students in development of the curriculum. The context of the GTP work was created by dialogue among teachers, students and researchers. Although the project began with the exchanges of teachers, administrators, and researchers, by 1992, student exchanges had begun, and during the period 1995–1998, more than 300 students were involved in exchanges between U.S. and Russian schools.

The GTP fostered an inquiry approach to learning by involving students in problems in their own communities, and extended inquiry to include dialog using email, bulletin boards, and videoconferences. Each project was designed to ask students to wonder and to ask questions that were relevant to environmental issues and problems in their own communities. The GTP focused on helping students to become capable of being citizen scientists, or in the words Dr. Galina Manke, biology teacher at School 710 and researcher at the Russian Academy of Education:

Fighters for the Environment (Борцы за окружающую среду)

The GTP Network

To link schools by computers to the Internet presented problems. For one, the Soviet schools had no computers, and we were unsure how we could connect them to the Internet if we could get computers for them. Phone lines were scarce in Soviet schools (American schools, as well), and often the phone line was in the Director's office, sometimes hundreds of feet from the location of science classrooms where the computers needed to be installed.[15]

Phil Gang of the Institute for Educational Studies suggested we contact Apple Computer to seek their support. It just so happened that there was a delegation of Russian teachers and researchers being hosted by our project in Atlanta.

They accompanied us to the Apple headquarters in Atlanta. Apple agreed to donate six SE 20 Macintosh computers and printers. Hayes Micro Modem Company donated six 2,400-baud modems. Apple also decided that Mr. Gary Lieber, a systems analyst with Apple should join us when we took the computers to Moscow. We carried the computers, printers and modems onto a Delta jet at the Atlanta airport, and flew them to Moscow to install them in schools and conduct teacher and student enhancement seminars.

At each school, Gary Lieber set up the technology that would enable teachers to logon to a network to send email using Apple Link, as well as post and read messages on bulletin boards we set up in the Apple Global Education network. Each computer and modem had to be programmed to connect with a service in Moscow, which connected to an interface in Western Europe and then to the U.S. through standard telephone lines. Amazingly, we got the system to work in every school in Russia, and by the end of the 2-week trip in December 1989 we had established the first Global Thinking Project Network consisting of ten schools (Hassard 1997) (Fig. 25.1).

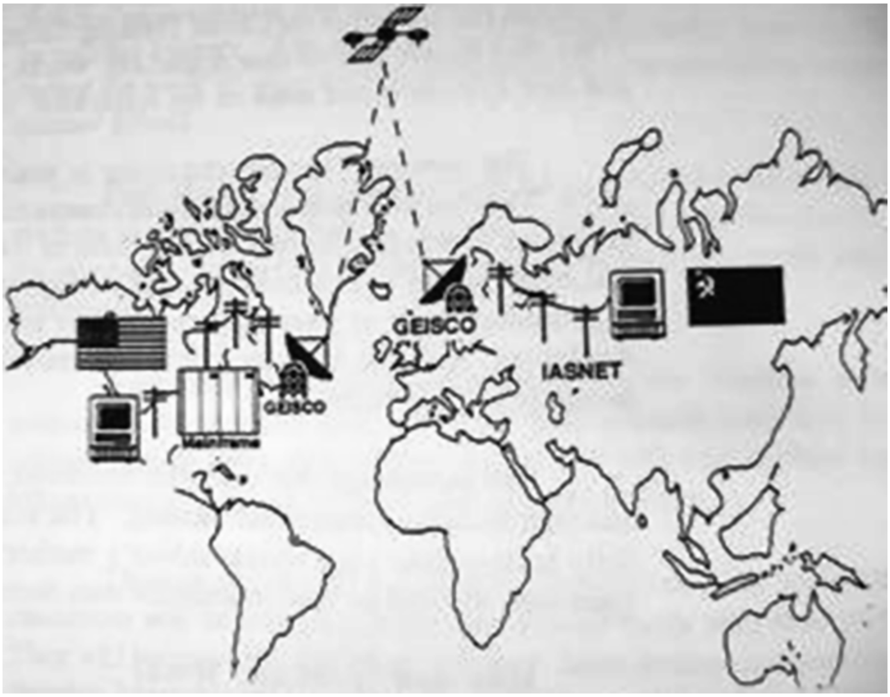


Fig. 25.1 The Global Thinking Project first telecommunications network using networks in the Soviet Union, Western Europe and the U.S. Apple Link accounts were set up on each Macintosh SE20 in the Soviet Union. American schools were able to provide their own computers. By December 1989, the GTP network was running

The GTP Curriculum

The GTP curriculum is a sequence of project-based experiences that are designed for students to investigate an environmental problem locally and simultaneously use telecommunications to collaborate with others, and to share their results using email and bulletin boards (Hassard and Weisberg 1993). When the GTP project got underway, the Internet did not have the technologies that we have today, especially after the World Wide Web was developed (Berners-Lee 1999) and browsers such as Mosaic and Netscape came on the scene. At first we used email and bulletin boards to post messages. We also used the ALICE network software developed by TERC. This software enabled students to send reports and data tables across the network. Students also used the ALICE software to analyze data, create graphs, and map the results of their work. In 1994, we designed a website that enabled teachers and students to access the GTP activities for each project, Internet forms for data sharing, data retrieval tables, web discussion boards, and resources.

The GTP framework provides teachers in different cultures with a way to engage their students in collaborative research and action taking with students in other countries.[16] The curriculum consists of a series of projects in which students learn to monitor important aspects of the Biosphere in order to study such topics such as weather and climate change, air and water pollution, and solid waste management. We go beyond this step by providing students with opportunities to apply their "new" knowledge by engaging in cooperative team projects that link students in classrooms globally. In each project, students take action on local environmental issues. Thus in the context of real problems set in the local setting, students are encouraged to take responsible action and to seek ways to be socially responsible.

The Biosphere and Deep Ecology

The scientific work of Vladimir Ivanovich Vernadsky (1926) on the Biosphere, and the more recent work in the field of deep ecology by Rachel Carson (1962), and Arne Naess (1989) influenced teachers and researchers in the formulation of the Global Thinking Project content. We were introduced to the Vernadsky's research on understanding that life, using energy from the Sun, transformed the Earth over eons of geologic time. Lynn Margulis, in the introduction to the English translation of Vernadsky's (1926) book *The Biosphere*, put it this way:

> What Charles Darwin did for all life through time, Vernadsky did for all life through space. Just as we are all connected in time through evolution to common ancestors, so we are all—through the atmosphere, lithosphere, hydrosphere, and these days even the ionosphere—connected in space. We are tied through Vernadskian space to Darwinian time.

Anatoly Zaklebny, professor of ecological studies at the Russian Academy of Education introduced us to Vernadsky's work. Zaklebny was an ecological educator, an author of ecological and environmental education teaching materials for Soviet schools, and ecological teacher educator. Anatoly understood and applied Vernadsky's conception of the biosphere, and used the concept of Biosphere to design teaching materials for Soviet ecological education. Zaklebny became the chief scientist on the GTP, and participated in all aspects of the project. We embraced Vernadsky's holistic view of the Biosphere, which resists the mechanistic reductionist nature of Western science. Vernadsky's ideas were late in arriving in the west, and it was only in the 70s and 80s, that his ideas gained prominence in western science.

Deep ecology is a term that Arne Naess coined. Rachel Carson's (1962) book, Silent Spring was one of the key influences on Naess conception of deep ecology. One of Naess' major ideas was that the living environment as a whole should be respected, or we might say, "Every thing is connected to everything else."

Global thinking reflected the holistic ideas embodied in the Vernadskian Biosphere, and Rachel Carson's and Arne Naess' idea of deep ecology. Thinking in wholes was crucial in being a global thinker, and as we will show, a citizen scientist (Fig. 25.2).

Fig. 25.2 Global Thinking Project home page, 1993–2002. GTP Archive available at http://global-thinking-project.org

The GTP Environmental Projects

Youth activism and citizen science were integral to the Global Thinking Project experience. Typically environmental programs teach students *about* the environment, whereas the GTP embraced the concept that Michel (1996) describes as "education *for* the environment" which evolved from conservation education. This concept of environmental education expanded to include environmental protection, and the role that citizens take (individually and collectively) in the solution of environmental problems. Each project in the GTP is designed to lead to youth activism and citizen science activity.

There are four stages in the GTP cycle of learning. The four stages include

- Stage 1: Eliciting prior knowledge and experiences
- Stage 2: Exploring a global environmental problems
- Stage 3: Propose explanations and solutions to an environmental problem
- Stage 4: Take-action on an environmental question posed by the students (Hassard and Weisberg 1999).[17]

Project Hello was designed to help students explore their initial ideas of global thinking, and understand how to use the Internet to communicate with other students or a community of practice. Project Green Classroom (http://global-thinking-project.org/green) is designed so that students rate the environmental quality of their own classroom, take action to improve the condition, and share their findings with other schools. Project Clean Air (http://global-thinking-project.org/ozone) was the first of a series of environmental problems that students investigate through using inquiry-based pedagogies. Other investigations included Project Solid Waste, Project Water Watch (http://global-thinking-project.org/water), and Project Soil.

During the month of April, Project Earthmonth (to coincide with Earthday) was designed to be an open-ended project that encouraged students to identify an important environmental topic, design investigations, and take action. Students created projects during Earthmonth that included persuasion (convincing others that a suggested course of action is needed), political action (putting pressure on political or governmental and/or individuals in an effort to influence environmental action) and eco-management (taking action to maintain an environment or to improve a weakened environment.

Communities of Practice

During the winter and spring of 1990, 11 schools (5 Soviet and 6 American) participated in the first Global Thinking Project field test. A second field test was conducted during the 1990–1991 school year involving the same schools. The project conducted an evaluation study, had experts in science education, curriculum and environmental science evaluate and make recommendations concerning the project

Table 25.3 Environmental projects by phase in the global thinking project curriculum

Phase I	Phase II	Phase III
Establishing the global thinking community	**Collaborating globally in environmental projects**	**Thinking locally: Acting globally**
September and October	December–February	March–May
Project hello	Choose one from:	Project earthmonth
Project green classroom	Project solid waste	
Project clean air	Project water watch	Project evaluation
	Project soil	

materials, and held a meeting among teachers, scientists and science educators to make suggestions for change (Hassard and Weisberg 1992). The results of these first efforts to link American and Russian students led to the development of the present Global Thinking Project curriculum framework (Tables 25.3, 25.4).

Cross-Cultural Student Activism: 1995–1998

Although the GTP had fostered student exchanges between American and Russian schools, only a few schools were able to fund exchanges. In 1995, the GTP received the first of three grants from the United States Information Agency to support the exchange of students and teachers between the U.S. and Russia. In the GTP-Georgia/Russia exchange project, 150 high school students from Georgia (USA) and 150 high school students from Russia participated in three, yearlong programs of collaborative environmental research and cross-cultural exchange.[18] In the research that we conducted on the exchanges, we found that environmental science education must stress not only cognitive but also affective outcomes necessary for the assumption of planetary stewardship (Hassard and Weisberg 1999).

The goal of the exchange program was to promote communication and understanding between students in Georgia (USA) and Russia through collaborative study, discussion, and action on local environmental problems (Robinson 1996). Through collaboration at a distance using the Internet, and through face-to-face meetings, we hoped to enhance the American and Russian students' awareness of each others' needs, difficulties and points of view as they worked side-by-side in each other's communities on environmental science action projects of mutual concern. The student exchanges have enabled us to work along side students and teachers in both countries as they investigated questions about the local environment, to begin to examine students' emerging ideas about what it means to 'think globally,' and to reflect upon the importance of cross-cultural exchanges in the development of this kind of thinking.

In all, 50 Russian and 50 American students from Georgia (aged 14–16) and a team of three teachers per school participated in a 1-year program marked by two, 3-week exchanges during each of the 1995–1996, 1996–1997, and 1997–1998 school years. Georgia and Russian schools were selected which represented a

Table 25.4 Dates, location, events & comments of American and Soviet delegation exchanges, conferences, field tests of the GTP 1989–1995

Date	Location	Event	Comments
July, 1990	Dahlonega, Georgia	Writing conference	First version of global thinking teacher's guide
October, 1990	Atlanta	Field test	Curriculum and telecommunications system used in two schools
December 1990	Moscow, Leningrad	Delegation of teachers and researchers	Transported Macintosh computers and installed them in five Soviet schools; established telecommunications.
February–May 1991	Atlanta, NW Georgia, Pittsburgh, Moscow & Leningrad	Online field test of global thinking project	Five American and five Soviet schools field test curriculum in their schools
May 1991	Moscow, Leningrad	Meetings with five Soviet field test schools	Feedback and evaluation
August 1991	Prague	3rd international conference on telecommunications	GTP represented at conference; 50 Soviets in attendance; Attempted coup in Russia
October 1991	Atlanta	Delegation of 16 Russian educators	Retreat among all GTP pilot teachers; GTP conference at Georgia State University
October 1991–April 1992	Atlanta, NW Georgia, Pittsburgh, Moscow, Leningrad	2nd field test of GTP	10 schools
May 1992	Atlanta	GTP Advisory Board Meeting	Recommendations for revision to GTP curriculum
October 1992	Atlanta	Global Summit '92	3-day conference for all 52 Georgia pilot teachers and students from Georgia, Russia, and Australia
October 1992–May 1993	Australia, Georgia, Russia, and Spain	Field test of the GTP	30 schools; EcoNet telecommunications
February 1993	Moscow, St. Petersburg, Yaroslavl	13 American pilot teachers join with Russian pilot teachers	Conferences held in each city
July 1993	Simpsonwood Conference Center, Norcross, GA	First annual GTP teacher leadership conference	22 teachers from Australia, Russia, Spain and US

(continued)

Table 25.4 (continued)

Date	Location	Event	Comments
September 1993–May 1994	Australia, New Zealand, Russia, Spain, UK and US	Field test of the GTP in 43 schools	Schools organized into four communities of practice
November 1993	Georgia State University	Symposium on Research on GTP	Results published by the GTP
July 1994	Simpsonwood Conference Center, Norcross, GA	Second annual GTP teacher leadership conference	30 teachers from Australia, Czech Republic, Russia, Spain and US
September 1994–June 1995	Australia, Czech Republic, New Zealand, Russia, Spain, UK and US	Field Test of GTP in 50 schools	Schools organized into five communities of practice

variety of geographical sites in their respective territories. The Georgia schools represented Metropolitan Atlanta, rural Georgia, and the coastal plain. The Russian schools represented five distinct sites including the small town of Pushchino-on-Oka, the Golden Ring town of Yaroslavl, Moscow, St. Petersburg, and the industrial complex in Chelyabinsk in the Ural Mountains (McIlveene 1996). The exchange program was built on an ongoing program of collaborative environmental science study, Internet activity, and teacher enhancement.

The GTP Georgia/Russia Exchange Program

Phase I. Teacher Leadership Institute

The Leadership Institute was an academic experience for educators focused on content of environmental science, philosophy, the pedagogy of cooperative learning, and intensive instruction on using computer technology and the Internet. Teams of Russian and American teachers developed ‘mini-proposals’ outlining elements of their collaboration prior to the exchanges, as well as specific environmental science topics that would be investigated during the Outbound (to Russia) and Inbound (to Georgia) phases of the exchange. Teachers from Australia, the Czech Republic and Spain attended these institutes.

Phase II. Internet Activity

From October through February the ten schools in the exchange used the Internet to establish e-mail links among the students. Schools began with an investigation looking into five different environmental components of their classrooms by participating in the GTP project how green is your classroom? (http://global-thinking-project.org/green/) They used the Internet to send data using the Web, and retrieved and analyzed other schools' data posted on the Web site. Teachers and students reported that the Internet activity was very lively. A number of American and Russian students had access to the Internet from home, facilitating the communication among GTP participants.

Phase III. The Exchanges

> We believe that nature is very fragile system—a chain that consists of many items (if you destroy one item, the chain would be broken). Most environmental problems stem from overpopulation. We believe that education (knowledge and awareness), participating (recycle, conserve, and organize), responsible attitude (every individual does their part) are needed. (Middle School Students from Pushchino, Russia and Lafayette, Georgia, Norcross, Georgia, March, 1996)

During the Outbound and Inbound exchanges, students and teachers lived for 21 days in their counterparts' homes, participated in an academic program at their respective schools, conducted joint environmental research activities, and visited significant cultural sites in each other's cities. Using monitoring equipment, students collected and analyzed data on air and water quality, sent e-mail reports to the GTP discussion group, and participated in videoconferences.

While on the exchanges, students were able to collect data on a number of environmental problems. Choice of students' environmental projects was made by the students themselves through collaboration among Russians and Americans and based on environmental problems indigenous to the students' city or town. Table 25.5, below, gives a summary of the students environmental projects conducted in Russia (Table 25.6).

Each exchange culminated with an environmental 'Summit,' during which each school pair was responsible for presenting its views on some aspect of an environmental problem or controversial issue. These summits were held in Moscow, St. Petersburg and Atlanta (at Simpsonwood Conference Center, Norcross, and Georgia State University).

Some of these reports involved the presentation and interpretation of student experimental data, while others required students to research different aspects of a pressing environmental public policy issue. For example, during the April 1997 'Summit', held in Georgia, students debated solutions the pollution of the Chattahoochee River in Atlanta from the perspective of homeowners, elected officials, land developers, scientists, and public policy experts.

The last summit of the GTP 3-year exchange project was held at Experimental-Gymnasium 710 in Moscow, Russia in April 1998. School pairs presented interdisciplinary interpretations of the ecological and historical significance of the Oka, Volga, Moscow and Neva Rivers in a variety of forms including poetry, singing, dramatic plays, and technical/scientific reports.

Table 25.5 Dates, location, events and comments of the global thinking project student and teacher exchanges, 1995–1998

Date	Location	Event	Comments
May 1995–June 1996	US Georgia and Russia	1st GTP student and teacher exchange[a]	Funded by USIA; 100 students and 30 teachers
July 1995	Simpsonwood Conference Center, Norcross, Georgia	3rd annual GTP leadership conference	Teachers from Australia, Spain, Russia and US
November 1995	Moscow, St. Petersburg, Pushchino, Yaroslavl	GTP outbound exchange	50 American students, 15 teachers, and 10 researchers for 21 days in Russia
February 1996	Dunwoody, Savannah, Conyers, Lafayette, Flintstone	GTP inbound exchange	50 Russian students, and 10 teachers, principals, and researchers to US for 21 days
September 1996–May 1997	US Georgia and Russia	2nd GTP student and teacher exchange	Funded by USIA; 100 students and 30 teachers
		Inbound: October 1996	
		Outbound: February 1998	
September 1997–May 1998	US Georgia and Russia	3rd GTP student and teacher exchange	Funded by USIA; 100 students and 30 teachers
		Inbound: October 1997	
		Outbound March 1998	
July 1998	Washington, DC	Final report to USIA[b]	

[a]Narrative of the GTP USIA proposal for funding for 1997 0–1998: http://www2.gsu.edu/~mstjrh/usia98proposal.html
[b]Narrative of GTP-Georgia/Russia Exchange Project 1996–1997 Final Report: http://www2.gsu.edu/~mstjrh/finalreport97.html

GTP Student Activists and Citizen Scientists

Education for ‘global thinking’ is not unlike education for ‘global citizenship’ or education for a ‘global perspective’; two other constructs which have been widely written about during the last two decades. All three emphasize the importance of perspective taking, which might be viewed as ‘learning to see problems and issues through the eyes and minds of others’ (Ramler 1991). Perspective taking incorporates elements of both empathy, being able to put oneself in another’s shoes, and intercultural competence, and being able to function within the norms and expectations of another culture (Lambert 1994). Global citizenship also includes

Table 25.6 Research problem, method, data collected, and results for school pairs on the outbound exchange in Russia, November 1995

School pair	Research problem	Methods	Data	Results
Bartlett Middle School – St. Petersburg 157	How does the quality of the water compare at different sites?	Tested water at different sites	Values for salinity, pH, dissolved oxygen	County water sites were cleaner than sites in city
Dunwoody High School – Moscow 710	What is the quality of the air in Moscow?	Monitored air daily at different sites in Moscow	Values for temperature, particulates, ozone, wind speed and direction	Community needs to work together to make the air cleaner
Lafayette Middle School – Pushchino 2	What is the quality of the air in Pushchino?	Monitored the air at different times daily for a week	Values for temperature, particulates, ozone, wind speed and direction	Air in Pushchino was very clean
Ridgeland Middle School – Moscow 91	What is the quality of the air in Moscow?	Monitored the air at different times daily for a week	Values for temperature, particulates, ozone, wind speed and direction	Not enough data to make conclusion
Salem High School – Yaroslavl 22	How does the quality of the air in Yaroslavl compare with the air quality in St. Petersburg?	Monitored the air in both cities at the same time, twice a day	Values for temperature, particulates, ozone, wind speed and direction	Ozone levels were higher in Yaroslavl than in St. Petersburg

recognition of the interdependence of global systems (Tye 1991; Merryfield 1997), and of the responsibility of individuals as well as nation-states to be actors on the world stage (Rasmussen 1998).

What 'global thinking' adds to these ideas is the notion of the citizen-scientist. A citizen-scientist is one who combines the processes and habits of mind of science (American Association for the Advancement of Science 1989) with public decision-making. As citizen-scientist, the student learns to monitor the environment, search for and collect data and information, and analyze and draw conclusions, as a citizen the student learns the importance of individual responsibility and acquire skills for democratic action taking (Dunkerly-Kolb and Hassard 1997).

Education for global citizenship therefore addresses the development of scientific understandings of global problems, enlargement of students' perspectives to include other nations and cultures, and the enhancement of student's sense of efficacy with respect to the environment. The GTP has been based on the notion that learning experiences that promote the development of scientific habits of mind, and involve students in real world collaboration with others to address environmental problems of local concern will promote the growth of global perspectives in students (Hassard and Weisberg 1999).

When students were asked to define citizen scientist after the exchanges, students characterized them as individuals who:

- Study the environment ('a person who conducts different experiments')
- Knows about the environment ('a person who knows a lot about the environment')
- Cares about the environment ('a person who cares about the environment')
- Takes action to improve the environment ('a person who uses their environmental knowledge in order make decisions which will have positive effects')

These students recognized that not only must citizens have knowledge and skills, but they must also have the disposition to care about and care for the environment. Thus, 'citizen scientists' are also activists who are motivated to apply their knowledge and skills to concrete efforts to improve their local environments (Kolb and Hassard 1997).

The Fruits of Cross-Cultural Collaboration

The Global Thinking Project was a grassroots effort that owed its existence to a small group of American and Russian classroom teachers and university professors who were interested in searching for ways to collaborate with each other in face-to-face and online environments. It began on the Russian train, the Tolstoy, and evolved into a cross-cultural collaboration that included curriculum development, implementation of project-based curriculum, teacher enhancement, and student exchanges. The effort became known as the Global Thinking Project, which established one of the first global telecommunications networks between America and Russia, but soon extended to other countries including Australia, Argentina, Czech Republic, and Spain (Hassard and Cross 1993). Although starting from unofficial visits to the U.S.S.R., the GTP became a viable curriculum project in schools in these and other countries.

The work that is described here was based on theoretical principles drawn from humanistic psychology, the learning sciences, cross-cultural studies, and new and emerging technologies. In particular, American and Soviet teachers and researchers engaged in deep discussions of humanistic psychology, especially the ideas of Abraham Maslow and Carl Rogers. Constructivist ideas of Piaget, von Glasersfeld and Vygotsky were also important when we held discussions about curriculum development and learning theory and classroom instruction.

In the end, a humanistic paradigm or model was the basis for the nature of our exchanges, the structure of the curriculum that was designed, and teacher enhancement seminars conducted by Russian and American educators. The GTP was based on a humanistic model (Hassard 1997) that includes the following principles:

- Innovative-flexible thinking
- Cooperative learning—students work collaboratively in small teams to think and take action together
- Interdependence—a synergic system is established in groups within a classroom, and within global communities of practice.

- Right-to-choose—students are involved in choice-making including problem and topic selection, as well as solutions; reflects the action processes of grass-roots organizations
- A new literacy insofar as "knowledge" relates to human needs, the needs of the environment and the social needs of the Earth's population and other living species
- Emphasis on anticipation and participation; on inquiry, learning how to learn, and how to ask questions
- Learning encourages creative thinking, and is holistic and intuitive

The Global Thinking Project was dedicated to helping us become citizen scientists (ecological citizens), fighters for the environment, scholars as well as activists. It was a project deeply rooted in systems theory that is based on the idea that the whole is greater than the sum of the parts—that we must integrate knowledge to make competent decisions. In their experiences in the exchange students and teachers learned to think in terms of the whole system of Earth (Biosphere), yet at the same time learned the importance of knowing their sense of place in their own local environment.

Notes

1. Citizen diplomacy is informal diplomacy, in which non-officials engage in dialogue to resolve conflicts and solve problems. Joseph Montville, a former US Foreign Service Officer in an article.
2. This discussion was not limited to Americans and Russians. The project expanded to other countries, including Australia, the Czech Republic and Spain. At teacher institutes in Atlanta teachers from these countries explored global environmental science issues.
3. For the first 10 years of this project, participants funded the exchanges. It wasn't until 1992 that the project received funding. The participants, mostly teachers, were partners in this grass-roots experiment and as a result were able to chart its goals and aspirations with limited influence from outside agencies. However, we have to point out that we were eager to find financial support to involve more people, especially middle and high school students, and from 1992 to 2002 we received funding from the United States Information Agency, the Environmental Protection Agency, the Eisenhower Higher Education Grant Program, Georgia State University, the Russian Academy of Education, Georgia Department of Education, schools in Georgia and Russia.
4. Fran Macy, Director of the AHP, and a dedicated environmentalist, energy activist and citizen diplomat, led the delegation. Fran did groundbreaking work with hundreds of activists in Russia, Ukraine, Georgia and Kazakhstan. He initiated scores of delegation and exchanges between Americans and their counterparts in the former Soviet Union, especially in the areas of psychology,

environment, and citizen action. Indeed, in 1961, just after receiving his master's degree from Harvard in Slavic studies, he led the first ever citizen diplomatic mission to the USSR where Soviet citizens met Americans for the first time. From 1964 to 1972, he served as Deputy Director of the Peace Corp in India and Director in all of Africa. He founded the Earth Island Institute's Center for Safe Energy, and the Director of the Institute for Deep Ecology. Fran Macy became my mentor and teacher, and helped me as I sought to develop an education component of the AHP exchange program. A Russian speaker, scholar, and humanist, Fran Macy was the inspiration for much of work that would follow in educator and student exchanges and global environmental activism.

5. The description of this first meeting was repeated at every institute and school we visited. After the formal introductions or lectures, participants to eager to break into smaller groups to talk, exchange ideas and papers, and make arrangements for even more informal get-togethers in our guests homes for dinner and drinks, and more talk.
6. From 1983 on annual exchanges occurred through 2001. In some years there were multiple delegations in Russia.
7. Nearly a dozen formal agreements were reached between North American and Soviet (Russian) institutions and even more among individuals and small groups.
8. Tom Greening, Editor of the Journal of Humanistic Psychology was a member of the first delegation, and facilitated many publications by Russians in the Journal of Humanistic Psychology. On the Russian side, Alexei Matushkin, editor of Voprosi Psikhologii, published several articles in that journal. Scores of articles have been written by American and Russian psychologists, researchers and teachers, and the Global Thinking Project Internet-based environmental science program was published in English, Russian, Spanish, Catalan, and Czech. Goodyear published the final program (Hassard and Weisberg 1999a).
9. Individual Russian psychologists and educators were received by the AHP, and from 1988, ten delegations of Russian teachers and researchers, and five exchanges of middle and high school students were supported by work at Georgia State University and Agnes Scott College.
10. These meetings were opportunities to meet with people whose lives were affected by human rights violations and emigration policies of the Soviet system.
11. Primary source materials documenting the US-USSR citizen diplomacy of the 1980s has been archived by Anya Kucharev at the Hoover Institution at Stanford University in cooperation with InterAct's Citizen Diplomacy Archive Project. http://www.digitalcitizen.tv/archives/world-projects/
12. The website for the institute is http://www.iskran.ru/engl/index-en.html
13. To make a phone call to the USSR during this period, it was necessary to go through an international telephone operator in New York, who then placed the call for you. There were limited phone lines available, so when you did get through you were simply amazed that you were talking to your friend in Moscow.

14. Dr. Julie Weisberg was the co-director of the Global Thinking Project, and was instrumental in writing, collaborating, and providing teacher education for American and Russian teachers. She co-authored the GTP curriculum materials, proposals to funding agencies, and research articles on the GTP. Her work on the project was revered by American and Russian educators. Dr. Weisberg is Associate Dean of the School of Education, Georgia Gwinnett College.
15. To solve the Director's office-classroom distance problem, I brought 1,000 ft of telephone line and used it in Schools 157 and 239 in St. Petersburg.
16. In the early stages of the project, schools from Australia, Barcelona, Spain, and the Czech Republic worked with us to formulate the curriculum.
17. More information about the GTP curriculum and project is available at http://global-thinking-project.org
18. Funding was received from the United States Information Agency (USIA) for the 3-year GTP-Georgia/Russia Exchange Project.

References

Aikenhead, G. S. (2005). *Science education for everyday life: Evidence-based practice*. New York: Teachers College Press.

Berners-Lee, T. (1999). *Weaving the web*. New York: HarperCollins.

Botkin, J., Malitza, M., & Emandjra, M. (1979). *No limits to learning*. Oxford: Pergamon Press Ltd.

Carson, R. (1962). *Silent spring*. Boston: Houghton Mifflin.

Davidson, W., & Montville, J. V (1981, Winter). Foreign policy according to Freud. *Foreign Policy, 45*, 1981–1982.

DeVall, B., & Sessions, G. (1985). *Deep ecology*. Layton: Gibbs Smith.

Dewey, J. (1938). *Experience & education*. New York: Kappa Delta Pi.

Dos Santos, W. L. P. (2008). Scientific literacy: A Freirean perspective as a radical view of humanistic science education. *Science Education, 93*(2), 361–382.

Dunkerly-Kolb, S., & Hassard, J. (1997). Citizen scientists: Student experiences in the GTP Georgia/Russia exchange project. *Journal of Science Education and Technology, 6*, 315–321.

Giroux, H. A. (2011). *On critical pedagogy*. New York: The Continuum International Publishing Group.

Hassard, J. (1990). The AHP Soviet exchange project: 1983–1990 and beyond. *Journal of Humanistic Psychology, 30*(3), 6–51.

Hassard, J. (1997). Teaching students to think globally. *Journal of Humanistic Psychology, 37*(1), 24–63.

Hassard, J., & Cross, R. T. (1993). The global thinking project: Shared concerns and shared experiences across the continents. *Australian Science Teachers Journal, 39*(3), 18–23.

Hassard, J., & Kolb, S. (1996, April 27). *Citizen scientists: Student experiences in the GT--Georgia/Russia exchange project*. Paper presented the conference on Telecommunications and Education, Callus, Spain.

Hassard, J., & Weisberg, J. (1992). The global thinking project. *The Science Teacher, 59*(4), 42–47.

Hassard, J., & Weisberg, J. (1993). *Global thinking teacher's resource guide*. Atlanta: Global Thinking Project. Retrieved from ERIC database (ED363521).

Hassard, J., & Weisberg, J. (1999a). *Environmental science on the net: Global thinking project*. Chicago: Good Year Books.

Hassard, J., & Weisberg, J. (1999b). The emergence of global thinking among American and Russian youth as a contribution to public understanding. *International Journal of Science Education, 21*(7), 731–743.

Leonard, G. (1988). *Walking on the edge of the world*. Boston: Houghton Mifflin.

McIlveene, M. (1996). *A comparison of Russian and American students' concerns about environmental issues: Implications for environmental education curriculum*. Unpublished doctoral dissertation, Georgia State University, Atlanta, GA.

Merryfield, M. M. (1997). A framework for teacher education in global perspectives. In M. M. Merryfield, E. Jarchow, & S. Pickert (Eds.), *Preparing teachers to teach global perspectives: A handbook for teacher educators* (pp. 1–24). Thousand Oaks: Corwin Press.

Michel, R. (1996). *Environmental education: A study of how it is influenced and informed by the concepts of environmentalism*. Doctoral dissertation, La Trobe University, Melbourne, Australia.

Naess, A. (1989). *Ecology, community and lifestyle*. Cambridge: Cambridge University Press.

Ramler, S. (1991). Global education for the 21st century. *Educational Leadership, 48*, 44–46.

Rasmussen, K. (1998). *Curriculum update*. Washington, DC: Association for Supervision and Curriculum Development.

Richmond, Y., & Hawkins, R. (1988). *U.S.-Soviet exchange: The next thirty years*. Washington, DC: The Eisenhower World Affairs Institute.

Robinson, W. (1996). *The effects of the global thinking project on middle school students' attitudes toward the environment*. Unpublished doctoral dissertation, Georgia State University, Atlanta, GA.

Rogers, C. R. (1961). *On becoming a person: A therapist's view of psychotherapy*. Boston: Houghton Mifflin.

Rogers, C. R. (1969). *Freedom to learn*. Columbus: Charles E. Merrill Publishing Co.

Springer, J. L. (1993). *A principal's perspective of the global thinking project at Dunwoody high school: Implications for administrators.* Unpublished doctoral dissertation, The Union Institute, Cincinnati, OH.

Tye, K. A. (1991). Conclusion: A look to the future. In K. A. Tye (Ed.), *Global education: From thought to action* (pp. 157–178). Alexandria: Association for Supervision and Curriculum Development.

Vernadsky, V. I. (1926). *The biosphere*. New York: Springer.

Vershlovsky, S. G., & Kulyutkin, Y. N. (1989). *World, profession and me: Assessing teachers' ideas and attitudes on world ecology and global relations*. Leningrad: Institute for Adult Education, The Academy of Pedagogical Sciences.

Jack Hassard is emeritus professor of science education, Georgia State University. After completing his Ph.D. at The Ohio State University, he was professor of science education at GSU from 1969 to 2003. While at GSU he did visiting professorships at Florida State University, The Far West Lab, The University of Hawaii and the University of Vermont. At GSU he was coordinator of science education, and co-developer of the TEEMS clinically-based constructivist teacher education program. In 1981 he made his first trip the Soviet Union, and for the next 20 years worked with American and Russian teachers, administrators, and researchers to create the Global Thinking Project. He is an active writer, and authors a progressive science education blog at http://artofteachingscience.org.

Chapter 26
Seeing the Forest for the Trees! Conservation and Activism Through Socioscientific Issues

Karey Burek and Dana L. Zeidler

There is a divide between what students are being taught within the classroom and what they experience in the real world (National Research Council 1996, 2009). Schooling is necessary insufficient enough to support lifelong science literacy, emphasizing the necessity of alternative learning environments and approaches for learning about science (Falk and Heimlich 2009; Falk et al. 2007). In England and Switzerland, educators are beginning to bring controversial environmental topics into the science classroom that afford students the opportunity to discuss issues-based science, connecting what they are learning to real world issues such as nuclear power and rainforest deforestation (Rickinson and Lundholm 2008). When students engage with these issues they might also take a larger role within conservation.

We explore the importance of utilizing socioscientific issues (SSI) with environmental topics in science classrooms and outdoor environments. We argue for the importance of creating critically thinking students at a young age who are exposed to real world science and internalize the principles of conservation, as well as and possibly inform decisions about environmental activism.

SSI allow students to view science realistically by integrating attitudes and ethics in making judgments about scientific information. The SSI framework makes use of meaningful discussions, formal debates and argumentative thinking as an important part in preparing students to use information in familiar and personally relevant contexts (Sadler and Donnelly 2006; Zeidler et al. 2009). Students exposed to the use

K. Burek (✉) • D.L. Zeidler
Department of Teaching and Learning, College of Education, University of South Florida, EDU105, Tampa, FL 33620-5650, USA
e-mail: beanwriting@aol.com; zeidler@usf.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_26

of personally meaningful discussions have the opportunity to learn that decision-making is complex. Consider how stem cell research, water shortages and habitat loss are all involved with solving scientific issues that prepare students to engage in argumentative thinking (Erduran et al. 2004; Simonneaux 2001).

Socioscientific issues coupled with highly contextual educational experiences have the ability to create scientifically literate citizens by enhancing students' understanding of how science works outside of the classroom. Zeidler and Sadler (2011) place particular emphasis on the quality of educative experiences that enhance people's quality of life. It is also possible that the pairing of conservation issues and SSI will help to cultivate students into informed and scientifically literate citizens (Burek and Callahan 2005; Burek et al. 2004). If the goal of scientific literacy is for students to understand complex scientific issues and make decisions based on their knowledge, then it is imperative that they are exposed to SSI embedded within these authentic contexts or learning environments (Zeidler and Sadler 2011; Zeidler et al. 2006; Dolan and Zeidler 2009). An SSI curriculum incorporates real world, ethically and morally debatable scenarios that are drawn from local communities that citizens deal with on a daily basis. The three main characteristics of the SSI movement are that issues are controversial in nature, open-ended, and include moral or ethical reasoning (Zeidler and Sadler 2008a; Zeidler et al. 2005). Components of this pedagogical and curricular approach provide students with opportunities to think critically and engage in discussions with students who may think differently. SSI is a multi-faceted tool needed to create critical thinking and meaningful dialogue.

Thinking About Conservation at an Early Age

It is important for children to begin the development of critical thinking at a young age, while focusing on conservation. Research has shown that adults who are more aware and involved with environmental issues were exposed to meaningful learning in the environment or alternative ways of learning as a youth (Rennie and Williams 2006; Falk and Heimlich 2009). Few studies have been done specifically focusing on using socioscientific issues as a base for the curriculum in children at the elementary level (Dolan et al. 2009).

Kellert (2009) notes that during middle childhood, defined as between the ages of 5–12 years of age, an impression of the natural world lasting only a few seconds may be imprinted for life. Learning to connect with the surrounding environment is key to this development at an early age. By the ages of 13–17 there is a more robust development of ethical reasoning and conceptual understanding about the natural world. If children do not have natural experiences at an early age, this development the later years may be incomplete (Kellert 2009).

Unfortunately, there are few programs that specifically cater to younger learners within free-choice learning facilities such as nature centers that may not have the resources or budget to cater to younger learners in a contextually rich manner. Those programs that do can orient young children toward a positive connection with science and the environment surrounding them. Several examples follow.

WINGS (Winning Investigative Network for Great Science) located in Florida, is a program designed to inspire adolescent students' long-term interest, understanding and involvement in science through the study of butterflies (Dunckel et al. 2008). This program focuses on student's ages 9–13 and promotes understanding of scientific inquiry through direct engagement with science, and by doing science outside of the classroom. One activity called "sort it out" has the students break into smaller groups and organize photos of butterflies into categories. Students discuss their ideas with one another in a small group setting and then share their views and hear how other groups came to their decisions and what their thought process was for the butterfly categories. This program engages students in citizen science, by offering students the opportunity to be researchers in the field, identifying butterfly species that are present in local counties. They then can deduce from their research what butterfly species are missing and discuss ideas as to why those species are missing in relation to environmental consequences.

Splash, Flash, Crank, Slide, Alive Tour at a Discovery Center in Tennessee provides inquiry based science activities for students PreK-2 that include small group problem solving (Ervin and Sadler 2008). While students get acquainted with splashing around a water table highlighting water cycles, students are questioned about pollution problems and conservation. They also are able to create waves and experiment with small boats as some of the few hands-on activities they do while in smaller groups, helping students develop problem-solving skills. The limitation to this project is the lack of follow-up where educators miss the opportunity to delve deeper into investigating and facilitating how younger students think about issues connected to pollution and conservation. This is an example where SSI for science experiences occurring outside of schools could be used to enhance students' ability to communicate, think critically, and make choices about issues dealing with the environment (Burek 2012).

Norwegian Framework Plan for the Content and Tasks of Kindergartens emphasizes democratic values by recognizing the equal worth of all humans, respect for life (human, animal and nature) justice, truth and honesty (Norwegian Ministry of Education and Research 2011). Students are taught in a nurturing environment that promotes their "zest" for creativity, problem solving and their innate sense of wonder. Research conducted in Norway suggests that the best way to achieve these democratic values is through learning situations in the outdoors because it allows for positive development through participation with other children due to the fact they are learning to cultivate relationships with living things outdoors, which transfers over to compassion for humanity (Aasen et al. 2009).

There is a growing need to connect SSI with the health of the environment and put them into a context with larger engrossing societal concerns that children as well as adults are faced with, such as access to clean drinking water, human health and safety and issues of social justice. The necessity is to better educate students about their place in the world and highlight the relationships they have with their local community and how future decisions influence the health of the earth

(Mueller and Zeidler 2010). If collectively we are pushing toward a society of democratically minded and environmentally literate citizens, students need to have a fundamental understanding of the systems of the world, both living and non-living, along with the analytical skills needed to weigh scientific evidence and policy choices. Brewer (2001) highlights the notion that one of the most important responsibilities educators have is helping students learn to make defensible judgments about scientific problems. The "No Child Left Inside" initiative is a growing movement that promotes environmental literacy by reconnecting children with nature and has been supported by new national laws being developed to set forth guidelines to enhance environmental literacy, bridging the gap between what is learned in the classroom and what is experienced outside within communities on a day to day basis (Louv 2007; Environmental Literacy Council 2002).

Towards the Integration of Free-Choice Learning and SSI

SSI and free-choice learning experiences have positive effects on students' understanding of environmental issues and their critical thinking skills. To this end, a brief introduction to the framework guiding SSI will precede arguments providing evidence that the use of a socioscientific-based curriculum would be beneficial to elementary school students. There are important links made to free-choice learning, argumentation and discourse and critical thinking that unite these themes in a proactive environmental approach to science teaching.

Free-Choice Science Education

While classrooms can provide an initial contextual framework for scientific conversations (Kelly 2000), free-choice learning experiences allow students to further explore environmental issues in an atmosphere that is conducive to hands-on learning (Dierking and Falk 2004). Many educators view these experiences as important for students, but their integration into elementary classroom curricula and contexts is difficult and often times it is this lack of cohesion that creates the loss of meaningful learning opportunities (Dewitt and Storksdieck 2008; Kisiel 2006). Teachers tend to maintain their task-oriented focus by having students fill out worksheets while taking field trips, or worksheets as a follow-up activity once back in the classroom because of the need for accountability (Ratcliffe and Grace 2003). While these experiences can result in learning for some students, it hinders the learning of others by reducing the opportunities to work in groups, foster creative thinking and share ideas. With the increasing emphasis on standardized testing, and with teachers and principals being held accountable for their schools' performance, the value of out-of-school learning experiences has become scrutinized in light of testing priorities (Dewitt and Storksdieck 2008).

Free-choice learning provides opportunities for students to grasp how science connects with their everyday lives by participating in educational experiences that are often situated outside of the schools (Evans 2005; Miller 2004). Gerber et al. (2001) suggest that students who participate in few free-choice learning opportunities such as inquiry based experiences have less developed schemata with which to relate their science instruction than those exposed to numerous free-choice learning opportunities that are non-inquiry based. According to the National Foundation for Educational Research, learning in outdoor environments can have varying positive impacts on cognitive development, affective, interpersonal, social and physical developments (Dillon 2002; Dillon et al. 2005). In Britain, Scotland and Wales, the development of Forest School is becoming an exceedingly popular to incorporate regular contact with woodlands or outdoor spaces for students. Forest School allows students to become more familiar with the open and green spaces, creating opportunities to learn and gain experience outside of the classroom (O'Brien 2009). This program has shown gains in conceptual understanding of scientific content because a theory taught in the classroom is made explicit by experiencing it in the outdoor environment, resulting in gains in student confidence and comprehension (O'Brien 2009). However, the Forest School has not gained popularity continentally and has a ways to go before impacting schools elsewhere.

Free-choice facilities such as zoos, aquariums, museums and science centers are striving to become centers for conservation education and environmental awareness by conducting scientific research, fostering dialogue about civic responsibilities, and offering engaging experiences to visitors with the hope of influencing the way people understand, care about, and participate in activities that help protect our global community (Dierking 2004). Community-based science education facilities have the potential to make a major contribution to its visitors' learning about science by providing information and offering opportunities for visitors to gain a clearer understanding about science as a process of building explanations about natural phenomena in ways that are contextualized by the general public of the prevailing culture. This type of understanding emphasizes more than knowing facts, it means knowing science as a way to think critically about information and using it to make rational decisions (Henriksen and Froyland 2000; Rennie and Williams 2006).

Science environments and learning experiences outside school play a crucial role in the interests and involvement of young children, hopefully whetting their appetite for environmental activism. The National Research Council (NRC) (2009) states that there is abundant evidence that informal programs and settings and even the experiences of everyday life such as walking in a park contribute to people's knowledge and overall interest in science. Learning in informal environments is diverse and has a broad range of intended outcomes. Outcomes can range from inspiring emotional reactions, reframing ideas, introducing new concepts, to communicating the social and personal value of science, promoting deep experiences of natural phenomena and showcasing cutting edge scientific development (NRC 2009). Using this knowledge and interest to create individuals ready to be environmental activists or participate in citizen science research programs is continuing to progress. What we have seen is the impact that free-choice learning experiences have focusing on cognitive learning outcomes that broaden knowledge beyond just facts and include process skills and awareness of community (Storksdieck et al. 2007).

When attempting to blend a free-choice learning experience into classroom academia in order to expose students to alternative learning experiences, unless there is a focus on identifiable learning outcomes that can be applied to accountability tests, the experiences are not academically valued in a system that places sole emphasis of success on test scores. DeWitt and Storksdieck (2008) explain that certain experiences have more potential to help teachers maximize student learning than others and the programs that are developed and aligned with current curriculum goals in mind can be integrated seamlessly back into the classroom. The integration of free-choice learning experiences into a structured classroom still seems like a difficult task for teachers to take on in the world of testing scores and accountability practices.

Several principles gleaned from the literature are noted as part of life-long scientific learning. These principles include the idea that knowledge, practice and science learning commence early in life. Effective science education reflects the ways in which scientists actually work, acknowledging that scientific knowledge is continually changing and growing. Free-choice science education settings tend to evoke emotional responses and support direct experiences with phenomena, developing positive attitudes towards science (Falk and Heimlich 2009).

There are six strands of learning reflecting these ideas, that free-choice science educators believe should be incorporated in informal programs and facilities in order to ensure the highest quality of learning experiences offered to the community (NRC 2009, pp. 2–29) (Table 26.1 below identifies each strand of learning, highlighting the richness that can be enveloped into programs).

Children at elementary school level are absolutists by definition, believing that information or knowledge is something that exists separate from them, coming from outside sources (Kuhn 2007). This suggests that there is value in the inquiry and argumentation skills needed to be introduced at a young age, which allow students the opportunity to practice these modes of inquiry that will be necessary for a reflective life. Free-choice science experiences for children can set the stage for them to

Table 26.1 Strands for positively integrating free-choice learning

Strand 1	Experience excitement, interest and motivation to learn about phenomena in the natural and physical world
Strand 2	Come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science
Strand 3	Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world
Strand 4	Reflect on science as a way of knowing; on processes concepts and institutions of science and on their own process of learning about phenomena
Strand 5	Participate in scientific activities and learning practices of others, using scientific language and tools
Strand 6	Think about themselves as science learners and develop an identity as someone who knows about, uses and sometimes contributes to science

grow into environmentally conscious adults (Holzer et al. 1997). In the past, it was thought that elementary students that participated in free-choice experiences didn't retain information and would not be influenced by their experience. However, Falk (2009) explains that elementary students retain as much as older age groups, being able to describe feelings, experiences they have while on a field trip.

According to Main (2004), researchers in the environmental education field believe that conservation education should promote the understanding of basic ecological concepts and it should be fun and enjoyable and motivate participants to engage in a life-long process of learning about the natural world. It should also create a strong value system, which places importance on nature. However, formal educators need to understand the value of free-choice experiences that can be developed to ensure that students get the hands-on science opportunities that free-choice experiences provide. To affect the goal of conservation, education needs to reinforce values and beliefs that have a positive effect on nature and change values and beliefs that have a negative effect.

Dierking (2004), Falk and Heimlich (2009), claim that facilities such as zoos, aquariums, outdoor environmental education centers, museums and other science learning centers are striving to become centers for conservation by conducting scientific research with participants, fostering dialogue about civic responsibilities among individuals and to the planet, and offering engaging experiences with the hope of influencing the way people understand, care about, and participate in activities that help protect wildlife. Obviously, there is a need for more focused research, particularly research about the impact of such experiences upon visitors' deeply held beliefs and values about science and the translation of those types of beliefs into caring actions that protect the environment.

Socioscientific Issues

The open-ended nature of SSI allows students to think critically about issues with others who may hold opposing viewpoints (Sadler 2004b; Simonneaux 2008; Zeidler and Sadler 2008b). The SSI movement focuses on enabling students to understand how scientific issues and the decisions they make about those issues have moral and ethical outcomes. Extensive research has been conducted on the use of SSI within the science classroom to connect students to science issues that are occurring within the community at large, increasing their moral sensitivity, advancing reflective judgment and improving the understanding of science (Fowler et al. 2009; Lee et al. 2012; Zeidler et al. 2009, 2011). One of the few studies to examine how SSI can impact young children in free-choice science learning conditions, seeks to explore possible relationships between a socioscientific issues embedded curriculum and outcome variables addressing environmental attitude and knowledge, oral and written argumentation and critical thinking skills (Burek 2012). Students take part in an outdoor hike with the environmental education instructor on-site at the ecological preserve 1 day during the school year. The theme for this day-long excursion is focused on water and land conservation. The experience allows for a 6–7 h in-depth outdoor environmental exploration experience, giving students ample time to explore and be immersed in the local habitats.

In this research, the treatment classes are taught using a variety of SSI as the basis for learning content. Small group discussions and debates, hands-on activities during outdoor environmental units take place at the on-site preserve. The comparison group is not taught using SSI, small group discussions or debates or hands-on activities. However, they do participate in the in-depth informal outdoor experience at the preserve, lasting 6–7 h on one visit. Once the students return to the school, the conventional curriculum of physical science and erosion are taught using traditional methods of instruction such as worksheets, classroom presentations by the instructor and reading from the textbooks; the students are exposed to the methods of teaching that are teacher-focused and text-focused. The treatment group is taught using socioscientific issues, and small group discussions and debate.

Quantitative and qualitative methods are used to examine both within and between class differences as well as individual differences between the beginning and end of a semester of fourth grade elementary school. Results indicate that the SSI approach assist students in developing their critical thinking skills while also providing students the opportunity to be exposed to and participate in local and global environmental issues influencing the community at large. Statistical significance is found between groups in revealing a more positive attitude toward the environment for students in the treatment group. Qualitative interviews also indicate that some students in the treatment group provide more advanced argumentation skills by articulating alternate viewpoints on controversial environmental topics.

SSI make it possible for students to see that conservation issues are multidimensional and easily discussed from several viewpoints. Others also suggest, as learned by the Burek and Zeidler study above, that this may assist in developing their critical thinking skills ultimately leading to the goal of scientific literacy, which requires critical thinking skills (Sadler and Zeidler 2005; Norris and Phillips 2003). The use of informal discussions using socioscientific issues exposes students to moral and ethical issues and diverging viewpoints, creating a richer experience for the student (Zeidler et al. 2009, 2011).

By allowing students to discuss real world problems and develop decision-making skills about those problems under the SSI framework, they can begin to understand the complexities of science, seeing that science goes beyond the classroom and can be linked to economic, political and moral issues (Hodson 2003; Zeidler et al. 2011). Providing students with free-choice learning opportunities can help put these issues into a realistic context. Cox-Petersen and Spencer (2006) support the use of free-choice experiences toward the goal of achieving scientific literacy because it allows for opportunities for discussion and interactions with other students, promoting brainstorming, the sharing of ideas and knowledge and exposing students to the reality that science is more than a set of memorized decontextualized facts.

While classrooms using SSI provide a productive contextual framework for the discussion of scientific concepts, a possible key to connecting students further with science may lie in the use of free-choice experiences to help students understand their inherent bond to the world of science. Students need to be presented with issues that not only stimulate learning but also raise awareness as to the complexity of scientific issues and the moral threads that are present within the topics being discussed in the classroom (Sadler and Donnelly 2006; Zeidler and Sadler 2011). SSI pedagogy presents science as an integral part of society, rather than the traditional idea that science is separate from society (Zeidler et al. 2009). While the use of socioscientific issues in the classroom is not to focus solely on economics and politics, many environmental issues such as global warming allow students to view the interconnectedness of these topics (Sadler and Klosterman 2009).

In another study focusing on young children, Dolan et al. (2009) investigate fifth grade students' understanding and engagement of science concepts through the use of socioscientific issues. Prior to including any SSI based issues or activities into the curriculum, the instructor makes sure that students have a solid comprehension of the science concepts that would be discussed. Three units were developed and implemented. Students were asked to think critically and utilize their analysis, synthesis and evaluative skills throughout these activities which include debate and continued dialogue about controversial issues ranging from beach erosion to harbor seal harvesting. Students show enthusiasm and deeper understanding as to the richness of science concepts in terms of how those issues influence the health of their lives and the environments and communities in which they live.

At first blush, SSI may seem too advanced and complex a task for younger students; however, the effectiveness of these units on younger learners based on the existing research above is encouraging. Students' enthusiasm and creativity brought to these scenarios bolsters learning and understanding of SSI. More studies focusing on elementary aged students and the plethora of methodologies and outcomes offered by the SSI framework will only enhance the field with new possibilities for research and practice to aid in reform in science education.

To be a scientifically literate citizen, one needs the ability to analyze claims and make decisions based on evidence with ethics and reasoning (Chowning 2009). Environmental issues such as climate change, Ebola and pollution issues are hot-button topics that students will be faced with in the future and need to be prepared to make informed decisions. Teachers need to understand a bigger picture is possible beyond simple retention of scientific content. Students need to recognize that the more clearly they can articulate their positions on SSI, the better prepared they will be to tackle the decision-making process and advocate for others.

Critical Thinking, Conservation and Activism

By providing students with the opportunity to discuss or debate controversial scientific topics presented within the SSI curriculum, students have the potential to develop skills associated with critical thinking. Critical thinking by broad definition is a form of reflective thinking that ultimately helps one decide what to believe or do (Ennis 1985, 1987, 1989, 2011). Skills such as analysis, inference, evaluation and interpretation are nurtured and developed through the use of SSI. Critical thinking is embedded within SSI curriculum by virtue of the fact that the topics are multi-faceted and address real world issues promoting students to compare, contrast, and generally examine the nuances of the issues and how such issues impact the everyday life of the student. The incorporation of SSI units within elementary education enables the students to become more open-minded, analytical and confident in their abilities to reason and solve problems (Zeidler and Nichols 2009). However, it is ultimately the teacher that needs to create an environment that will stimulate and promote critical thinking (Carr 1988; Chepesiuk 2007).

An example of the successful integration of SSI, free-choice learning and critical thinking can be made through a program offered at a county nature preserve in Central Florida. To engage younger students in actively observing their surroundings while outside in wilderness, a program entitled Wildlife Scene Investigators (WSI) was developed. This program takes participants on a journey, developing a relationship with nature that is more intimate than what they experience on a daily basis. Guides lead teams of young students through the woods teaching them to listen for birds, bugs, water sources and look for evidence of animal tracks, scat and markings. While hiking, guides lead the learners to sites where animals had been spotted previous to the students arriving. Upon arriving at these sites, hike guides allow the learners to work as a team to analyze what they have come upon. Students then infer what could have possibly happened, what creatures were fighting, eating or marking territory. The guides encourage the students to evaluate all the scenes that they have come upon throughout the hike and then interpret through discussion what took place based on the evidence found at all scenes. Students engage in discussions about invasive species, habitat loss and encroachment that are prevalent in this area of Florida and how they would participate in environmental activism by becoming engaged in educating members of their communities. Programs such as WSI can be used on the schoolyard, in the backyard or on a hike through local preserves or parks to connect young learners with what is around them.

Conservation can serve as a concrete topic for young children to develop a basic understanding of environmental literacy and stewardship. It is crucial that students learn the importance of conservation in order to make decisions about their community at large when called upon. Using topics within the classroom that deal with environmental conservation, how to actively participate in the solution of environmental problems and challenging students to think critically about such topics is an integral part of allowing students to become members of a collective democratic society. By integrating argumentation, critical thinking and discourse into the elementary school classroom, students may be faced with their own fallacious reasoning, exposing them to alternate ways of viewing topics and perhaps realizing that there are other ways of examining evidence (Zeidler 1997; Zeidler et al. 1992).

Critical thinking should also be considered an important aspect of science education because of the importance it ultimately has on quality of life. At the root, critical thinking is the analysis and evaluation of how one thinks and the knowledge that there is always improvement and growth to be had through thinking skills; it requires students to use higher order thinking (Sadler 2004a). Without the exercise of proper skills, poor decisions can lead to economic, environmental or social chaos (Zeidler et al. 1992; Zeidler 1997).

Critical thinking has many functions including evaluating the arguments of others, evaluating ones own argument, resolving conflicts and understanding resolution. The promotion of critical thinking within the curriculum is to teach students to use these skills beyond the actual classroom, applying the strategies in practical situations (Allegretti and Frederick 1995), such as whether to turn off the faucet while brushing their teeth to conserve water or to actively talk to members of their community about conserving resources (Burke et al. 2007).

Critical thinking is a skill needed throughout life and should be cultivated at an early age to provide children with necessary intellectual tools and experience to navigate through scientific information. The ability to reason well is a prerequisite to responsible environmental activism, to be expressed by engaging in actions such as community conservation projects, school recycling or environmental programs, volunteering at local preserves or animal rescue facilities or participating in outreach programs to inform others of conservation and environmental issues within their community. The habits of mind which characterize critical thinking include:

- Inquisitiveness with regard to a wide range of issues
- Concern to become and remain well informed
- Alertness to opportunities to use critical thinking
- Trust in the processes of reason inquiry
- Self-confidence in one's own ability to reason
- Open-mindedness regarding divergent worldviews
- Flexibility in considering alternatives and opinions
- Understanding of the opinions of other people
- Fair-mindedness in appraising reasoning
- Honesty in facing one's own biases, prejudices, stereotypes or egocentric tendencies
- Prudence in suspending, making or altering judgments
- Willingness to reconsider and revise views where honest reflection suggests that change is warranted (Facione 2007, p. 10).

One study conducted by Burke et al. (2007) focuses on the use of thinking skills in elementary school education within Scotland. The study examines how teachers perceive the teaching of thinking skills within the curriculum. All 48 primary schools in a region of central Scotland are surveyed with 36 returning the survey for a total of 127 completed surveys to analyze. Teachers are asked to rate how frequently they perceive each of six main thinking skills (searching for meaning, critical thinking, creative thinking, metacognition, decision making and problem solving), which are utilized within the classroom curriculum. Specifically focusing on critical thinking skills, teachers are asked to rate how regularly they teach the skills of making predictions, formulating hypothesis, drawing conclusions, giving reasons, distinguishing fact from opinion, determining bias, the reliability of evidence, being concerned about accuracy, relating causes and effects and designing a fair test. Teachers believe that the critical thinking skills of drawing conclusions and giving reasons are provoked within their classroom curriculum and that designing a fair test and determining bias are the least promoted. It is also found that critical thinking skills are taught most in the subject areas of science and technology with little difference between age levels. The researchers find this result particularly interesting because they believe the higher order thinking needed to determine bias and relating cause and effect is be too advanced for children in the early years of elementary school. However, teachers self-reported data on their use of critical thinking (or the lack thereof) may not reflect a common understanding of the construct, nor if their approach to critical thinking is particularly effective.

These studies provide evidence that scientific literacy and critical thinking skills can be introduced to younger students so that they can carry these skills, continuously developing them throughout their academic career so that they may apply them when they are faced with making decisions as adults (Zeidler and Sadler 2011). To actively and conscientiously participate in a democratic society, responsible citizens must be able to make decisions about scientific information and understand the outcomes of such decisions (Reis and Galvao 2009; Zeidler et al. 2014).

Striving to conserve the environment and taking an active role in how this is accomplished can be viewed as a form of critical thinking. SSI pedagogy can provide exposure and the emotional catalyst to students becoming engaged in environmental conservation and activism. By providing students with the opportunity to discuss multifaceted, ethically rich topics within the environmental conservation genre, students will be exposed to issues that may be influencing their local community. This can lead to students taking an active role in solving these issues or making a difference on a smaller scale within their school or community environment; preparing them for a larger role in our society as they develop into critical thinkers throughout their lives.

Promoting Immersive Learning

There is quite a rich area of research yet to be examined involving the amalgamation of SSI and free-choice learning when focusing on younger learners. Few studies have utilized a long-term treatment to investigate the use of SSI-based curriculum in general and the use of SSI pedagogy on learning opportunities in particular on elementary school students. Examining the potential these approaches hold for conceptual scientific learning, conservation and activism is vital to future environmental integrity. Learning experiences in informal settings provoke emotional responses, raise ethical and moral questions about conservation and have the potential to motivate learners. In this sense, free-choice experiences hold an important role in the learners' development and infrastructure of science learning. These experiences, in a broader sense, have strengths that are an asset to the strengths of classroom learning. A free-choice experience can be as easy as moving the classroom outside to a quiet area for discussion of a topic being taught in the classroom, and as intricate as using outdoor spaces for implementing science investigations dealing with various topics from land erosion, to examining the impact of land use on local flora and fauna. Authentic experiences such as these give students and teachers an opportunity to connect what is being learned within the classroom to what is happening right outside the classroom window. The goal of scientific literacy is to provide students with the knowledge and skills needed to make decisions about important environmental issues facing them now and in the future, and to have the ability to take action when necessary (Louv 2007; Aasen et al. 2009). Allowing students opportunities to visit informal science facilities or to learn in informal environmental contexts may be helpful in exposing and engaging students to a wide range of science topics.

Research dealing with the impact of SSI-based curriculum focusing on elementary school students is limited and should be explored further to gain a more complete understanding as to how young children think critically and make decisions about environmental issues. For example, how do young learners view the environment? Is it separate or a part of their everyday reality? Are they aware of how science is all around them and that what choices they make, what they consume and what they waste has an impact on their local community and health of the environment at large?

To move forward with educational reform, research into how the capacity for young students to think critically and cultivate their moral sensitivity to environmental issues will help determine how to shape curriculum and learning modules to best suit the needs of the students. Socioscientific issues invite students to explore science that is multi-faceted and rich with ethical queries. The use of SSI has the potential to allow students to utilize their critical thinking skills so they can better analyze and synthesize the scientific information needed to support arguments that have moral and ethical consequences Dolan et al. (2009), thereby fostering considerate actions in a local context.

Kuhn (1993) points out that young children are naturally curious about the world around them, but that their curiosity should be guided toward scientific argumentation and scientific thinking more fully. Moral issues are an embedded part of environmental and conservation topics. Therefore, it is possible for free-choice experiences to be effective and contextually reinforcing experiences when brought back into the classroom successfully (Falk and Dierking 1992; Falk and Heimlich 2009). These experiences may lead to an embedded sense of environmental stewardship by offering students a glimpse at how decisions and actions made today can have a strong impact on our future.

References

Aasen, W., Grindheim, L. T., & Waters, J. (2009). The outdoor environment as a site for childrens' participation, meaning-making & democratic learning: Examples from Norwegian kindergartens'. *Education, 37*, 5–13.

Allegretti, C. L., & Frederick, J. N. (1995). A model for thinking critically about ethical issues. *Teaching of Psychology, 22*, 46–48.
Brewer, C. (2001). Cultivating conservation literacy: "Trickle down" education is not enough. *Conservation Biology, 15*(5), 1203–1205.
Burek, K. J. (2012). *The impact of socioscientific issues based curriculum involving environmental outdoor education for fourth grade students*. Doctoral dissertation, University of South Florida, Tampa Fl.
Burek, K., & Callahan, B. E. (2005, August). *Argumentation in the science classroom*. Paper presented at the biannual conference of Science, Math and Technology, Victoria Island, BC.
Burek, K., Callahan, B., & Zeidler, D. L. (2004, October). *Argumentation for scientific literacy: Seal hunting in Canada*. Paper presented at the annual meeting for the Southern Association for the Education of Teachers of Science, Gainesville, FL.
Burke, L. A., Williams, J. M., & Skinner, D. (2007). Teachers' perception skills in the primary curriculum. *Research in Education, 77*, 1–14.
Carr, K. S. (1988). How can we teach critical thinking? *Childhood Education, 65*, 69–73.
Chepesiuk, R. (2007). Environmental literacy: Knowledge for a healthier public. *Environmental Health Perspectives, 115*, A494–A499.
Chowning, J. T. (2009). Why societal issues belong in science class. *The Science Teacher, 76*, 8.
Cox-Petersen, A., & Spencer, B. (2006). Access to science and literacy through inquiry and school yard habitats. *Science Activities, 43*(2), 21–27.
DeWitt, J., & Storksdieck, M. (2008). A short review on school field trips: Key findings from the past and implications for the future. *Visitor Studies, 11*, 181–197.
Dierking, L. (2004). A guest editorial. *Curator, 47*, 233–239.
Dierking, L., & Falk, J. H. (2004). Using a behavior change model to document the impact of visits to Disney's Animal Kingdom: A study investigating intended conservation action. *Curator, 47*, 322–343.
Dillon, J. (2002). Editorial perspectives on environmental education-related research in science education. *International Journal of Science Education, 24*, 1111–1117.
Dillon, J., Morris, M., O'Donnell, L., Reid, A., Rickinson, M., & Scott, W. (2005). *Engaging and learning with the outdoors – The final report of the outdoor classroom in a rural context action research project*. Slough: NFER.
Dolan, T. J., & Zeidler, D. L. (2009, November). Speed kills! (Or does it?). *Science and Children*, 20–23.
Dolan, T. J., Nichols, B. H., & Zeidler, D. L. (2009). Using socioscientific issues in primary classrooms. *Journal of Elementary Science Education, 21*, 1–12
Dunckel, B. A., Malone, K. C., & Kadel, N. K. (2008). Inquiry is taking flight through project butterfly WINGS. In R. E. Yager & J. H. Falk (Eds.), *Exemplary science in informal education settings* (pp. 31–46). Arlington: NSTA Press.
Ennis, R. H. (1985). A logical basis for measuring critical thinking skills. *Educational Leadership, 43*, 44–48.
Ennis, R. H. (1987). A taxonomy of critical thinking dispositions and abilities. In J. Baron & R. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 9–26). New York: W.H. Freeman.
Ennis, R. H. (1989). Critical thinking and subject specificity: Clarification and needed research. *Educational Researcher, 18*, 4–10.
Ennis, R. H. (2011). Critical thinking: Reflection and perspective – Part 1. *Inquiry, 26*, 1.
Environmental Literacy Council Environment and Society. (2002). Retrieved March 2011, from http://www.enviroliteracy.org
Erduran, S., Simon, S., & Osborne, J. (2004). Tapping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education, 88*, 915–933.
Ervin, B. T., & Sadler, K. C. (2008). Splash, Flash, Crank, Slide, Alive! Interactive standards-based science experiences for grades preK-2 at discovery center. In R. E. Yager & J. H. Falk (Eds.), *Exemplary science in informal education settings* (pp. 153–166). Arlington: NSTA Press.

Evans, E. A. (2005). The neighborhood nestwatch program: Participant outcomes of a citizen-science ecological research project. *Conservation Biology, 19*, 589–594.
Facione, P. A. (2007, Update). *Critical thinking: What it is and why it counts*. http://www.insightassessment.com/dex.html
Falk, J. H. (2009). *Identity and the museum visitor experience* (302pp.). Walnut Creek: Left Coast Press.
Falk, J. H., & Dierking, L. D. (1992). *Museum experience*. Washington, DC: Whalesback Books.
Falk, J. H., & Heimlich, J. E. (2009). Who is the free-choice environmental education learner? In J. H. Falk, J. E. Heimlich, & S. Foutz (Eds.), *Free-choice learning and the environment* (pp. 23–38). Lanham: Altimira Press.
Falk, J. H., Dierking, L. D., & Storksdieck, M. (2007). Investigating public science interest and understanding: Evidence for the importance of free-choice learning. *Public Understanding of Science, 16*(4), 455–469.
Fowler, S. R., Zeidler, D. L., & Sadler, T. D. (2009). Moral sensitivity in the context of socioscientific issues in high school science students. *International Journal of Science Education, 31*, 279–296.
Gerber, B. L., Marek, E. A., & Cavallo, A. M. (2001). Relationships among informal learning environments, teaching procedures and scientific reasoning ability. *International Journal of Science Education, 23*, 535–549.
Henriksen, E. K., & Froyland, M. (2000). The contribution of museums to scientific literacy: Views from audience and museum professionals. *Public Understanding of Science, 9*, 393–415.
Hodson, D. (2003). Time for action: Science education for an alternative future. *International Journal of Science Education, 25*, 645–670.
Holzer, D., Scott, D., & Bixler, R. (1997). Long lasting effects of early zoo visits. *Curator, 40*, 255–257.
Kellert, S. R. (2009). Reflections on children's experience of nature. *C&NN Leadership Writing Series, 1*, 1–5.
Kelly, J. (2000). Rethinking the elementary science methods course: A case for content, pedagogy and informal science education. *International Journal of Science Education, 22*, 755–777.
Kisiel, J. (2006). More than lions and tigers and bears: Creating meaningful field trip lessons. *Science Activities, 43*, 7–10.
Kuhn, D. (1993). Science as argument: Implications for teaching and learning scientific thinking. *Science Education, 77*, 319–337.
Kuhn, D. (2007). How to produce a high-achieving child. *Phi Delta Kappan, 88*, 757–763.
Lee, H., Chang, H., Choi, K., Kim, S. W., & Zeidler, D. L. (2012). Developing character and values for global citizens: Analysis of pre-service science teachers' moral reasoning on socioscientific issues. *International Journal of Science Education, 34*, 925–953.
Louv, R. (2007). *Last child in the woods: Saving our children from nature-deficit disorder*. Chapel Hill: Algonquin Books.
Main, A. (2004). Mobilizing grass-roots conservation education: The Florida master naturalist program. *Conservation Biology, 18*, 11–16.
Miller, B. (2004). Evaluating the conservation mission of zoos, aquariums, botanical gardens and natural history museums. *Conservation Biology, 18*, 86–93.
Mueller, M. P., & Zeidler, D. L. (2010). Moral-ethical character and science education: Ecojustice ethics through socioscientific issues (SSI). In D. Tippins, M. Mueller, M. van Eijck, & J. Adams (Eds.), *Cultural studies and environmentalism: The confluence of ecojustice, place-based (science) education, and indigenous knowledge systems* (pp. 105–128). New York: Springer.
National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.
National Research Council. (2009). *Learning science in informal environments: People, places and pursuits*. Washington, DC: National Academies Press.
Norris, S. P., & Phillips, L. M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science Education, 87*, 224–240.

Norwegian Framework Plan for the Content and Tasks of Kindergartens Laid down by the Ministry of Education and Research 1 March 2006, amended by Regulation 10th of January 2011 No. 51.

O'Brien, E. (2009). Learning outdoors: The forest school approach. Invited paper. *Education, 3–13*(37), 45–60.

Ratcliffe, M., & Grace, M. (2003). *Science education for citizenship*. Buckingham: Open University Press.

Reis, P., & Galvao, C. (2009). Teaching controversial socioscientific issues in biology and geology classes: A case study. *Electronic Journal of Science Education, 13*, 1–24.

Rennie, L. J., & Williams, G. F. (2006). Adults learning about science in free-choice settings. *International Journal of Science Education, 28*, 871–893.

Rickinson, M., & Lundholm, C. (2008). Exploring students' learning challenges in environmental education. *Journal of Education, 38*, 341–353.

Sadler, T. D. (2004a). Moral and ethical dimensions of socioscientific decision-making as integral components of scientific literacy. *Science Educator, 13*, 39–48.

Sadler, T. D. (2004b). Informal reasoning regarding socioscientific issues: A critical review of the literature. *Journal of Research in Science Teaching, 4*, 513–536.

Sadler, T. D., & Donnelly, L. A. (2006). Socioscientific argumentation: The effects of content knowledge and morality. *International Journal of Science Education, 12*, 1463–1488.

Sadler, T. D., & Klosterman, M. L. (2009). Exploring the sociopolitical dimensions of global warming. *Science Activities, 45*, 9–15.

Sadler, T. D., & Zeidler, D. L. (2005). Patterns of informal reasoning in the context of socioscientific decision-making. *Journal of Science Teacher Education, 17*, 217–241.

Simonneaux, L. (2001). Role-play or debate to promote students' argumentation and justification on an issue in animal transgenesis. *International Journal of Science Education, 23*, 903–927.

Simonneaux, L. (2008). Argumentation in socio-scientific contexts. In S. Erduran & M. P. Jimenez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 179–200). Dordrecht: Springer.

Storksdieck, M., Robbins, D., & Kreisman, S. (2007). *Results from the quality field trip study: Assessing the LEAD program in Cleveland, Ohio*. Summit proceedings, Cleveland: University Circle Inc.

Zeidler, D. L. (1997). The central role of fallacious thinking in science education. *Science Education, 81*, 483–496.

Zeidler, D. L., & Nichols, B. (2009). Socioscientific issues: Theory and practice. *Journal of Elementary Science Education, 21*, 49–58.

Zeidler, D. L., & Sadler, T. D. (2008a). Social and ethical issues in science education: A prelude to action. *Science & Education, 17*(8–9), 799–803.

Zeidler, D. L., & Sadler, T. D. (2008b). The role of moral reasoning in argumentation: Conscience, character and care. In S. Erduran & M. Pilar Jimenez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research*. Dordrecht: Springer Press, Springer.

Zeidler, D. L., & Sadler, T. D. (2011). An inclusive view of scientific literacy: Core issues and future directions of socioscientific reasoning. In C. Linder, L. Ostman, D. A. Roberts, P. Wickman, G. Erickson, & A. MacKinnon (Eds.), *Promoting scientific literacy: Science education research in transaction* (pp. 176–192). New York: Routledge/Taylor & Francis Group.

Zeidler, D. L., Lederman, N. G., & Taylor, S. C. (1992). Fallacies and student discourse: Conceptualizing the role of critical thinking in science education. *Science Education, 76*, 437–450.

Zeidler, D. L., Sadler, T. D., Simmons, M. L., & Howes, E. V. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education, 89*, 357–377.

Zeidler, D. L., Applebaum, S., & Sadler, T. D. (2006, January). *Using socioscientific issues as a context for teaching content and concepts*. Paper presented at the annual meeting of the Association for Science Teacher Education, Portland, OR.

Zeidler, D. L., Sadler, T. D., Applebaum, S., & Callahan, B. E. (2009). Advancing reflective judgment through socioscientific issues. *Journal of Research in Science Teaching, 46*, 74–101.

Zeidler, D. L., Applebaum, S. M., & Sadler, T. D. (2011). Enacting a socioscientific issues classroom: Transformative transformations. In T. D. Sadler (Ed.), *Socioscientific issues in science classrooms: Teaching, learning and research* (pp. 277–306). Dordrecht: Springer.
Zeidler, D. L., Berkowitz, M., & Bennett, K. (2014). Thinking (scientifically) responsibly: The cultivation of character in a global science education community. In M. P. Mueller, D. J. Tippins, & A. J. Steward (Eds.), *Assessing schools for generation R (responsibility): A guide to legislation and school policy in science education*. Dordrecht: Springer.

Karey Burek earned her doctorate from the University of South Florida in Curriculum and Instruction with a focus on science education. Her research and background are in socioscientific issues, environmental and free-choice learning in outdoor environments. She currently is a NAI certified hike guide at local preserves in Florida, connecting the community with the nature in their own backyard.

Dana L. Zeidler is a professor and program coordinator of science education at the University of South Florida, USA. His research program incorporates aspects of argumentation, moral reasoning and character formation, epistemology and the nature of science into a theoretical framework using socioscientific issues as a means to facilitate scientific literacy.

Chapter 27
Section Editorial – Ponder This: Taking Educated Action with and in Science

Angela Calabrese Barton

> We know what we are doing. We know how to make a difference. We know how to save energy and how to convince others of better ways to do things with electricity. That is one way we are experts. The [green] roof is the best example because we saved the club money. (Janis)

Janis, a 13-year-old African-American, is speaking about her participation in a community-based program focused on investigating energy issues in her community. She refers to herself as a *Community Science Expert [CSE]* because of what she knows about science and her community. To Janis and her peers, CSEs are "committed," "ready to learn," "willing to take on big problems to help your community," "take educated action" and are "make-a-difference experts."

I take the youths' ideas here seriously. Why did they come up with the term community science expert? What is it about the blending of different knowledges and practices that matter so much to them? What does it mean to use these different knowledges and practices to take, as they say, "educated action?"

Taking civic action using scientific expertise has gained traction in the science education community, despite the fact that it has not been central to reform initiatives. In the United States, for example, science education policy has been grounded in the idea that scientific understanding is enough to prompt informed and reasoned action. The new framework for science education and the Next Generation Science Standards further cements this divide, with almost exclusive attention on the cognitive dimensions of science learning (Committee on Conceptual Framework for the

A. Calabrese Barton (✉)
College of Education, Michigan State University,
327 Erickson Hall, 620 Farm Lane, East Lansing, MI 48824, USA
e-mail: acb@msu.edu

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2_27

New K-12 Science Education Standards 2012). However, research in the social sciences and education suggest otherwise. Scientific understanding has been shown to bear little impact on the decisions people make on civic engagement (Allum et al. 2008; Sadler 2004).

And yet, as the health of our planet continues to be impacted by human behaviors and interactions with various environments, it has become clear socioscientific issues are not simply worries earmarked for future generations. The shifting timeframe of concern places a greater importance on building understandings of socioscientific issues and taking action based upon those understandings (Skamp et al. 2013). Thus, an individual's capacity to build understandings and take action on socioscientific issues of local, national and global importance is a responsibility of democratic citizenship for both adults and youth alike.

Each one of the chapters in this section takes on the challenge of describing and advancing what the youth I work with refer to as educated action. Each one of these chapters asks and answers questions around knowledge, practice, positioning, and action in ways that are thought provoking, critical and forward thinking. Indeed, each one of these chapters asks: When and how and why do young people take action with and through science?

The youth, with whom I have had the privilege to learn from, have been clear that taking educated action with and in science means *making a difference because of what you know and care about*. They ground their actions in an understanding of the world around them, drawing from multiple knowledges and perspectives. Essential to their view is the very idea that taking action on socioscientific issues requires more than knowledge of science. As one of the youth stated, "you can be an expert in science, but if you do not know my community, then your knowledge will not be powerful." This same idea is captured in the opening quote of Hassard's chapter by Jenny, one of the collaborating principals, "We must be scholars and activists. It is simply not enough to be scientists – that is to measure and calculate, but rather we must be willing to dedicate ourselves to cause--o be activists who are willing to commit to environmental and humanitarian issues."

Central to Jenny's and Janis' comments, and across the manuscripts in this section, is the very idea that activism in science is grounded in multi perspectived view of the problem spaces we face in our world. Deep understandings of science – in both its knowledge and practice – is elemental but insufficient. And so, in this section, I use the ideas raised in the chapters to reflect upon the ideal of educated action, and to ask why the science education community should care about it.

To accomplish this goal of unpacking educated action and its implications for science education, I first present a case study from my own work regarding middle school youths' efforts to make sense of, take action upon and challenge their states policy initiative, Change a Light, Change Michigan. Using this case I raise several points regarding a set of core principles that frame educated action. I weave in ideas from the chapters to deepen this discussion and to raise questions regarding a future research and practice agenda.

Change a Light, Change Michigan

Investigating the Policy Initiative: Change a Light, Change Michigan[1]

During the 2009–2010 school year, the youth in GET City,[2] a year round club focused on green energy technology and engineering design, had been investigating the newly introduced statewide policy initiative, "Change a Light, Change Michigan." This policy initiative targeted Michigan families, and encouraged each family to replace one incandescent light bulb with one compact fluorescent light bulb. The core of the initiative was aimed at behavior change – the physical act of changing a light bulb. It was not aimed at educating the public on the reasons behind the desired change. This is not surprising. The challenge with many science related public policy initiatives is that they tend to focus on action-oriented goals and behavioral changes with little attention on promoting understandings of the science behind it.

We began our investigation of Change a Light with the question, "What was this initiative asking residents of our state to do and why? Why should we care?" Our goal was to help the youth get smarter about the energy related science underlying Change a Light Change Michigan, so that they would understand and challenge if necessary the proposed actions. We delved into several months of scientific investigation, including experiments designed to produce electricity from different sources, explore energy supply and consumption in their city, and the relationship between energy conservation and efficiency and carbon emissions.

The investigation was built around the idea that people and organizations have "carbon footprints," and that we, as people, have some control over the size of our carbon footprints. In other words, individuals and people contribute to the amount of carbon (CO_2) emitted through daily activity (i.e., driving a combustion engine car, using electricity to power lights, etc.) and that our choices can influence our personal carbon footprints.

The first part of the investigation involved gathering data to determine one's own carbon footprint, and that of the community-club, which hosts GET City. Using online calculators, GET City youth surveyed their own and their families' energy practices to determine the size of their carbon footprints, how that compared to each other, and to youth around the globe. They audited their homes for appliance usage, and interviewed each other and their family members about their energy practices. They asked their parents and other family members how they kept track of their energy usage practices, if at all. They interviewed grandparents to gain insight into how appliance usage has changed over two generations. They also audited the community club for its energy practices – what appliances were used, how often and for what purposes, where appliances left on or off when not in use and so on. Embedded within these investigations were core ideas regarding energy, such as how electrical energy is measured in units of kilowatt-hours. They learned the law of energy conservation and determined the power needs of representative electrical items in homes and businesses. They learned about the relationship between personal actions and energy usage.

The second part of the investigation involved youth designing and building their own devices to produce electricity. For youth to understand that energy consumption contributes to carbon emissions, they have to understand how flicking on the light switch is related to carbon, through, for example, the harvesting and burning of coal. They built hand cranks using magnets, copper wire and micro amp bulbs to produce electricity through human power. They visited the local coal fired power plant. They used these ideas to write and produce musical raps about the production of electricity (http://getcity.org/blog/2010/01/30/coal-rap/).

In the third part of the unit, the youth then returned to the Change a Light, Change Michigan policy initiative to delve more deeply into the initiative. The youth came up with questions such as: Why would changing the style light bulb make a difference? Are CFLs really safe? What should be done about the cost, as my family cannot afford them? In response to their curiosities, the youth conducted several experiments comparing power requirements, heat and light output of compact fluorescent light bulbs (CFLs) and incandescent light bulbs using digital probes and spreadsheets. They also studied the design of CFLs and looked into heavy metal poisoning.

It was during this portion of our investigation, however, that the local school district announced major budget cuts, which would eliminate after school programming. Three of the GET City youth – Etta, Chloe and Chantelle – were particularly upset by these cuts and decided to use their knowledge of “Change a Light, Change Michigan” to take action. They believed, if they could figure out how much money the school might save by moving from incandescent to compact fluorescent light bulbs, they may be able to save after-school programming while reducing their school’s carbon footprint.

Using Science and Community Knowledge to Take Action

Together, with video recorder, surveys and cameras in hand Etta, Chloe and Chantelle set out to perform an energy audit of their school. They counted the number of incandescent bulbs and documented their locations in the school building. They recorded the kilowatt hour expenditure, the need for light in each location, and conjectured based on school routines how often the light would need to be on. They put their data into excel spreadsheets and calculated overall energy expenditures by the incandescent bulbs, and compared it to the same calculation they performed as if all the bulbs were CFLs. Using the difference they calculated how much money and how many pounds of carbon emissions would be saved if the school switched each incandescent bulb with a CFL. With findings in hand, they also interviewed teachers and students on the topic, and on their energy practices in their classrooms.

Using much of their own time, but also time in GET City, the three girls set out to turn their findings into a 4-min video, "The Light Bulb Audit" (see: http://getcity.org/blog/2010/02/27/make-that-change/), which (a) explained the problem of energy consumption through incandescent bulbs at their school, (b) showcased their evidence regarding the numbers of bulbs located and their impact, (c) provided an argument for the importance of energy efficiency and its relationship to electrical production and environmental sustainability, and (d) made a case for how much money and carbon emissions would be saved through switching light bulbs. They targeted their school leaders and peers as the audience of their video.

"The Light Bulb Audit" is serious and humorous, scientifically complex yet accessible for their intended audience. The video starts with a series of images while the lyrics of the song stated, "Waiting on the world to change" (Mayer 2006). The first image shows youth playful and dancing in their school. Two additional images follow of an incandescent light bulb then a CFL bulb accompanied by the text, "MAKE A CHANGE". The video then transitions to the youth in front of their school explaining their decision to conduct a light bulb audit, and asking the viewership whether they think their school is being green. Next, the video transitions to the youth engaged in a light bulb audit of each bathroom in the school to determine how many CFLs they can find over the less energy efficient incandescent light bulbs. In between inspections of each bathroom, the youth infuse information about the number of watts used by incandescent light bulbs versus CFLs, and the energy inefficiency of incandescent bulbs. They also good-naturedly chastise their teachers for not being green. The girls discover that all but one classroom bathroom used incandescent bulbs, helping to set up their content storyline regarding why their school must make a change.

The next segment of the video uses music, text, and vivid images to detail how and why becoming energy efficient reduces carbon emissions and is better for their environment. As background music, they use Michael Jackson's *Earth Song*, which lyrics question, "What have we done? Look what we've done." They juxtaposed images of coal mines and coal harvesting with text declaring, "This coal mine used to be filled with trees and grass." The music fades and Chloe asks the viewer, "Have you ever seen those smoke stacks?" Next, we see a picture of the local power plant with the text "LANSING'S ECKERT COAL PLANT" layered on top. Then, three stacks with billowing smoke with an ominous burnt orange hue as the music asks "What about flowering fields." The image of the mine reappears but the now text reads, "This land and our atmosphere may NEVER be the same."

In the last segment of the video, the girls present their calculations for how much money and carbon would be saved if their school changed their bulbs. The video focused on human actions but also offers a chance for the audience to remediate habits and be empowered to make a change. The video closes with the scrolling text reviewing how incandescent light bulbs used more energy requiring more coal burning and CO_2 release that leads to global warming as the song played "I'm asking you to make a change." The girls leveraged their knowledge of energy related science, what was happening in their school and their IT skills to package an educational message to members of their community.

Making REAL Change

GET City youth decided that it was imperative to share their findings with their school. Using the "The Light Bulb Audit" as the centerpiece, the youth prepared a 30-min workshop on energy efficiency for the school's student congress (25 students), which focused on why the school should switch their bathroom lights from incandescent to compact fluorescent (CFL). In addition to "The Light Bulb Audit", the youth also prepared an experiment highlighting energy consumption and emissions of incandescent and CFL bulbs and the safe handling of these bulbs. They created a musical rap that put the science content of incandescent bulbs, carbon emissions and climate change into a youth-friendly song. Lastly, they prepared a pledge for committing to change the bulbs, with careful handling. Youth used these tools to help the student congress understand the scientific basis for an energy audit and light bulb upgrade at their school.

As a result of the workshop, which included stories about the financial hardship the policy initiative imposed upon families, the local power company donated 1,000 CFL bulbs to GET City youth to distribute to their schools, community and family to "make a change." The GET City youth took their workshop and the bulbs on the road to their churches and other community centers until all of the bulbs were distributed.

What Is Educated Action

I began with this opening vignette because it captures, broadly, what I mean by the ideal of educated action. In this vignette, we can see how the youths' scientific investigations were based in and about their school, community and families. The youth interviewed members of their family, performed energy audits of their school and club and designed messages to educate local audiences. While their work required a deep understanding of energy-related science, they needed to make sense of this science in the context of their community needs and concerns. Their questions, for example, integrated environmental, economic and health concerns. Their investigation – of light bulb usage, cost, barriers to change, and motivations – blended these concerns. All of these ideas are captured in how one youth talked about how their approach to Change a Light mattered to her grandmother, "First, she got her light bill and it was so high! She almost lost her mind! … When she got her light bill back was like "oh no!" but it didn't and she was so proud! The rest of the money she had left, she spent on the needs that she really needed!"

When the youth designed their workshop, which included their videos, raps and pledge, they authored messages geared toward a local audience of peers, community members and teachers. The youth used expert knowledge of their audience (e.g., their likely background knowledge, interest, and needs) when designing messages to share their findings of energy investigations. Their goal was to have a "real impact." As the youth described afterwards:

Chantelle:	Most of the people we talk to just seriously changed their light bulbs.
Caitlyn:	The message changes because like when we went to talk to the kids, well we had to talk to them in a different way so they would understand it better but with grown ups you have to talk more sophisticated so they will understand.
Chantelle:	Yeah they actually wanted to learn how to do it and get CFLs and change their light bulbs and stuff.
Jana:	Also like we donated CFLs to the school and um, a couple of months ago we, well we didn't sell them but we gave out free CFL light bulbs to people
Chantelle:	Yeah and it changed them. We got cards back that said they want four free light bulbs and that they lived in Lansing and we got past our limit which was a thousand bulbs.
Caitlyn:	We got about two thousand five hundred [more] of them.

It was the youth who decided on the types of action that they would take, when and how. This mattered because they owned the action; it was replete with their knowledge of science and community, and their motivations. As GET Citian Jessie noted about her participation in GET City, "You listen then start letting your community hear you (and) get your point across to the world. You are saving the world and its power. Think about it, I'm a 11 year-old sixth grade girl saving the world and its people."

As this vignette suggests, educated action involves the capacity to leverage relevant scientific and community knowledge and practices to take informed action. We can see that educated action in science requires leveraging multiple areas of knowledge, including scientific and place-based knowledge, as well as the desire to act. I believe that cutting across the chapters in this section, we see the same message, but contextualized and discussed in unique ways. Based on my own work, and these chapters, I assert undergirding this view of educated action in science are three core principles that we must consider: (1) critical co-engagement with the discipline, the context, and the people, (2) working within incompleteness; (3) generative movement between two forms of action: the educative and the transformative.

Critical Co-Engagement with the Discipline, the Context, and the People

Educated action in science revolves around critical co-engagement with the discipline, ideas, and people involved. In the light bulb audit, the youths' learning of the science behind the "Change a Light" policy initiative, alone, would not have yielded educated action. These youth needed to bring community ideas and concerns to bear in order to frame the scientific ideas, and to author a message that attended to both. The policy initiative is based on the idea that incandescent light bulbs are energy inefficient. As youth learned about energy transformations, energy expenditures, and the broader electrical production and consumption systems, they developed the scientific understandings needed to understand the initiative. However, knowing this by itself was not fully helpful. An awareness of what kind of bulbs were both available and affordable in their communities, as well as an understanding of biological hazard of mercury in the bulbs, were essential to how they framed the specific educated actions they took. In so doing, they *modified* the "actions" of the policy initiative – it is about more than replacing light bulbs. It is also about understanding the safety of the change, and also about how to acquire lower cost or free replacement bulbs.

The critical co-engagement of the discipline, context and people reframes scientific engagement as centrally about multiple perspective taking. Indeed, it suggests that multiple perspectives, and the more complex problem space which emerges from multiple perspectives, supports more powerful and just forms of educated action. We see this very idea at the core of the global thinking project discussed by Jack Hassard (*From Citizen Diplomacy to Youth Activism*). Hassard argues that a critical dimension of activism in science is being able to see issues "through the eyes and minds of others." This kind of perspective taking in science, according Hassard, involves incorporating elements of empathy and intercultural competence towards the goals of using science in public decision making in ways that account for others. Such perspective taking repositions the citizen scientist from one who engages in scientific inquiry on scientists terms, to one who leverages multi-knowledges and experience to do science in just ways. The "disposition to care about and care for the environment" and to frame this disposition from different cultural standpoints, for example, are crucial elements of being a citizen scientist (p. 14).

Likewise, in Hathcock and Dickerson's chapter (*Hitting the Big Screen*), youth investigated a heavily polluted waterway of the Chesapeake Bay. The youth then used the tools of filmmaking to synthesize their ideas in order to share with others. Filmmaking supported youth in "creat[ing] personal relationships with them and the science" as well as centralized "their voice in the community" with "important information to share" (p. 4). The young people's investigation and filmmaking flipped the lens of the inquiry and action to one that was youth centered – for it reflected what youth chose to capture in their video cameras, and how they culled findings and information together towards a narrative that made sense to them.

A second point these same authors make is that critical co-engagement with the discipline, context and people positions youth as producers of knowledge, rather than simply consumers as our formal science classrooms often do. This repositioning makes it possible for youth to own what they know and more powerfully author their own actions towards change. We see this same repositioning of ownership in the vignette I shared earlier, and across the chapters (see in particular Schusler and Krasny's chapter). In other words, critical co-engagement with the text of science, context and people deprivilege the authority of text and teacher, thereby expanding opportunities to more fully define and situate scientific problems, describe methods, and pose limitations to knowledge claims.

Working Within Incompleteness

The teaching and learning of science often represents science in its final form, yielding descriptions of content that appear complete and stable rather than as knowledge-in-the-making, incomplete knowledge, or knowledge as framed by values, contexts, or culture. Furthermore, values are generally not recognized part of the teaching and learning of science, at least in schools and other formal learning environs.[3] Activism in science has been accepted in the discourses of teaching/learning science in so far as individuals can take action on science-related topics. However, how educated action can also transform the daily practice of doing science through the necessary integration of values and motivations to do good have not been considered a part of science education.[4]

As we see across these chapters, taking educated action in science is not just about the actions one takes to right the wrongs one observes or has experienced armed with the tools of science. Doing good and just activity involves recognizing the limits of one's knowledge and experience, and seeking out different others who might provide needed ideas or perspective. While such a simple idea, it is radical, for in science classrooms we teach students that they, as individuals, can acquire all of the needed knowledge to solve a problem. Rather, the point made across these chapters, is that we, as individuals, will always have incomplete knowledge, *and* we always filter that incomplete knowledge through incomplete perspectives (e.g., how we, as individuals, have come to understand the world). We need others to help us to see this incompleteness, and to complexify it. In other words, an important part of working within incompleteness is in acknowledging the social networks that facilitate and constrain individuals as they seek to perform the necessary tasks and sociocognitive work of science. "Lone individuals do not solve problems, but rather problem solving is embedded in a social network that collectively performs necessary tasks and cognitive work" (Nasir and Hand 2008, p. 144).

What stands out to me across these chapters is the idea that learning to take educated action demands on-going, multiple, and scaffolded opportunities for youth to (a) voice and integrate what they know with what they believe and value, and (b) see the limitations in their knowledge/view at both the individual and collective level in a safe environment. Take, for example, the chapter written by Desjardins, Hauser, McRae, Ormond, Rogers and Zandvliet (*Harnessing Youth Activism with/in Undergraduate Education*). These authors describe the importance of *designing for* action competence. Here, action competence is defined as "a capability, based on critical thinking and incomplete knowledge, to involve yourself as a person with other persons in responsible actions and counter-actions for a more humane world" (p. 3). The authors go on to describe factors that support teaching for activism in a university-level course, entitled "Change Lab." These factors can be summarized as: the inclusion of multiple stakeholders with a range of perspectives and expertise, opportunities to pitch a range of ideas towards action taking, experiential learning opportunities, and a strong sense of community despite differences in views, experiences and ideals. What is important in these authors' argument is not just that the change lab provided these affordances. Rather, these affordances worked together to support and promote students in learning to feel comfortable with incompleteness in what they, as individuals, know and care about. Such incompleteness forms the basis of action, where action requires knowledge and perspective building with others, and a willingness to be just as transformed as the transformations sought through action.

Schusler and Krasny (*Science and Democracy in Youth Environmental Action*) offer another way to think about the value of incompleteness. Using the lens of civic engagement to frame activism in science, these authors discuss the importance of connecting the dispositions and skills that youth learn relevant to both science and civic engagement. In presenting stories of young people's experiences engaged in environmental action, the authors argue for scientific inquiry *as a part of taking action.* This blending of doing science and doing citizenship challenges us to think about how scientific knowledge is made manifest, and the roles that individuals play in this process. The authors share an interesting quote from a young man, which captures this juxtaposition well: "it goes beyond just the green roofs. It's also … learning about how the impact we're making on the environment and the culture that we're living in and how to change it so we can make the world better." (p. 9). Here, this young man finds deeper meaning in scientific investigation when he understands its purpose. But more importantly, that purpose is tied to something larger – a broader problem space that grounds the science that one might do. What it means to "go beyond" is part of this incompleteness. Activism in science here means not only understanding how and why science might matter in solving a local problem, but also positioning youth (and their learning) as part of a larger public purpose.

Generative Movement Between Two Forms of Action: The Educative and the Transformative

With attention paid to the role of the everyday in the critical engagement of science as discussed in the two previous themes, educated action in science incorporates knowing and being in science and taking action. Educated action thus privileges two forms of action: the *educative*, where individuals or collectives seek to use their subject locations to educate others from within; and the *transformative*, where emphasis is placed on moment-to-moment actions meant to work towards a just world one step at a time.

Bencze, Alsop and Ritchie (*Pursuing Youth-led Socioscientific Activism*) describe an after school club they developed for teenagers, called Science (in) Action (SinA). The goal of the club has been "to encourage and enable youth to self-direct research-informed action projects to address personal, social and/or environmental issues associated with fields of science and technology" (p. 4). In designing this club the authors attempted to account for the ways in which youth are differentially networked, shaping what they know, care about, and desire to do. Working with youth reflexively, they sought to open up the possibility for educated action to be largely guided through question asking, creating spaces for youth to develop awareness of the "powerful societal actants" which shape knowledge production and associated activity (p. 11).

It is interesting that in their science in action work, the youth felt almost trapped, so to speak, in what the authors refer to as a "*panopticon* (Foucault 1977) – a detention structure, in which prisoners self-regulate their behavior and are inhibited from protest largely because of their belief in the ever-presence of all-seeing guards" (p. 11). Of course, the panopticon is not purely physical for the youth as a real detention structure might be, but socially constructed through economics and politics in ways that are both real and perceived. Consequently youth target both "local and familiar and/or distant and unfamiliar actants" towards making change, with change existing at both educating oneself and others about the actants which can (de)anchor activism, and changing those actants through counter-hegemonic messages.

However, these dual targets of educated action, as Bencze et al. point out, can be slow to take form, given the historical, political and institutional momentum they challenge. Indeed this very point is exactly the primary focus of Theobald and Bedward's chapter (*Balancing Economic Utility with Civic Responsibility*). The authors argue for shifting the purposes and goals of science education to incorporate the educative and transformative. However, they focus on just how and why this is an uphill battle. Transforming the goals of science education to include activism means not only re-educating the public but also working against corporate entities "where shareholder value and maximizing profit is of paramount importance" (p. 2). As the authors point out, the process is slow and piecemeal, but unless and until we help young people "re-imagine community" in the here and now, no matter how local the problem, then the process cannot move forward.

Looking Ahead

Learning science is imperative for informed citizenship and opens possibilities for affecting one's community. However, the purposes and goals of science education have largely been predicated on a vision of science literacy that focuses on knowledge and skill development. Indeed, as I noted in my introduction, many hold the view that if we simply teach students "enough" science (whether it be content or practice) then they will have what it takes to engage in civic society (NRC 1996, p. 22; see also Ryder 2001). However, this functional view of science literacy attends to participation in the world as it is now, without attention to what could be. It ignores the integrated knowledge and practice that may support young people in working with and in science to bring about a more just world for individuals or communities while also, themselves, being transformed by broader and more diverse participation.

The papers in this section thus push beyond functional science literacy towards critical science literacy (see Schusler and Krasny for a specific discussion of critical science literacy). Each chapter embracing the broader notion that individuals ought to have facility with the big ideas and practices of science, but only in so far as such facility privileges critical co-engagement with text, ideas, and ways of knowing and being that frame the knowing and doing of science towards educated action. Indeed, the examples offered in these chapters highlight youths' and teachers' work as incomplete parts of a broader narrative that can serve to make a difference in their communities as well as in their current and future lives. The focus on designing for youth activism and civic engagement, on understandings of how learning environments and/or the broader sociopolitical structures and histories afford or constrain activism, and specific narratives of the youth, teachers and other participants all speak loudly to how and why educated action in science is desirable and possible. The models provided herein make concrete the potential pathways that we can take to making such activity a very real part of the science education agenda. While such efforts are difficult for they challenge power structures locally or from a distance, they are not impossible. The questions that we, as science educators, should be left with after reading these chapters is when and how we might make educated action a central goal to the work we do with young people, teachers and communities.

Notes

1. For a more complete discussion of the Change a Light investigation, see Calabrese Barton et al. (2013).
2. http://getcity.org
3. It is important to note that feminist, multicultural and queer perspectives on science do take on the relationship between scientific knowledge and practices and values.
4. Weinstein's discussions of street medics and guinea pigs are excellent examples of activism transforming the daily practice of science (see Weinstein 2006, 2008a). However, he, too, notes that such a stance is divorced from the discourse and practice of school science (see Weinstein 2008b).

References

Allum, N., Sturgis, P., Tabourazi, D., & Brunton-Smith, I. (2008). Science knowledge and attitudes across cultures: A meta-analysis. *Public Understanding of Science, 17*, 35–54.

Calabrese Barton, A., Birmingham, D., Sato, T., Calabrese Barton, S., & Tan, E. (2013). Youth as community science experts in green energy technologies. *After School Matters, 18*, 25–33.

Committee on Conceptual Framework for the New K-12 Science Education Standards. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.

Mayer, J. (2006). Waiting on the world to change. On *Continuum* [CD]. New York: Columbia Records.

Nasir, N. S., & Hand, V. (2008). From the court to the classroom: Opportunities for engagement, learning, and identity in basketball and classroom mathematics. *Journal of the Learning Sciences, 17*, 143–179.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

Ryder, J. (2001). Identifying science understanding for functional scientific literacy. *Studies in Science Education, 36*, 1.

Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41*, 513–536.

Skamp, K., Boyes, E., & Stanisstreet, M. (2013). Beliefs and willingness to act about global warming: Where to focus science pedagogy? *Science Education, 97*, 191–217.

Weinstein, M. (2006). Slash writers and guinea pigs as models for a scientific multiliteracy. *Educational Theory and Philosophy, 38*, 583–599.

Weinstein, M. (2008a). Captain America, Tuskegee, Belmont, and righteous guinea pigs: Considering scientific ethics through official and subaltern perspectives. *Science & Education, 17*, 961–975.

Weinstein, M. (2008b). Finding science in the school body: Reflections on transgressing the boundaries of science education and the social studies of science. *Science Education, 92*, 389–403.

Angela Calabrese Barton is a professor in teacher education at Michigan State University. Her scholarship focuses on equity and social justice issues in science education, with a particular emphasis on the urban context. Drawing from critical methodologies, she conducts longitudinal ethnographic and case study research focused on student learning in urban community-based and school-based settings. Her work focused on the design of informal learning environments for engaging youth in engineering has been recently recognized by with MetLife Foundation 2012 After School Innovator Award for Digital Learning and is also noted as an Exemplary Program for University/Community Engagement & Outreach by the Association of Public & Land-Grant Universities. She is currently co-editor (with Joe Krajcik) for the *Journal of Research in Science Teaching*.

Index

M.P. Mueller, D.J. Tippins (eds.), *EcoJustice, Citizen Science and Youth Activism*, Environmental Discourses in Science Education,
DOI 10.1007/978-3-319-11608-2