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Samuel B. Fee
Brian R. Belland *Editors*

The Role of Criticism in Understanding Problem Solving

Honoring the Work of John C. Belland

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Preface

We began this project as an effort to honor the memory of John C. Belland. A practitioner and scholar of educational technology, he served his field and his students for decades. And while all good careers eventually come to an end, he is sorely missed for his contributions and support.

John was always questioning. His ongoing pursuit of knowledge and deep understanding of complex issues encouraged all of us to fully understand the tenets of instructional design, and then challenge the preconceived notions of the field. It was never good enough to merely understand the state of the field—to be successful practitioners, we needed to have those understandings, but also be thinking about where we were heading and why.

This text is in many ways a continuation of that mindset. Certainly, we look backward at *Paradigms Regained*, a volume that John Belland and Denis Hlynka authored in 1991. However, our effort here is not to merely take that work forward, but to reevaluate it, consider the state of the field today, and propose ways in which we might think of heading forward in our studies of the theory that drives our practices in educational technology and instructional design. We hope that this volume will serve as an originator of new ideas as well as a tool for prompting reconsideration of preexisting knowledge.

For our part, we would like to thank our coauthors—all of whom have put up with numerous emails, various levels of feedback, and multiple queries regarding deadlines and other minutiae. They have been a pleasure to work with, and we are very proud to have their contributions for this volume. In many ways, the quality of our contributors speaks for the quality of the text.

Brian would also like to acknowledge support from the National Science Foundation (Early CAREER Grant 0953046). Any opinions, findings, and recommendations in this book are those of the respective authors and do not necessarily represent official positions of NSF.

We would also like to thank our families and friends who have supported us throughout this lengthy project, and have been very understanding when we have had to "put the time in" for this volume. Your understanding has always been very deeply appreciated.

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Contents

Understanding Criticism and Problem-Based Learning: An Introduction

Samuel B. Fee and Brian R. Belland

In 1991, Denis Hlynka and John Belland released *Paradigms Regained*, a text that proposed criticism as a mode of research in educational technology (Hlynka & Belland, 1991). Our efforts involve updating some of those ideas initially proposed in *Paradigms Regained*, and extending the conversation into the contemporary discourse regarding problem-based learning (PBL), a pedagogical approach that is enjoying considerable interest among educators in various fields right now. This text will relate criticism and PBL to current trends in educational research, thus making it helpful for practitioners in the field of educational technology.

The Role of Criticism in Understanding Problem Solving reflects upon how learners engage in the processes of problem solving and critical thinking by exploring the critical theories that undergird these processes. It is important to note the distinction between criticism, which is a practice involving interrogation, analysis, and response, and critical theory, which is the body of knowledge that undergirds criticism. Critical theory explains the various impulses and positions that shape educational practices.

The theoretical approach informing this book reflects the ideas of post-structuralist thinkers like Foucault and Derrida, who rejected structuralist assertions that all social constructs reflect certain sets of universal ideas (or structures). Instead, they posited self-perception as central to meaning making. According to post-structuralism, the world is a construct of one's own meaning making, and not a world of preexisting objective structures.

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Central to a discussion of post-structuralism is the idea of epistemology, or the origins of knowledge. If the world is a construct of one's own meaning making, and not a universal set of ideas, then students should learn about the world by making meaning through authentic experiences with the world (Matthews, 2003). In short, they should construct knowledge through learning opportunities that are experiential, active, and collaborative and that also develop problem-solving skills (Jonassen, 2000). The goal for the learner is not to passively absorb and reproduce information, but rather to actively engage with content, work through it with others, and effectively solve problems. The ultimate goals of such learning experiences are content mastery and the development of problem-solving and other critical-thinking abilities.

Problem-Based Learning

PBL is a pedagogical approach in which student learning is centered around authentic, ill-structured problems. Ill-structured problems differ from the story problems traditionally used in education in that the former have multiple possible solutions and solution paths (Jonassen, 2000). In PBL, students also need to learn content to enable problem solving. PBL orients students "toward meaning making over fact collecting" (Rhem, 1998). This of course means that the student is an active participant in the learning process (Bonwell & Eison, 1991). The result is a necessary relaxing of the more traditional classroom structure (with an authoritative instructor) so that students can pursue ideas in a fashion that makes sense to them individually, rather than the specific prescribed approach that the teacher may have in mind. Indeed, many approaches could be relevant for attaining the knowledge developed by the intellectual task at hand. Therefore, students need to be free to develop those knowledge constructions in their own way. This does not mean that there is no structure to the process as some might suggest (Kirschner, Sweller, & Clark, 2006). Rather, a looser structure governs the endeavor and allows the student to maneuver in several different directions under the guidance of an engaged instructor. Of course, there are numerous pedagogical approaches that enable a constructivist way of knowing.

From its origin in medical education (Barrows, 1996), PBL has since spread to many subjects and grade levels ranging from middle school science (Belland, 2010) to university statistics (Mercier & Frederiksen, 2007). For an in-depth discussion, the inaugural issue of *The Interdisciplinary Journal of Problem-Based Learning* contains a particularly useful introduction that lays out the essential elements of PBL (Savery, 2006).

Elements to Bear in Mind

The process of PBL is by no means easy—developing good problems for students to solve is a very challenging and critical step in providing effective instruction (Duch, Groh, & Allen, 2001). These problems need to be reasonably understandable as students begin developing their problem-solving skills, but increasingly ill structured as students progress throughout their education. Developing quality problems is hard—especially when considering the disparity of student knowledge in any given educational environment—and considerable instructor time must be devoted to the processes of gaging student abilities and designing suitable problems. Furthermore, PBL requires a substantial amount of effort working directly with students, as the instructor must be available to mentor students in the problem-solving process as well as the additional exploration of content. Such mentoring diminishes as students become more capable of such thought on their own, but at the introductory level this mentoring requires considerable effort on the part of the instructor to remain effective.

Scaffolding

Another way that instructors can facilitate the process of PBL for students is through scaffolding. Students need some basic content knowledge in order to solve problems and build new understandings. Furthermore, problem solving is generally a more complex process than simply learning basic concepts. This complexity and need for basic content knowledge can be addressed through scaffolding (Land, 2000). Scaffolding refers to assistance that enables students to meaningfully participate in and gain skill at tasks that they would otherwise be unable to complete (Vygotsky, 1978; Wood, Bruner, & Ross, 1976). Scaffolding focuses on students' developing skills (e.g., problem solving) and can be in the form of dynamic teacher-provided assistance or assistance provided by computer-based tools (Saye & Brush, 2002). Within the context of PBL, scaffolding can provide the basis for building more complex conceptual understandings and enable meaningful participation in problem solving.

Other Challenges

One of the frequent complaints heard from students in PBL experiences is that they are being asked to do things they "have not been shown how to do." Usually, this means that the instructors have shown the students the pieces that are required to solve the problem, but have not shown them explicitly how to synthesize these concepts in order to reach their own goals. From an instructor's perspective, this is intentional: the process the student needs to follow has been illustrated and practiced, but the student is now expected to explore how this process applies to a new setting. To the student, this experimentation seems to "get in the way" of the immediacy of completing the task for a grade. But without experiencing the process of experimentation with possible solutions and possible mistakes, students will not be able to become self-sufficient problem solvers.

As a teacher, one should recognize that for students, experiencing some discomfort while pushing instructional boundaries is a good thing. Nonetheless, the focus on independent solving and student-directed exploration encouraged in PBL can lead to novice students feeling overwhelmed by the degree of flexibility they have been permitted (Kay et al., 2000). And this is certainly an issue that any instructor implementing PBL should be watchful for. Additionally, students often erroneously believe that they can solve PBL problems by following algorithms in a lock-step manner.

And, while it is appropriate to allow students a certain degree of intellectual discomfort and uncertainty, it is also important that the cognitive leaps they are being asked to make are within their grasp and that they can see a path to success. The challenge for the instructor, then, is to allow students to experience these frustrations while preventing their frustration from becoming so severe that they give up. Scaffolding provided during PBL approach leads students effectively along this path of negotiating frustration and achieving success. Educators may also find the process of criticism helpful in gauging the effectiveness of their work as well as questioning certain tenets of PBL when planning their treatments.

The Critical Approach

A common goal in education is to get students to "think critically" about premises, findings, and recommendations. Instructors want students to carefully weigh the evidence that supports or contradicts the concepts being considered. Teachers want them to undertake a real process of criticism and not a simple absorption of content. In many ways, this concept represents the distinction between collecting information and generating knowledge.

Of course, researchers look to do the same thing: consider the data presented and question the analysis of those data. Were the appropriate methodologies used? Were all variables fully identified and considered? When evaluating professional work, educators are always questioning. This critical mindset is paramount to our ability to understand theory, research, and the analysis of the contents of our fields.

Critical theory informs the development of epistemologies. An epistemology is a way of knowing—the critical questioning of what knowledge is, and how we know what we know. These ways of knowing then inform selections of instructional models or pedagogy. In turn, this forms the foundation of what educators do professionally when they develop pedagogical approaches or educational treatments.

The Past: The Critical Paradigm

Paradigms Regained proposed the idea of criticism as a third alternative to empirical educational research—the first two being qualitative and quantitative. In doing so, Paradigms Regained sought to bring an artistic or humanistic approach back into the mainstream of educational research and evaluation. Hlynka and Belland (1991) termed this the "critical" paradigm.

The critical paradigm as explored by *Paradigms Regained* was neither quantitative nor qualitative. Its methodology was not scientific—there were no proposed statistical models or any participant observation. Instead, Hlynka and Belland (1991) proposed an approach that could find itself more at home in the worlds of art or literary criticism. The methodological approaches suggested in *Paradigms* included critical theory, criticism and connoisseurship, and semiotics, as well as postmodern and deconstructionist tactics. Many of the readings in *Paradigms* explored the broader context of criticism along with the idea of how the field might implement these ideas.

But the concept of criticism as a tool for research did not become well established in educational technology although it should be noted that it is well established in other educational research traditions such as curriculum studies—not to mention art and literature. Unfortunately, it is not always clear how criticism can be applied to educational technology research. Thus as a methodology for technological research or evaluation, criticism has never really become widely adopted. Nonetheless many professionals in the field of education remain intrigued with the notion and have sought to consider how they might employ more criticism throughout their work—or at the very least, more critical thinking in their analyses.

Revisiting Criticism and Moving the Idea Forward

Perhaps now is a good time to revisit the ideas of *Paradigms Regained* and think about their applicability to the field and how teachers and researchers work today. Criticism can be applied toward both educational research and practice. Educators can reflect critically on data collection, interpretation, and analysis of research. Likewise, instructors can critically consider some of the basic assumptions regarding PBL.

When considering PBL, there are several assumptions that require a critical view. For instance, educators should think carefully about whether PBL will automatically be experienced as authentic by students. It could be argued instead that this would be largely dependent upon students' preexisting knowledge and experiences. Similarly, one may question if students will gain transferrable problem-solving skills by participating in PBL. Transfer is indeed an enigma in educational research; often predicted, it is rarely found. The use of criticism to examine these and other assumptions of PBL can help move PBL research forward.

The approach then that this text takes is to view criticism as a way to step back and look at an educational intervention through a particular critical lens. We view criticism as a valuable approach to guiding meta-analyses and theoretical studies, and think that it can serve to prevent the proverbial "spinning of the wheels" that often happens in educational research. By indicating new potential research questions and directions, a critical approach can invigorate educational research. We are not so much presenting it as an alternative to empirical research; we are saying that it is a type of reflective activity that needs to take place along with that research. Contrary to some, we view criticism not as a subset of a qualitative approach, but rather as an explicitly separate endeavor.

Bringing the Ideas Together

This book starts the conversation concerning how to critically examine the assumptions underlying PBL research. It does this by revisiting the ideals of criticism and exploring their usefulness for studying educational technology interventions to support PBL. Specifically, it does so by exploring a few foundational pieces to set the stage for the conversations on criticism and critical theory. Then the text considers how criticism can be applied to the field of education. It moves from there into a study of criticism as a tool to enhance analysis and interpretation of current research and development work in PBL, with some current examples of activities, specific tools, and research studies. Finally, it concludes with a series of case studies addressing the central concepts of the text and illustrating examples of the application of PBL in various contexts. Within each section of the text, the individual chapters reflect each author's take on the issue at hand, whether it relates to criticism or PBL. In some instances, authors address both; in others, they focus on one topic or the other.

The Structure of This Volume

As mentioned, the text contains four primary sections, each a collection of chapters addressing the specific theme for that section. Each section represents a collection of thinking and activity in the field of Educational Technology over the 20 years since *Paradigms* was published. Specifically, these sections and their chapters include the following.

Critical Theory

This section revisits some of the initial theses presented in *Paradigms*, and allows us an opportunity to include some additional works useful in considering criticism as a way of looking at the educational process. This section includes updated material regarding Hlynka and Belland's arguments regarding postmodernism and connoisseurship. Where *Paradigms* suggested criticism as a third research approach, our argument is for criticism as a tool for analyzing research results from empirical approaches and considering their applicability.

In chapter "Argumentation, Critical Reasoning and Problem Solving," J. Michael Spector and S. Won Park look at criticism as articulated in *Paradigms*—as an additional paradigm for research. They also discuss the impact that criticism has on instructional design work, and how a broad understanding of multiple theories is necessary for practitioners in the field to be truly effective in their practice.

Chapter 3 by Denis Hlynka in this volume, is a twenty-first century primer of postmodernism. Denis updates and continues some of his work from the original *Paradigms* and further considers the role of criticism and the concept of connoisseurship that John Belland put forward years ago.

In chapter "What Does a Connoisseur Connaît? Lessons for Appreciating Learning Experiences," Pat Parrish brings Belland's Connoisseurship idea forward into today's practice. Parrish explains that the complexities of the learning process cannot be simplified by objective measurement. He suggests that criticism actually allows researchers to address questions that more holistically reflect the entirety of the learning process.

Applications to the Field

These chapters build the connections between critical theory and research in educational technology. Specifically, this section addresses criticism in instructional design, how educators might apply theory to practical development endeavors, and the ways in which criticism can inform the assessment of instructional design and development work. The focus here is on developing a critical view of the work as well as how a consideration regarding how it relates to broader cultural issues in general.

In chapter "Developing a Critical Stance as an E-learning Specialist: A Primer for New Professionals," Brent Wilson encourages educational technologists to take a critical stance in their development and problem-solving activities. To assist in this endeavor, he provides a careful consideration of several foundational concepts to help students and practitioners alike contemplate how to evoke that critical stance within their work.

In chapter "Critical Theory and the Mythology of Learning with Technology," Norm Friesen de-mystifies critical theory—especially in regard to how it can be applied to the issues of technology, politics, and social change. The chapter highlights the importance of the need to think critically, since not doing so leaves practices open to the manipulation of the dominant hegemonic influences of culture.

Brian Belland illustrates the practice of applying critical theory to educational technology by looking at technology integration in chapter "Habitus, Scaffolding, and Problem-Based Learning: Why Teachers' Experiences as Students Matter." He applies the sociological concept of habitus to explore teachers' past experiences as a precursor for observations of limited technology integration. He offers suggestions for future research as well as teacher education.

Michele Dickey concludes this section with her chapter, "The Aesthetics of Game-Based Learning: Applying John C. Belland's Connoisseurship Model as a Mode of Inquiry." Michele proposes that video game environments, as a reflection of the combinations of art and science, are well served by a critical mode of evaluation.

Problem-Based Learning

The focus of this section is to provide a collection of recent findings in the PBL literature and to critically analyze the current thinking on PBL. Specifically, the focus is on the current issues and debates revolving around educational technology applications that support PBL, such as scaffolding, modeling, and the instructional design of PBL units.

This section begins with Hung and Lockard's chapter, "Integrating Metacognitive Prompts and Critical Inquiry Process Display to Scaffold Learners' Development of Problem-Solving Skills." This work details a problem-solving support tool and considers its effectiveness at creating meaningful problem-solving strategies using a scaffolding approach.

Chapter "Issues in Problem-Based Learning in Online Teacher Education," written by Brenda López Ortiz, considers how PBL is applied in online teacher education. This chapter provides a critical analysis of several studies relating to the design and practice of online education.

Chapter "The Fallacies of Problem-Based Learning Viewed as in a Hermeneutic Perspective of Better Teaching Practices," by Margaret E. Bérci, closes out this section of the text. Margaret continues the discourse surrounding six fallacies of PBL and suggests that by hermeneutically examining each in turn, they might be viewed as strategic advantages.

Case Studies and Current Practice

A collection of case studies builds upon an exploration of the central concepts of this volume text form the last section of the book. Most important, these represent the praxis of the theoretical discourse within the earlier sections. Examples include individual instructional models, implementation into the classroom, and curricular models.

Charlotte Belland's chapter describes a course in which design students need to build conceptual knowledge while also building themselves up as independent learners. She considers specific content that needs to be delivered, as well as how that fits into the general curriculum, then shares an overall assessment of the outcomes for the course.

In the next chapter, Rick Voithofer considers a project designed to teach genetic literacy to middle school students. He looks at the role of a critical approach to scientific knowledge in the development of this PBL treatment. Of particular note, this project draws upon existing research about under-represented groups to offer an approach to genetic literacy that considers the needs and perspectives of groups who are often left out of scientific discourses.

Chapter "Correlating Problems Throughout an Interdisciplinary Curriculum," by Fee and Holland-Minkley, considers the use of PBL across an entire curriculum as opposed to a single course or individual learning exercise. In this case study, the complexity of problems increases as the students' problem-solving skills build upon skills previously acquired through coursework.

The final chapter covers service learning, extending the context of PBL beyond the classroom and into the lives of students. Nick Eastmond and Jon Thomas view the subject through their own critical lens in this chapter and contemplate the potential ethical dilemmas presented through a PBL approach to service learning.

These chapters come together to form a theoretical but practical view of the field of educational technology—particularly in terms of criticism and PBL. The argument here is not for a new paradigm, but for criticism as a lens for viewing the work that educators do: in terms of both instructional development, and the evaluation and assessment of those activities. This critical approach enables us to effectively place legitimate education treatments into a diverse and ever-changing world. The result is learning that reflects more successfully the needs of our society: critical-thinking abilities and problem-solving skills.

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Part I
Critical Theory

Argumentation, Critical Reasoning, and Problem Solving

J. Michael Spector and S. Won Park

Human cognition is wonderfully complex and multifaceted. Memory of past events, misremembering past events, recognizing friends, mistaking one person for another, planning a vacation, deciding what course of action to pursue, shopping for a gift, and solving a puzzle all involve cognitive processes that are generally taken for granted. Not surprisingly, it is when we discover a memory error or learn that we have mistaken one person for another that we are inclined to pay attention to our cognitive abilities. “Why did I misremember that event?” “Why did I think that person was someone else?”

Such questions, which seem to be associated with a natural desire to be correct and accurate, might lead one to an investigation of how knowledge is developed, which in turn could lead one to investigate the nature of reasoning. Philosophers have investigated such questions for many centuries. More recently, psychologists have turned an investigative eye to the nature of cognition, including reasoning and problem solving. More fundamentally, most people come to think about their own reasoning processes from time to time. The focus in this chapter is on a combination of these traditions with regard to reasoning and problem solving. Of particular interest is a naturalistic approach (Spector, 2010) that looks at how individuals reason through challenging problems and develop expertise in the broad area of critical reasoning. A naturalistic approach takes into consideration noncognitive aspects of reasoning and problem solving that occur in actual cases. Of course, it is well established that different kinds of problems require different kinds of reasoning (Jonassen, 2004), but a more general view of reasoning and problem solving will provide a perspective that can inform more specific support for reasoning and problem solving.

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Engineers, instructional designers, planners, and many others work with problems that are complex and ill structured. What makes a problem complex is partly based on the nature of the problem (e.g., many factors influencing the problem situation, factors that interact in nonlinear ways, delayed effects of actions and decisions, and ill-defined aspects of the problem) and partly on the nature of the problem solver (e.g., an experienced person may regard a problem as relatively straightforward and simple whereas an inexperienced person may be puzzled by the very same problem situation).

Examples of potentially complex problems include (a) the design of a bridge to span a particular body of water, (b) the development of an economic policy to resolve a persistent budget deficit, (c) determining how best to treat a patient suffering from multiple chronic illnesses, (d) finding the fault or faults in an electronic circuit that fails intermittently, and (e) planning a large social event. In short, complex problems occur in nearly every aspect of life and in nearly every subject domain.

Jonassen and Hung (2008) pointed out that complexity of problems can be determined by four aspects: (a) the breadth of knowledge, (b) the difficulty level of the major concepts in a problem, (c) the intricacy of problem-solution procedures, and (d) relational complexity among major concepts in a problem. Complex problems embody many different sets of knowledge and often involve various constraints and alternatives. Complex problems are often ill structured and dynamic in nature, requiring regular monitoring and adjustment as the situation evolves and new information is revealed (Dörner & Wearing, 1995; Funke, 1991; Funke & Frensch, 1995). There are no single decisive solutions to complex, ill-defined problems; in other words, there are multiple paths to solutions. Effective problem solvers should not only possess the capability to manage a huge knowledge set but also have the ability to execute higher-order, critical thinking skills. How do these effective problem solvers develop this vast knowledge base and advance their critical reasoning skills?

To motivate the discussion, first consider a representative problem-solving situation that many persons have experienced—planning a trip. Here is the scenario:

> George and Grace recently received an invitation from their close friends, Julio and Julietta, to meet them in LA (Lower Alabama) to spend a week in a beach house on the Gulf coast renewing their friendship. They have not seen each other for more than 2 years. Upon receiving the invitation, George and Grace look at their respective schedules to see if the proposed dates will work, and they do. Then they look at their savings to see if they can afford such a trip, and, as it happens, they do have adequate funds for the trip. Next they begin to reminisce about old times with the other couple. They need to give an answer to Julio and Julietta soon, so they then begin planning details, keeping in mind their schedules and budgets, to see if they can indeed follow their initial inclination to commit to the trip. Questions they might ask each other include what to pack, how best to get there, what gifts they might bring to their friends, would another location be preferable, and so on.

The point of this scenario is to emphasize that (a) there are both cognitive and noncognitive aspects to many problems (e.g., facts about schedules and finances as well as feelings about friendship and the location), (b) some aspects of the situation are related and likely influence each other (e.g., the location and their budget), (c) previous experience with similar problems are relevant (e.g., prior trips to LA and maintaining relationships with other friends), and (d) alternative solutions may exist that would satisfy their desire to renew the friendship while keeping savings intact.

These four kinds of considerations can be found in many different problem-solving situations and are likely to influence one's reasoning about the solution. Addressing such considerations often requires some reflection on the nature of the problem and some deliberation about alternative means to resolve the situation.

In summary, reasoning is a critical element of problem solving. What is the nature of reason and of being a rational individual? A traditional definition of being rational (Friedman, 2002) includes such things as:

- Being goal oriented—having an identifiable goal or purpose that one wants to attain for whatever reason.
- Conducting an analysis of the current state of affairs and the desired state of affairs—this involves being able to specify both the goal and the current situation, which will then lay the foundation for identifying alternative means of achieving the goal and then analyzing which means might be more feasible or optimal in attaining the goal according to one or more criteria.

Goals arise frequently in every aspect of life. Some are short-term—"I want to have fish for dinner" or "I want to renew our friendship"—and some are longer-term—"When I grow up I want to be a teacher" or "I want to maintain a lifelong friendship." The second characteristic (conducting means–ends analysis) is often more challenging than the first. An analysis of alternatives implies (a) that one can identify multiple ways of reaching the goal, (b) that one can determine both desirable and undesirable aspects among the alternatives, (c) that one can prioritize the alternatives in some way, and (d) that one can then select the most desirable alternative according to relevant criteria (Spector, 2001). The second characteristic of rationality may also include an examination of assumptions that apply to the goal sought as well as an examination of the consequences and implications of pursuing one course of action rather than another.

In short, the second characteristic of rationality implies a process of deliberation. One might characterize this kind of deliberation on assumptions and implications as a reflective process—reflecting on the quality of one's reasoning. Some might even call such reflection a form of metacognition since it is directed at one's own reasoning processes (Kuhn, 1999). Being rational implies that a person engages in deliberative, reflective thinking. In any case, deliberation and reflection seem desirable, but they require one's time and conscious effort. This kind of reasoning is not so easy or natural as simply deciding to act out of habit and grab some already prepared fish and chips at the closest fast-food provider.

Reasoning

The landscape of reasoning has been discussed in a number of ways by both philosophers and psychologists (Braine, 1990; Rips, 1984; Schauble, 1996). There are several traditional distinctions to consider. One is between formal and informal reasoning. A second is between deductive and inductive (nondeductive) reasoning, which is often associated with logic. The word "logic" is derived from the Greek word "logos" which is used alternatively for "word," "plan," or "reason." Logic has come to be used in a number of ways in modern times. In everyday use, being logical is considered roughly equivalent with being rational. Within the professional community of logicians, the domain of logic is comprised of arguments.

An argument can be defined as a collection of statements, some of which are offered in support of another (Halpern, 1989; Toulmin, 1958). Those supporting statements are called premises and the statement being supported is called the conclusion. So the landscape of logic is comprised of arguments, each of which consists of statements offered in support of another statement. It seems that argument or argumentation skills do not naturally develop. Kuhn (1991, 1993) studied 160 people at different ages and found that only a few of them could consistently develop quality arguments. Other studies also indicated difficulties and weaknesses of adolescents and young adults in constructing arguments and developing argumentation (Brem & Rips, 2000; Klaczynski, 2000).

One concern is on determining the quality of arguments—distinguishing good arguments from bad arguments, or sound reasoning from unsound reasoning. Like other enterprises involving quality determinations, standards or criteria are needed to sort out the good ones from the bad ones. Since the nature of an argument is to offer statements intended to support another, one place to start is to determine the kinds of support that might be offered. Two kinds come to mind immediately: conclusive support and nonconclusive (suggestive) support. The nice thing about this distinction is that it is all-inclusive and the two categories are mutually exclusive. Moreover, such a distinction allows for correction of the type of support offered—that is to say that the person presenting the argument may believe that he or she is offering conclusive support when only suggestive support has been provided.

Before evaluating the adequacy of the support actually offered, one ought to be sure the argument is located in the proper category since the evaluation standards are different. An example of this problem can be found at the end of a correlation study in which the researcher claims that the study proves a certain point. Proof is a strong notion that is best reserved for the strongest types of argument, which are generally considered to be of the conclusive variety (deductive arguments). Correlation studies may suggest or show something, but they do not establish conclusions with certainty. Even rigorous controlled experimental studies aimed at establishing causality do not establish conclusions with certainty; rather they may establish conclusions with high degrees of probability. Mathematical proofs are familiar examples of the deductive variety. Statistical studies are familiar examples of the inductive or nondeductive variety. It would be wrongheaded to hold both kinds of arguments to the same standard. Next comes a short discussion about these two types of arguments.

Deductive Arguments

In assessing the adequacy of the premises of a deductive argument in supporting the conclusion with certainty, another distinction should be considered—that between form and content. As it happens, all that is needed to guarantee the truth of the

Table 1 Logical connectors

	P	Q	P and Q	P or Q	Not P	If P, then Q
1	True	True	True	True	False	True
2	False	True	False	True	True	True
3	True	False	False	True	False	False
4	False	False	False	False	True	True

conclusion based on the truth of the premises in a deductive argument is to consider the form of the argument—valid deductive argument forms are exactly those which are guaranteed to preserve truth—that is to say that in a valid deductive argument, if the premises are true, the conclusion must be true.

In determining the quality of a deductive argument, the focus is not on the content of the argument—validity has nothing to do with the actual truth or falsity of the statements that comprise the argument. Rather, validity is totally determined by the form of the argument. To determine validity one strips away the content and leaves behind just the logical form of the statements involved. This process is worth illustrating. Consider this argument implied in many discussions about American presidential elections:

If a Republican is elected President, then a Democrat will not be elected President.
A Republican will not be elected President.
Therefore, a Democrat will be elected President.

For the sake of this illustration, ignore the difference in tense ("is elected" and "will be elected" are considered synonymous). Is this a valid argument? It seems reasonable, and one might be inclined to simply accept the argument as reasonable and proceed on one's merry way.

It is customary to adopt the convention of representing discrete, simple assertions embedded in a compound statement by different letters. It is also customary to use a set of statement connectors based on familiar English usage, such as: and, or, not, and if-then. The commonly accepted definitions of these familiar connectors in a two-valued logic are based on a truth table (Table 1).

What does this truth table mean? It means that a conjunction of the form *P and Q* is true in just one situation—namely when both P and Q are true (see row 1 and column 3 in Table 1). Likewise, a disjunction of the form *P or Q* is false in just one situation—namely when both P and Q are false (row 4, column 4). Such usage generally conforms to the ordinary use of these connectors. The one case where the truth table definition may be different from common usage is with regard to IF-THEN statements when the antecedent (the statement following *IF*) happens to be false. These statements are called counterfactuals (rows 2 and 4 and column 6) and are treated as true in a two-valued logic since no evidence is produced to demonstrate that the entire compound IF-THEN statement is false—the person who knowingly utters a counterfactual admits no evidence can be produced to show that the statement is false; the only IF-THEN statements that take a risk are rows 1 and 3 in Table 1, which is the case with the antecedent being true. A person making a counterfactual claim (rows 2 and 4 and column 6), in an important sense, takes no risk, and there is nothing at stake. So the two cases with an admittedly false antecedent are considered true. Beware people who utter counterfactuals—they (both the statements and the people who utter them) are vacuous (as in devoid of meaningful content).

What then is the logical form of the argument involving Republican and Democratic candidates? Let "R" stand for "a Republican is elected" and "D" stand for "a Democrat is elected." The logical form can then be represented as follows:

If R, then not D.
Not R.
Therefore, D.

Does this logical form preserve truth? Can there be a case where the premises of such an argument would be true but the conclusion false? It is possible to build a complex truth table for this very complex statement: "[If (If R, then not D) and (not R)] then D"—that would be the case representing true antecedent and a false consequent in an IF-THEN statement (row 3 in Table 1). Building such a table seems like hard work. Here is an alternative to reason through the determination of validity. When could both premises of this argument be true? Well, when "R" is false, the second premise is true, since the NOT operator simply reverses the true value of the statement negated. But, when "R" is false, the first statement represents a counterfactual—one of those vacuous claims made by vacuous people—and it would be true regardless of the truth value of "D." Imagine that. "D" could be false and the first premise would be true when the antecedent is false (when "R" is false). So, the row in a truth table that has "R" false and "D" false would be a case that makes both premises true but the conclusion false.

However, some would say that the argument still makes sense since a person can only belong to one political party at any point it time and that only one person will be elected President in any particular election in the USA, which has only two active political parties. It would be wrong to say that the argument as represented makes sense, though. Fallacious arguments can be easily constructed with the same logical form. Consider the following example:

If a rich person is elected, then there will not be a decline in taxes for the poor.
But a rich person is not elected.
Therefore, there will be a decline in the taxes for the poor.

This argument has the same form as the previous argument. Is it a convincing argument? Should anyone be persuaded? If not, why should one be persuaded by the prior argument? In fact, both arguments fail the test of validity and should convince no one. Nevertheless, those who have accepted the first argument might have unconsciously added an additional premise: "A Democrat or a Republican will be elected"—"D or R." That simple additional premise rules out the one case that invalidates the simpler argument. So there is some value in examining one's assumptions—especially in making those assumptions explicit. Here is a revised and valid argument form:

If R, then not D.
Not R.
D or R.
Therefore, D.

Table 2 Toulmin's argument structure

1. Claim	Standpoint that people hold
2. Data	Statements that serve as evidence to support the claim
3. Warrant	Statements that justify the relationship of the data to the claim
4. Backing	Underlying assumptions of the claim that are often implicit
5. Qualifier	Conditions under which the claim holds true, which add the degree of force from data to claim
6. Rebuttal	Assertions that contradicts the claim or represent exceptions to the claim

In this argument, it turns out the first premise is not needed at all. The truth of the second and third premises is sufficient to establish the truth of the conclusion—this is called a disjunctive syllogism for those taking notes. An important lesson to be learned in this excursion into deductive logic is that identifying unstated assumptions is a critical aspect of critical reasoning.

Inductive Arguments

There are far too many variations of inductive arguments to treat at the same level of detail just provided for deductive reasoning. However, the same general concerns and kinds of tests apply. First, one examines the form of the inductive argument. If the form is acceptable, then one can investigate whether or not the premises are *probably* true. The kinds of evidence that are involved in supporting probable truth are far more complex and involve a variety of statistical inferencing methodologies. As already mentioned, the tests for an acceptable inductive argument form are more complex than those for a valid deductive argument form. It should be noted that this discussion of inductive arguments intentionally ignores matters of rhetorical style and persuasiveness, as those issues have nothing to do with validity. Unfortunately, many people count on rhetoric and persuasive techniques rather than on the validity and soundness of the reasoning involved.

Toulmin's (1958) model of argument analysis is most frequently used to develop criteria for evaluating the quality of an inductive argument in the literature. Toulmin identified six elements that a sound argument may comprise: (a) claim, (b) data, (c) warrant, (d) backing, (e) qualifier, and (f) rebuttal (see Table 2). According to Toulmin, arguments can be analyzed with these categories and those containing six components are considered strong although some of them need not necessarily to be explicit.

While Toulmin's model focuses on the structure of arguments, more recent studies on argumentation have started emphasizing a dialectical aspect of argumentation. The contemporary argumentation theorists acknowledge that argumentation should be regarded as a discourse that involves the social process between two or more individuals (Kuhn & Udell, 2003; Nussbaum, 2008, 2011); this happens to be true for both deductive and inductive arguments. Arguments (collections of statements offered in support of another statement) can be viewed as the products of dialogical argumentation and discourse (O'Keefe, 1982). Revealing hidden assumptions (as illustrated above) and identifying the implications of accepting the conclusion often occur in a dialogical or discursive context. This more comprehensive view of arguments has raised discussion about constraints in the Toulmin's model of arguments as an evaluative tool. That is, Toulmin's model fails to consider argumentation as a social process that involves two sides (van Eemeren & Grootendorst, 1999). Several alternative frameworks of argumentation have been proposed, including van Eemeren and Grootendorst's (1999) model of a critical discussion, Walton's (2000) dialogue theory, and the Bayesian model of everyday arguments (Andriessen, 2006; Nussbaum, 2011). These alternative models are more practical for evaluating the content of arguments as they take into account the dialectical process of generating arguments.

Reasoning Going Forward

To conclude this section on reasoning, it is worth noting that other forms of reasoning and logic have been proposed by philosophers and psychologists, including abduction, multivalued logic, and so on. What is worth carrying forward for the purpose of this discussion is that when reflecting on one's own reasoning that understanding the kind of reasoning involved and especially the form of that reasoning is important. Moreover, when deliberating on the quality of one's reasoning, a critical factor is in determining whether or not adequate evidence has been developed to support the conclusion or decision to be taken. Reflection, deliberation and consideration of alternatives are important aspects of reasoning regardless of the kind of reasoning involved. Critical reasoning involves examining assumptions as well as implications and this process is likely to occur in a dialogical or discursive context. Consequently, argumentation and critical reasoning can be as regarded in a naturalistic way as social processes involving others.

Mental Models and Schemas

The quality of an argument can be viewed as a product of sound reasoning. Arguments are an external representation of one's reasoning. What mental processes are involved in developing valid arguments? The internal representations of an individual's reasoning can be grouped together using the term "mental models" (Johnson-Laird, 1983, 1989; Norman, 1983). The internal cognitive processes of deliberation and reflection are hidden in the sense that they are not viewed directly and immediately. People make inferences about those processes based on external representations and observable entities and events, such as things that people say or write, diagrams that people create, actions that people take, and solutions to problems that people solve.

Cognitive psychologists are in general agreement that people have the ability to process a variety of different kinds of information and act appropriately in many different situations. These abilities include perception, pattern recognition, storing and retrieving different kinds of information, and acting on previously gained experience (Anderson, 1983; Atkinson & Shiffrin, 1968; Schunk, 2008). Pattern matching is an ability at which humans excel (Rumelhart, Smolensky, McClelland, & Hinton, 1986). Humans can quickly recognize an object, as shown by the ability of most people to recognize a familiar face in a group of people. Pattern recognition is a critical cognitive process that involves perceiving, remembering, and comprehending, which are all essential in many decision-making and problem-solving situations.

Pattern matching and recognition are generally believed to be based on schema, which are well-established in memory based on past experiences (Gagné, Yekovich, & Yecovich, 1993; Schraw, 2006). Moreover, it is not simply patterns of familiar objects that people can recognize and match with prior experience to help select appropriate actions. People also recognize more general situations that call for particular kinds of responses, such as the way that a restaurant is organized with a host or maitre-de who will seat you, with a different person taking your order, and possibly with others bringing you drinks and clearing the table when you are finished. Because such a situation has been experienced many times, you generally know what to do in a restaurant even though it may be your first visit to that particular restaurant. Schank and Abelson (1977) and others refer to the ability to recognize such general situations and respond appropriately as scripts rather than as schemas. In what follows, the term "schema" will be used to refer to specific cases involving previous experience in that situation as well as general cases involving unfamiliar objects set in a familiar kind of situation. Schemas involve somewhat complex but well-established internal representations that enable a person to respond immediately without any thought in a particular situation. It is often the case that a person may have difficulty in explaining why he or she acted automatically in a certain way in a particular situation, which is evidence that the internal representation is so well established and so automated that little or no conscious thought is devoted to retrieving and activating the schema. With regard to identifying and reflecting on one's assumptions in reasoning through a particular problem, when schemas are involved it is sometimes a challenge to bring all relevant assumptions into consideration. It should be obvious that a schema necessarily involves a simplification of the actual situation in which it is invoked. Only a few key aspects of the situation are needed to activate a schema, such as a host or hostess at the front of the restaurant for seating or a receipt left inside a holder on a tray for payment.

Many problems do not lend themselves to resolution based solely on retrieving and activating schemas (well established prior experience). According to cognitive psychologists (Greeno, 1989; Johnson-Laird, 1983, 1989), humans have another way to resolve unfamiliar and puzzling problems. We naturally create internal models of the situation and use those internal representations to think through an unfamiliar problem. These models are created just when needed and are typically called mental models (Johnson-Laird, 1983, 1989). Mental models are generated to represent the perceived structure of the external world or puzzling phenomenon. These mental models are not and could not be replicas of the world. Like a schema, a mental model is necessarily a simplification. Such simplifications are useful in helping a person understand an unfamiliar situation or puzzling phenomenon. Including relevant aspects of the problematic situation are critical for the development of useful mental models; this will be taken up again in a subsequent section involving the implications of internal representations for the design of effective learning and problem-solving support.

Mental models and schemas are related and interact in many problem-solving situations. A person confronts a problem or situation and creates one or more internal representations to respond to the situation. Domain-specific knowledge previously learned, established schemas and newly created mental models may be brought to bear in this process of understanding the problem at hand. The main purpose of this process is to create a causal explanation of the puzzling problem or phenomenon like building an argument. As Kant noted in The Critique of Pure Reason, it is natural and unavoidable for people to think in terms of cause and effect, just as space and time are added to our experience of the world. The reasoning process of invoking schemas and integrating newly constructed mental models fits well with Piaget's (1985) epistemology. When a schema is invoked and a newly constructed mental model can be fit easily within that schema, one might say that assimilation has occurred. When no existing schema is found to help resolve the situation, a newly constructed mental model might be said to lead to a process of accommodation, which involves a refinement of an existing schema. One might also introduce the notion of an internal cognitive structure, which is akin to a repository of schemas (Gentner, 1983; Schraw, 2006). Humans are generally very good at modeling their experiences. We can anticipate new states of affairs and predict likely outcomes of existing states of affairs with relative ease, thanks to our ability to create and manipulate internal representations (mental models and schemas). Figure 1 suggests that over time, mental models are constructed and become associated with other mental models and eventually with schemas, which may be modified in order to take into account what has been learned from activation of the mental models and schemas.

It is possible to distinguish two different kinds of mental models: perceptual models and thought models (Stachowiak, 1973). Glaser, Lesgold, and Lajoie (1987) and Johnson-Laird (1983) consider perceptual models to be appearance or structural models that are used to represent an external reality. This kind of model serves to mediate between internal visual images and external representations in the form of statements, whereas thought models also include qualitative processes and inductions that support the construction of artifacts to represent complexity and causal relationships. In any case, the point here is that there is an interaction between the construction of internal models and external representations of those models. The construction of internal models serves as a basis for critical reasoning and associated external representations such as argumentation; in turn, critical reasoning and argumentation can advance and proliferate mental models, which as a whole facilitates better problem solving.

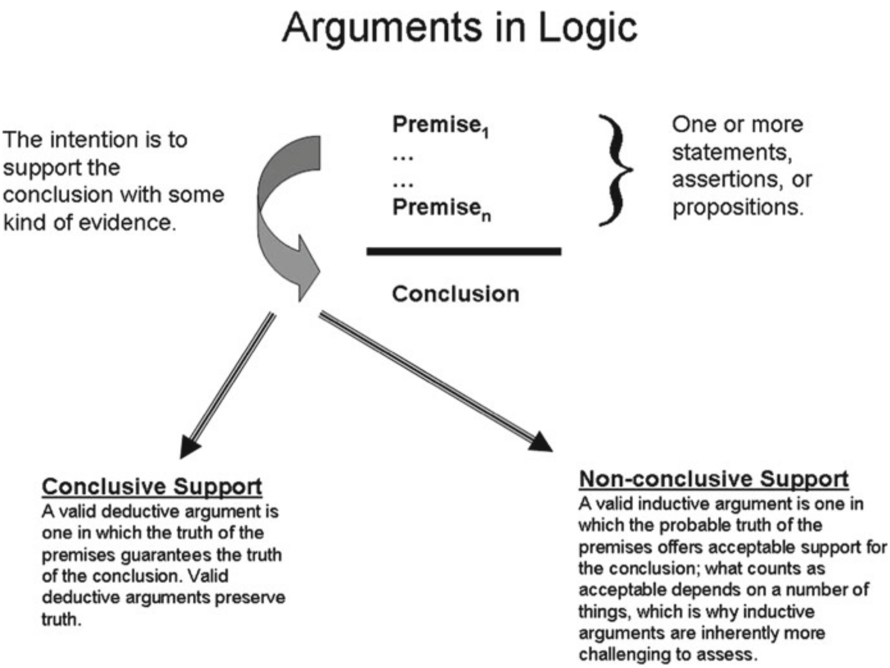

Fig. 1 Mental models, schemas, and the development of expertise

Implications for Learning and Instruction

Researchers are typically familiar with and concerned about ecological validity, which is the degree to which an experimental situation reflects a naturally occurring, real-world situation. Instructional designers have a related principle that suggests that primary instruction and practice should involve problems and situations that closely resemble problems and situations that are likely to be encountered subsequent to instruction. Instruction itself as well as research designs should have a high degree of ecological validity. With regard to instruction, understanding how people process information and reason about problems is a critical aspect of instructional ecological validity. Instruction that ignores how people process information and reason about problems is less likely to be effective (Farnham-Diggory, 1972; Reigeluth, 1999). Many examples can be cited to support this basic instructional design principle. The limitations of working memory are well established. When an instructional system or learning environment violates those limitations by presenting too much information all at once with too little learning support, cognitive overload results, learning outcomes become suboptimal, and many learners become frustrated (Hambrick & Engle, 2003; Sweller, 1988). The major implication from the previous discussion for learning and instruction, therefore, is that mental models and schemas should be taken into account when designing instruction and implementing support for learning and performance (Seel, Al-Diban, & Blumschein, 2000).

While this implication for designing learning support may seem obvious to many, there is the subsequent challenge to be more specific about all that is implied in such a principle. How can learning designs take into account the hidden processes of constructing mental models, activating schemas, and developing ever more useful and productive internal representations? If one is only concerned about performance and learning outcomes, then perhaps such questions are not a pressing concern. However, if one believes that the development of robust and flexible internal representations is critical for the development of competence and expertise, then such questions become a foundation concern for instructional design, which is what is being proposed in this chapter.

When learners are in an instructional situation, they will naturally be engaged in activating schemas and constructing mental models, based on the earlier discussion. Another way to think about the implications for the design of effective instruction is through the lens of cognitive efficiency, which can be defined as the optimal effort required to solve a problem correctly or perform a task in a satisfactory manner (Hoffman & Schraw, 2010). The notion of cognitive efficiency involves a tradeoff between time and resources and desired outcomes. There are three primary measures of cognitive efficiency: (a) instructional efficiency, (b) processing efficiency, and (c) outcomes efficiency (Hoffman & Schraw, 2010). The first and third are already familiar to most instructional designers who are concerned that learners achieve acceptable performance in a reasonable amount of time. Processing efficiency is most directly related to the reasoning processes discussed previously and clearly influences both instructional and outcomes efficiency. Measures of cognitive efficiency and the means to enhance it are well known to instructional designers. There are two factors that have yet to be fully explored in the research literature on cognitive efficiency and instructional design research: (1) individual differences that impact internal cognitive processes, and (2) how cognitive efficiency improvements and other instructional design principles can be effectively applied to situations involving complex and ill-structured problem-solving tasks. These considerations are likely to be important challenges for future research (see the last section of this chapter).

While there is much that is unknown and difficult to determine with regard to how individuals process information, solve problems, and develop competence in reasoning about challenging situations, some initial steps have been taken. First, it is now well established that instruction should be centered around meaningful and realistic problems (Lave & Wenger, 1990; Merrill, 2002). Second, when analyzing problems and tasks to be learned, it is also well established that there are different kinds of problems requiring different kinds of learning support (Jonassen, 2000). Third, representations of internal mental models and schemas are now being used explicitly to support learning (Spector, 2010, 2011).

Before presenting a general framework to support model-based reasoning, a discussion of the different kinds of models that might be used in alignment with internal models is relevant. Just as there are different kinds of internal representations, there are a variety of different kinds of external representations or models. External models come in many forms. Some are mathematical in nature, such as a regression model. Some are graphical, such as a schematic drawing. Some are in the form of arguments

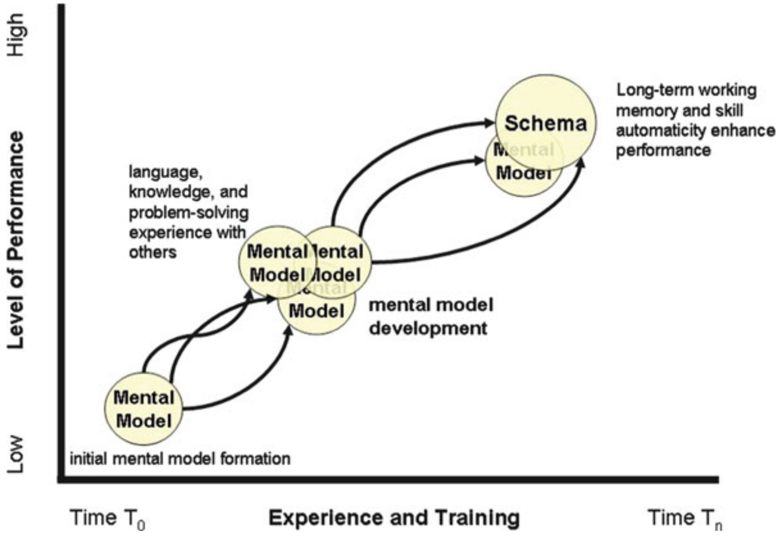

Fig. 2 Arguments involved in reasoning

with premises and a conclusion. Some models involve video or animation depicting how a device works. Some involve a combination of different forms of representation. Figure 2 can be considered an external representation of a mental model about the nature of arguments; others might represent their mental model of arguments quite differently. Table 1 can be considered an external representation of the definition of ordinary conjunctions in English; others would surely represent their understanding of those connectors differently. The equation $e=mc^2$ might be considered an external representation of Einstein's mental model of the relationship between energy and mass.

Which external representations are effective when, for whom, and why? One temptation is to think at the level of learning styles and preferences based on a belief that those individual differences are key factors in learning effectiveness. Certainly learning styles and preferences are often relevant, but they do not reach a level that aligns easily with how a person processes information. Some learners may say that they are visual learners, for example. They may even have some evidence for such a claim. However, this does not resolve the issue of which visual models will be easily aligned with a particular learner's internal representations and, as a consequence, be likely to help that learner.

Another approach is to have a general sense of common problems encountered when confronted with different kinds of challenging tasks. A cognitive task analysis can be a start along these lines, and cognitive task analysis has proven useful for the design of instruction (Clark, 2008). Those who have implemented intelligent tutoring systems have developed libraries of commonly encountered mistakes and misunderstandings that can be used to inform an instructional decision such as selecting an appropriate learning activity or providing targeted feedback (see van Lehn, 1988, for example). Dörner (1996) reported that those confronting complex and ill-structured problems experience common challenges and difficulties, including: (a) a failure to grasp the full breadth of a problem situation with a tendency to focus on just one component or familiar aspect of the problem, (b) the inability to reason effectively about nonlinear relationships among different aspects of the problem, and (c) difficulty in understanding and predicting delayed effects and the accumulation of effects over time.

A third approach to taking into account internal cognitive processes that has recently been explored is to elicit from a learner representations of that learner's internal mental models and schemas and use those in the course of instruction (Seel, 2003; Seel, Al-Diban, & Blumschein, 2000).

The question of whether and how we can influence model-building activities through instruction has long been at the core of various educational approaches (see, for example, Karplus, 1969), and in the field of research on mental models we can also find a strong pedagogical impetus from the very beginning. According to Johnson-Laird (1989) and other authors we can distinguish between several sources for the construction of mental models: (1) the learner's ability to construct models in an inductive manner, either from a set of basic components of world knowledge or from analogous models that the learner already possesses; (2) everyday observations of the outside world combined with the adaptation of cultural models; and (3) other people's explanations and their adaptation. Among these sources, the third one seems to be especially relevant for instruction.

According to Carlson (1991), it is possible in principle to design instruction to involve the learner in a process of inquiry in which facts are gathered from data sources, similarities and differences among facts noted, and concepts developed. In this process, the instructional program serves as a facilitator of learning for students who are working to develop their own answers to questions. On the other hand, instructional programs can present clearly defined concepts followed by clear examples. A designed conceptual model may be presented ahead of the learning tasks in order to direct the learner's comprehension of the learning material. More generally, we can distinguish between different paradigms of model-oriented instruction depending on whether they aim at (a) self-organized discovery and exploratory learning, (b) guided discovery learning, or (c) learning oriented toward the imitation of an expert's behavior or the adaptation of teachers' explanations.

In the next section, a framework that integrates aspects of all three of these approaches into a general framework will be presented. This framework should be considered provisional at best. Research to explore this and other possibilities will conclude the discussion.

A Framework for Integrating Models in Learning and Instruction

A well-established instructional design framework that has wide applicability is cognitive apprenticeship (Collins, Brown, & Newman, 1989). The cognitive apprenticeship model involves six different methods and the notion that learners new to a domain require more support than more experienced learners. The six methods are: (a) modeling (e.g., show how an experience person solves the problem), (b) coaching (e.g., observe performance and provide timely and constructive feedback), (c) scaffolding (e.g., implementing explicit support to facilitate learners' problem solving), (d) articulation (e.g., getting learners to talk about how they are thinking about solving a problem), (e) reflection (e.g., encouraging learners to compare their solution with that of others), and (f) exploration (e.g., allowing learners to investigate new problems and problem approaches on their own with little or no guidance).

The cognitive apprenticeship model is consistent with Gagné's (1985) nine events of instruction (a claim that many will find to be quite controversial) as well as with Merrill's (2002) first principles of instruction, just as the relative new notion of cognitive efficiency is consistent with a great deal of traditional instructional design. Essentially, cognitive apprenticeship can be characterized as a significant and explicit cognitive extensive of earlier instructional design models. What is really new and only recently emerging is the recognition that it is important to take into account how individuals think about complex problems and process information in the course of solving problems. In any case, there is a great deal of evidence that cognitive apprenticeship is a useful instructional design model (Palincsar & Brown, 1984; Roth & Bowen, 1995; Schoenfeld, 1994; Shuell, 1996). The next step is to refine that model to explicitly account for internal reasoning processes.

Model-facilitated learning (MFL) is an instructional design approach aimed explicitly at promoting model-based reasoning. MFL builds on cognitive apprenticeship (Collins et al., 1989) and Merrill's (2002) first principles. MFL is centered around and facilitated by models in the form of expert and student representations of a problem or problem space, a solution approach, and/or a solution. The models may or may not be created by learners, but learner interaction with models is generally an integral aspect of learning activities just as interacting with models is an integral aspect of living and learning in general.

The particular area for which model facilitated learning was designed involves complex and challenging learning tasks and problem-solving situations. Complex learning tasks tend to have many interacting components, some of which may be incompletely defined, and with some nonlinear relationships and delayed interactions among the various components (see Dörner, 1996; Sterman, 1994). Such problems occur in economic forecasting, engineering design, environmental planning, management decision making and in many other every day problem-solving situations. Using models of complex phenomena to help learners gain a holistic and meaningful sense of the problem is one aspect of model facilitated learning. Having learners engage in modeling activities to gain insight into the complexity of a problem situation is a second aspect of MFL. MFL assumes three stages of learning development and has associated instructional guidelines for each stage (Milrad, Spector, & Davidsen, 2003). The first stage is problem orientation in which problems or related sets of problems are presented to learners and learners are asked to solve relatively simple versions. The second stage of learner development involves inquiry exploration in which learners are challenged to explore a complex task domain and asked to identify and elaborate the relationships among the various components of the problem. The third stage of learner development involves policy development in which learners are asked to reason in a more global and holistic with regard to rules and heuristics to guide decision making with regard to various problem situations that may arise in that task domain. Principles to guide the elaboration of learning activities and instructional sequences within these stages include such notions as (a) situating the learning experience in the context of meaningful and realistic problems (Merrill, 2002), (b) presenting problems of increasing complexity, involving learners in a sequence of related tasks involving the initial problem scenario (van Merriënboer & Kirschner, 2007), (c) involving learning in an increasingly set of complex inquiries and explorations with regard to the problem situation, and (d) challenging learners to develop rules and guidelines to guide decision making in anticipated problematic situations.

The foundations for model facilitated learning are derived from system dynamics (see, for example, Sterman, 1994), educational and learning psychology (see, for example, Lave & Wenger, 1990; Spiro, Coulson, Feltovich, & Anderson 1988), and from instructional design (see, for example, Merrill, 2002). In addition, MFL adopts the principle of graduated complexity (Milrad, Spector, & Davidsen, 2003) in the form of guidance for the elaboration of instructional sequences. Graduated complexity in MFL is implemented consistent with cognitive apprenticeship methods (Collins et al., 1989). According to the principle of graduated complexity, instructional sequences should challenge learners to:

1. Characterize the representative behavior of a complex system, indicating how it behaves over time; this is similar to the first method in cognitive apprenticeship but is specifically elaborated with regard to complex and dynamic problem situations.
2. Identify a desired outcome and key variables and points of leverage with respect attaining that outcome; this is consistent with the coaching method in cognitive apprenticeship but is again elaborated with regard to critical aspects of a complex and dynamic problem situation.
3. Identify and explain alternative causes for observed phenomena; this can be combined the first method and is consistent with the expectation that people naturally seek cause and effect relationships; asking learners to accomplish this step at some point is consistent with the articulation method in cognitive apprenticeship.
4. Reflect on how the system and associated variables seem to change over time and through interventions; this challenge requires perceptual processing but the critical aspect is the ability to focus on key problem components and how they change over time and with intervention; this is also consistent with the reflection method in cognitive apprenticeship.
5. Develop a rationale to explain complex phenomena in terms of an underlying system structure, including decision-making and policy formulation guidelines; this challenge is aligned with both articulation and reflection in the cognitive apprenticeship model.
6. Broaden understanding through diverse and new problem situations; this challenge addresses near and far transfer of learning, is consistent with Gagné's (1985) ninth event of instruction as well as with the exploration method in cognitive apprenticeship.

Further Research

The ability to solve complex problems depends in large part on the ability of individuals to construct productive mental models and activate relevant schemas. Mental models are useful in explaining puzzling phenomena and complex systems, especially in terms of cause and effect (Hale & Barsalou, 1995; Seel, 1999). Those who are confronting challenging problems are likely to construct mental models in order to provide explanations for the new or unusual phenomena. Greeno (1989) suggested that productive mental models should be encouraged along with the significant properties of external situations and appropriate interactions; this principle has strong implications for the design of learning and instruction. Moreover, such a principle is consistent with a constructivist approach to learning that suggests that the learning environment should serve as an information resource which can be used by a learner to focus on relevant aspects of a problem and activate relevant schemas and prior knowledge. Learning activities are, consequently, required that enable learners to explore and interact with the learning environment in a meaningful, problem-centered context. Consistent with cognitive apprenticeship and model-facilitated learning, support and scaffolding should be provided to help problem solvers to be successful and develop both competence and confidence (Keller, 2010). This general approach can also be found in what is currently being called learning by design (Kafai & Ching, 2004; Kolodner et al., 2004). Additionally, Kirschner, Sweller, and Clark (2006) and Mayer (2004) have argued that minimal guidance during instruction, especially with learners new to a problem-solving domain, is not effective. Consistent with cognitive apprenticeship and model-facilitated learning, explicit coaching and overt learning support should be provided to those inexperienced in the domain.

What is not known or well established is how best to support the development of expertise and insight with regard to complex, problem-solving activities in specific problem domains (Spector, 2010). Future research is necessary to determine with confidence how well and in what circumstances MFL-based instruction works in terms of developing competence and expertise, especially in comparison with other instructional methodologies. Which kinds of models (student-created, expert-created, partially complete, etc.) are effective with different learners and learning tasks is also not well known, nor is it well known how external models align with internal models in specific problem-solving situations. While versions of MFL have been implemented and evaluated in the first two stages indicated above (problem orientation and inquiry exploration), very few MFL environments exist to promote learning at the last stage of learner development (policy development). As a result, research on effective MFL techniques to promote policy development knowledge remains very open for further research and development, and additional research is needed in the first two stages as well. Additionally, effective MFL instructional sequences for complex problem task domains is not very well established. A central underlying problem concerns the need for well-developed means to assess the progressive development of student understanding in complex task domains. This requires validated means to elicit and evaluate student generated models in response to a wide variety of problem types and scenarios, yet those means are still in the early stages of development. Finally, integrating external models of various kinds and aligned those with individually generated internal models remains an important area open for further exploration.

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Postmodernism: A Twenty-First Century Primer to Problem-Based Learning

Denis Hlynka

A 2010 book titled *Habermas: Introduction and Analysis* by David Ingram began with a contemporary twenty-first century definition of postmodernism. He wrote:

> The term postmodernism designates a criticism of reason conceived as a universal and certain foundation for knowledge and morality, and of modern culture, understood as a progressive unfolding of knowledge and morality.
>
> Postmodern themes regarding the fragmentation (or deconstruction) of reason bear on sociological dislocations associated with multiculturalism, the destruction of tradition, the dissolution of moral agency and the delegitimization of scientific and political forms of authority.

These lines need to be unpacked carefully to make sense of the postmodern phenomenon.

Within the first of the two sentences is a definition of reason (the term *modernism* may be substituted for *reason*) as "a universal and certain foundation for knowledge and morality and of modern culture." Second, modern culture is further understood as "a progressive unfolding of knowledge and morality." Postmodernism, then "designates a criticism" of that view.

The next sentence identifies five postmodern themes: (a) a fragmentation of reason, caused by multiculturalism, (b) the destruction of tradition, (c) the dissolution of moral agency, (d) the delegitimization of scientific authority, and (e) the delegitimization of political authority.

All in all, postmodernism sounds like a pretty horrific construct, and one would be tempted to ask: Why would anyone want to align themselves with such a perspective/viewpoint/philosophy?

However, there is a different way of looking at postmodernism. What if postmodernism were not a philosophy that one buys into, but in fact a description of the

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"condition" of modern society? In fact, Jean Francois Lyotard used exactly that word for the title of his 1979 book: *The Postmodern Condition: A Report on Knowledge*. In other words, perhaps one should not go around saying, "I am a postmodernist (or not)," but rather one should be astute enough to notice that the world itself is postmodern, by default. Postmodernism is nothing more than a characteristic of contemporary society, especially the world of McLuhan's *global village*. One of the major factors for this contemporary view of society as postmodern is … technology.

There is a second point that can be made about the initial quotation. That quotation has a rather negative tinge to it, a radical perspective. What if postmodernism was examined not through radical lenses, but through benign lenses? What might that mean? It would mean that postmodernism is not something to fear, but something that is natural and needs to be observed.

Reading the initial quote with benign lenses leads to a different conclusion.

Here is the quote again:

> The term postmodernism designates a criticism of reason conceived as a universal and certain foundation for knowledge and morality, and of modern culture, understood as a progressive unfolding of knowledge and morality.
>
> Postmodern themes regarding the fragmentation (or deconstruction) of reason bear on sociological dislocations associated with multiculturalism, the destruction of tradition, the dissolution of moral agency and the delegitimization of scientific and political forms of authority.

The next thing to note is that postmodernism criticizes/critiques the idea that there is a universal and certain foundation for knowledge. Upon closer examination, that is not such a radical idea after all. The world is divided into many different cultures, hundreds of nations, at least half a dozen major religions, and a variety of potential philosophies. In the USA there are two major political parties (Republican and Democrat); in Britain there are Labor, Tories, and Whigs, while in Canada they are called Conservatives, Liberals, and New Democrats. Each of these has a different foundation for "knowledge and morality," though each also has much in common. So what is the big deal? This is simply "the way of the world," always has been, and always will be. Postmodernism simply says it up front and out loud: There is no one best way.

Classic Definitions of the Postmodern

Definitions of postmodernity abound. Most are long and erudite and not particularly helpful to the uninitiated. Here are some short, perhaps more useful definitions. Being short, they do not quite grasp the significance and power of the concept, but on the other hand, they do provide a succinct vocabulary of postmodern essentials.

> The classic definition, and perhaps least contentious, comes from Lyotard (1979) as simply:
> "incredulity towards metanarratives."
>
> Architect Christopher Jencks (1987) used an equally brief phrase:
> "a double-edged coding."
>
> The physicist Ilya Prigogine and Stengars (1984) calls the postmodern
> "a radical change towards the multiple, the temporal, and the complex." (Prigogine, p. xxvii).

Some readers will note that these definitions come from the 1980s, which makes them some 20–30 years old. Sometimes older definitions are just fine. Those above provide a succinctness and elegance often missing in some of the longer and not necessarily more accurate designations.

Here, for example is Bullock et al. (1977) suggesting that the postmodern is associated with a revolt against authority and signification; a tendency toward pastiche, parody, quotation, self-referentiality, eclecticism: "It is an amorphous body of developments and dictions marked by eclecticism, pluriculturalism, and often a postindustrial high tech frame of reference with a skeptical view of technical progress."

Here are a few variations for our own century. Debra Shaw (2008) saw postmodernism as a "historical epoch in which uncertainties about the future predicted by Enlightenment rationalism are expressed in art and culture." Elsewhere (p. 4) she wrote:

> Postmodernism tends to be a catch-all term used to describe the sense in which we live in a global culture mediated by technologies of vision and computer networks, suffused by a popular culture that does not recognize previous distinctions in taste and class and in which the boundaries between previously distinct categories of ideas have become fluid and unstable.

This is a cultural and historical definition, expanding the concept to hitherto unintended regions.

In summary, what is postmodernism? Quite simply: the melding of multiple conflicting discourses. When at least two discourses exist and they disagree, then it is a postmodern event. The problem is that this is not an unusual phenomenon. Often the results do not even matter. It always happens.

A simple example is the conflict of a round earth and a flat earth. It is a curious conflict because it is universally acknowledged that in fact the earth is round. It is well known that the earth rotates on its axis every 24 h, and that it moves around the sun, every 365 days. So why then, every morning, does the radio or television announcer say that the sun is about to rise (or has just risen)? The audience is told the exact second. Yet, the sun does *not* rise, so obviously this is just a phrase of convenience. But the subterfuge is accepted anyway. And it is known that to the west of us, the sun is going to rise a little later. So the idea of a rising sun cannot even be a constant. It keeps changing as the earth keeps spinning. Two conflicting discourses, and most are able without any problem whatsoever to step back and forth within both of them. The sun rises and sets around a constant unmoving earth? Sure why not? The earth is a sphere that revolves around the sun? Of course it is. Two conflicting discourses, and no one minds.

Who Is Afraid of Postmodernism?

Notwithstanding the just explained example, it is perhaps understandable that postmodernity can be unsettling. One criticism is that postmodernism makes all beliefs equal, even if they are outlandish. This is not the case. Postmodernism recognizes that there *are* multiple discourses, and that they are contradictory; it does not provide a value judgment. It certainly does not imply that each discourse is of equal value. A second criticism is that postmodernism is nihilistic, that is, it has a negative view of the world. On the contrary, postmodernism recognizes uniqueness and multiculturalism as natural components of society. That is not being nihilistic; it is common sense. It is also very clearly representative of all components of culture. Third, it is argued that postmodernism results in relativism. Once again, that is a misunderstanding of postmodern thinking. Postmodernism serves only to identify alternative perspectives, not to valorize them.

What postmodernism does do, is to argue against the modernist philosophy that there is one best way, and that way is our way, or worse yet, my way. The modernist view lies in opposition to a postmodern epistemology; thus is likely at the center of discourse concerning the disagreements among scholars regarding cognitive theories or pedagogical approaches that embrace a postmodern view.

What Are Twenty-First Century Variants?

In the twenty-first century, the term postmodern for some has been adapted to our new century. Some of the contemporary variants include post-democratic, digimodern, post-postmodern, and even post-Indian. Post-democratic suggests a follow through that provides a critique to new democracies, particularly since the 1990s, especially, but not limited to the fall of the USSR. Post-democratic society represents the uncomfortable idea that anyone can do anything. In the study of indigenous cultures, George Visinor uses the word survivance, as a combination of survival and resistance. Visinor also uses the term post-Indian as a specific variant of postcolonialism.

Within a contemporary information technology-based culture Alan Kirby has used the term *digimodernism* (a blending of the words *digital* and *modernism*) to describe "how new technologies dismantle the postmodern and reconfigure our own culture." He argued that in this new era "one phones, clicks, presses, surfs, chooses, moves, downloads" (Kirby, 2006). This new cultural paradigm introduces "New form of textuality characterized in its purest instances by onwardness, haphazardness, evanescence, and anonymous social and multiple authorship," all of which "manifests itself in the digimodernist traits of infantilism, earnestness, endlessness and apparent reality." (Kirby, 2009, p. 1). Such digimodernist texts are rampant across contemporary popular media forms from reality TV to Wikipedia, from Twitter to Facebook.

Working independently but in a similar vein, Andrew Potter (2010) deconstructed the entire contemporary idea of *authenticity*. Noting that "it is impossible to build an authentic personal identity out of the cheap building blocks of consumer goods" (p. 3), Potter argued that "we live in a world increasingly dominated by the fake, the prepackaged and the artificial" (p. 4). The problem may be in the idea that a curious contradiction appears as the democratic ideal becomes universal, and becoming universal, becomes meaningless. Democracy reverses into a babble of mediocrity. Over 100 years ago, comic opera writer Gilbert (1889) poked fun at that same concept in the musical comedy *The Gondoliers* (1889), based on the premise "When everyone

Table 1 Tentative concepts of modern, postmodern, and post-postmodern thought

Modern	Postmodern	Post-postmodern
Universal	Particular	Haphazard
Truth	Truths (multiple)	–
Progress	Retrieval/reversal	Hype
Reason	Contingency	Anonymity
Tradition	Multiplicity	Onwardness
Scientific	Temporal	Hurriedness
Authentic	Complex	Kalaidescopic
Critique of the transcendental signified	Critique	Death of the author
		–
"One Best Way"	Bricolage	Information overload
Grand theory	Distrust of grand theories	–
Authorial intent	Montage	–
Meaning in author/text	Meaning in reader	Meaning everywhere

is somebody, no-one's anybody." In a post-postmodern society, authenticity deconstructs. Traditional concepts become blurred in a world when anyone can post anything, and the role of the editor and publisher disappears. A phenomenon like Wikipedia features anonymous authors being validated by anonymous editors, and touted as an encyclopedia by everyone, for everyone. The very word authenticity takes on suspicious overtones.

It is fashionable today to pronounce the death of the postmodern, though it seems that scholars have always been pronouncing the postmodern movement's death. Kirby (2010) explored the alleged fall of the postmodern, and has suggested a variety of new contenders to take its place: digimodernism, and post-post have already been suggested, but also hypermodernity, supermodernity, altermodernity, and automodernity.

In the field of public administration, McSwite (2002) defined post-postmodernism as "a dramatic erosion of the symbolic order and the fundamental social bond" (pp. 69–70). Continuing McSwite's argument, Meyer-Emerick (2002) identified the new dangerous metanarrative as globalization, which demands the same incredulity as did postmodernism two decades earlier. She wrote, "globalization implies an endless chain of production and consumption in the name of "market efficiency" without regard for basic human rights." (p. 577). This, she argued, is the "administrative evil inherent in all technical rational systems" (p. 578). It is a sobering thought.

Modern, Postmodern, and Post-Postmodern

Given all these differing ways of knowing the world, it rapidly becomes unwieldy to grapple with the multiple components of understanding required to truly track the jargon within the discourse. Table 1 highlights concepts relevant to each of the major three categories, and hopefully helps new readers quickly see the difference between these labels.

Postmodernism of course allows for and recognizes the concurrent existence of all these world views simultaneously; modernity does not.

Postmodernism and Educational Technology

The incorporation of postmodernism into educational theory and its relation to educational technology practice is nothing new. *The Handbook of Research on Educational Communications and Technology* devoted space to the topic (Jonassen, 1996, 2004). In addition many connections can be made between advocates for constructivist instruction and a postmodern epistemology (Wilson, 1997). Therefore, the idea of connecting instructional design models to the postmodern way of thinking is fairly prevalent. But differences of opinion arise as the arguments regarding instructional design practices become obfuscated when scholars try to determine *how* all this ties together. As practitioners, educational technologists have been thinking about postmodernism as an underlying philosophy for some time, and setting forth agendas for future research and activities (Solomon, 2000). Despite this, the community continues to struggle with tying an epistemology or philosophy such as postmodernism, with an active approach to instruction which more often that not leads to substantial debate (Solomon, 2002; Voithofer & Foley, 2002).

The problem here could very much be the conflict between epistemology and pedagogy. Obviously these are two very different ideologies. But they are sometimes conflated by the uninitiated when considering educational practices, or simply over-argued by scholars seeking a definitive answer to the question of how best to go about teaching and learning. But these concepts are not interchangeable and they represent different domains (Kirschner, 2009). An epistemology is a way of knowing and understanding the world. A pedagogy is a specific style of methodology of instruction. One can inform the other, however.

The Postmodern Condition and Problem-Based Learning

So, why does a book on problem-solving instruction need a chapter on postmodernism? The answer should be relatively obvious: problem centered instruction (e.g., problem-based learning) is itself a postmodern phenomenon. It is postmodern because it meets all—or at least most—postmodernism criteria. At the very least, it is enough to say that a major characteristic of problem-based learning (PBL) is that it does not require one best way, or one best approach. In fact, a PBL model subsumes a postmodern perspective. Herrington et al. (2003) suggested that PBL has ten key characteristics. These are (1) a real world relevance, (2) ill-defined structure, (3) complex and sustained tasks, (4) employ multiple perspectives, (5) collaborative, (6) value laden, (7) interdisciplinary in nature, (8) authentic assessment, (9) a created authentic product, and (10) multiple possible outcomes.

Clearly several of these are postmodern constructs, but the reader's attention should be drawn in particular to items 4 and 10 above. Those two are arguably the essence of postmodernity. Through more traditional teaching models based on older cognitive theories, there is typically one best answer, one set of competencies, and one best way to achieve closure. Postmodernism not only allows for, but revels in, multiple perspectives. This indeed is also the essence of authenticity, which immediately dissolves into an inauthentic environment when pushed too far. Thus postmodernism actively encourages the pursuit of multiple answers for consideration, abandonment, or acceptance; which is a valid process for problem solving.

But in the end, PBL is a constructivist approach to instruction, and constructivist theories of cognition fit very well within a postmodern epistemology. It could be argued that our epistemological stance informs our selection of pedagogical approach as much as data. If that viewpoint is accepted, then it follows that holding to a postmodern epistemology would imply value to a PBL approach to instruction.

Conclusion: What Postmodernism Says to PBL

Postmodernism may seem to be a rather theoretical perspective that has no direct relation to PBL. On the contrary, practitioners who wish to employ PBL need to understand the postmodern underpinnings of their endeavor.

1. *Direction*. Postmodernism justifies the PBL strategy that all learners can move according to their own personal interests. There is no one focus for everyone.
2. *Technology*. Technology is a natural component of communication. However, technology is not to be seen as only that which has been invented since the beginning of the twenty-first century. Technology may also mean traditional technology, low technology, or appropriate technology. In that sense, all communication is technological. But this means that technology has built-in biases that in turn can influence the results of any PBL investigation. The presence or absence of any given technology matters. Technology makes any inquiry postmodern. Technology ultimately biases the PBL endeavor.
3. *Multidisciplinarity*. A postmodern approach crosses disciplines. It breaks boundaries naturally. A generic problem can be explored scientifically, culturally, aesthetically, pragmatically, or technically.
4. *Assessment*. Postmodernism means that each individual learns something different. There is no one common set of learnings. There is no one best solution. This results in a unique problem of assessment in which traditional rubrics no longer hold.

Any exploration into the concept of PBL requires a basic understanding of the postmodern condition. At the very least, an understanding of postmodernism provides a corrective adjustment to the mad dash toward a future world characterized by hype, rhetoric, spin-doctoring, and corporate fraud. Postmodernism allows different ideas to be explored, and different paths to be taken. A “one best way” modernist approach is fast and efficient. A postmodern approach is messy, uncertain, and exploratory. There is no quick fix. American poet Howard Nemirov (1989, p. 141) captured this dilemma in a well-framed poem:

We praise without end the go-ahead zeal
of whoever it was invented the wheel
but never a word for the poor soul's sake
that thought ahead, and invented the brake.

Postmodernism is not a prescriptive philosophy that will help apply that brake, but it does assist in seeing where the brake is. The next step is up to the research community.

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What Does a Connoisseur Connaît? Lessons for Appreciating Learning Experiences

Patrick Parrish

Why Apply Connoisseurship?

In the essay on Developing Connoisseurship in Educational Technology, John Belland (1991) opened doors by expanding the available paradigms for research on learning experiences with educational technology. Building on the work of Eisner (1985, 2002), Belland argued that navigating the inherent complexity and getting to the heart of what is most important about of what we do as educational technologists requires broader appreciative skills than those offered by traditional educational research paradigms (1991).

Belland summarized the role of the connoisseurship paradigm in this way:

> The connoisseur "gets inside" experiences. He/she enjoys the care lavished on an instructional system by a sensitive designer. He/she is thankful for the attention paid to aesthetic details. He/she can sense the intellectual and affective intensity which the instructional medium or system will evoke in the learner. (p. 35)

In this comment, Belland expressed equal concern for the affective, aesthetic, and intellectual qualities of learning. This reflects a belief that learning experiences are more complex than can be reduced to a single way of knowing. Learning experiences, like all experiences, are based on an individual's transaction with the world—the give and take of the person's endeavors and the world's responses (Dewey, 1938/1997). For this reason, they have a spectrum of interacting situational and individual influences—including the personal intentions and interpersonal interactions of those involved; the immediate, temporally unfolding, and historical qualities of the experience; and their degree of malleability to influence by those engaged in the experience (Parrish, Wilson, & Dunlap, 2011). Experiences are also to varying

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degrees compelling and coherent, or dry and scattered, and are influenced by the degrees of trust and presence of those involved. They include expected and desired outcomes, as well as unintended and serendipitous consequences—some of which can be more influential than anticipated outcomes. While at times it can be valuable to narrow the data under consideration for more precise research and evaluation questions, broadening the allowable considerations to all of these influences on experience expands our understanding of their deeper complexities. These complexities are worth considering because the development of qualities such as open-mindedness and learning engagement can be outcomes just as important for educational experiences as are content knowledge and cognitive skills and can even be considered preconditions for these. Connoisseurship facilitates the broadening required to uncover the complexities of experience.

Belland (1991) suggests that connoisseurship is not simply a matter of possessing something as intangible as "good taste," but that connoisseurs of all kinds develop skills and tools to apply their special capacities for appreciation. These include (a) fine perceptual discrimination, (b) concepts with indeterminate limits (recognizing that orthogonal concept systems can be limiting in matters of taste and fine discrimination), and (c) hierarchies of concepts that describe the qualities of artifacts at increasing levels of specificity. For example, film critics have perceptual discrimination that allows them to "see" more of a film, noticing subtle details of lighting, editing, and composition only subconsciously experienced by average viewers. They also use broad, overlapping concepts to distinguish film types for the purposes of analysis, with genre definitions whose purity are often challenged, as with the merging of science fiction and film noire in the film, Blade Runner (Scott, 1982). Film critics apply hierarchical units of analysis regarding film images—such as sequence, scene, and shot, and further subdivide these by analyzing the mise-en-scene, composition, camera movement, transitions, and dramatic content of the frames that comprise them.

Belland (1991) also describes some driving principles of connoisseurship, including (a) the understanding that one never finishes learning about the object of appreciation—that each experience has unique nuances to be discovered, (b) the need for courage of one's convictions—that one's personal experiences are valid interpretations worthy of public disclosure, and (c) the openness to adopt modes of inquiry from other disciplines as they appear useful for a particular situation. So rather than offering another prescriptive approach to educational research, Belland is suggesting a stance from which to conduct inquiry, a new jumping off point based on the need to honor each situation by being willing to adjust to its circumstances. This stance is also based on trust that individual perceptions and affective reactions are a valid addition to our sources of knowledge about learning experiences, especially because learning outcomes are highly malleable to individual intentions to begin with. The subjective nature of learning experiences is not just unavoidable, but in fact, required and desired, being as they are always about personal change. Learning experiences beg for connoisseurship for more complete understanding.

Most importantly, connoisseurs of whatever product, undertaking, or art form (e.g., wine, dramatic performances, travel) also understand their objects of study as more than the sum of its qualities. Connoisseurship is about the quality of the experience. Connoisseurs apply a refined, unbiased subjectivity to capture the nature of their personal responses, and in describing them, they create virtual worlds of experience for the audience of their critiques.

To summarize, connoisseurship is the application of perceptual discrimination, flexible and hierarchical conceptual categories that allow exploration of unfolding complexities, and sensitivity to one's subjective responses, to making qualitative judgments about an experience. In educational technology, connoisseurship suggests a fundamental shift from being concerned only with measurable learning outcomes to a concern for the broader learning experience, and it is one way to open a research study or evaluation to include all sorts of subjective, but sharable, sensations and situational transactions that widen our knowledge and appreciation of the experience. While connoisseurship shares in common with phenomenological research methods the consideration of broad and un-predefined impacts, it takes arts practice and criticism as its primary source of inspiration for methods, recognizing that aesthetic qualities are important in that they influence the transformative potential of learning (Parrish, 2009).

Among his recommendations for developing connoisseurship, Belland (1991) includes the need for educational technology professionals to read critical literature in other fields. This chapter extends his work by doing just this, by briefly examining several examples of criticism in mostly unrelated fields to uncover their approaches to understanding experience, and where possible, drawing parallels for the application of connoisseurship in educational technology. Although the writing of these brief explorations applies the same freer form approaches used in the fields of connoisseurship they explore, you will note reflections of the skills, tools, and driving principles mentioned by Belland. But they will demonstrate a few additional characteristics as well. The concluding section outlines some of these skills, tools, principles, and additional observations.

Drama Criticism: *The Art of The Seque*, The Threepenny Review (Vineberg, 2010)

When average viewers experience a dramatic performance, their goal is to give themselves up to the story, to be moved by the performances, and to let the staging develop the aura of an alternative reality. They believe enjoyment of the experience is based on passivity—that the work is merely entertaining them while they sit back. The connoisseur knows better. For the connoisseur, the trick is to let the work carry them away (if it is working), and also to bring their personal cache of knowledge and discrimination to bear to appreciate the skill behind the artifice that makes the experience possible. Some imagine that connoisseurship represents a loss of the innocence required to become immersed in an artistic creation, as if one can know too much about the processes of creation to appreciate their artifacts (ignorance is bliss). But asking whether having a rich knowledge of the cinema diminishes your ability to appreciate a film is like asking whether knowledge of weather diminishes the ability of a meteorologist to appreciate a sunny day.

In Vineberg's (2010) review of a recent play by Andrew Bovell, *When the Rain Stops Falling*, his enjoyment of the work is as clearly evident as his critical skill and vast knowledge base of the art form. He uses words like "gripping" and "dazzling" to describe his reactions to Bovell's work, clear indicators of subjective enjoyment rather than mere analysis, and shows delight in developing his lengthy plot analyses of the trademark interlocking relationships between Bovell's numerous characters. Bovell, the rapt theater-goer, is never far away.

However, probably the most notable feature of the review is Vineberg's lack of any direct discussion of the play under review until fully one-third of the way through. Instead, after the first sentence describing it as "the most gripping new play of last season," he proceeds immediately to a long discussion of Bovell's previous work, particularly the related play, *Speaking in Tongues*, and his screenplay based on that work for the movie, *Lantana*. While this format might not be acceptable in more popular venues, the structure points to a common feature of many, if not most, serious critical reviews of art works—that they view works of art in their historical context. In this case, the examination is mostly in the context of the growing body of work of a single *auteur*, seeking to find coherence within Bovell's corpus that helps to explain the new work and say something larger about the art form than a single work can express. However, Vineberg also connects the work to more popular contemporary "ensemble" dramatic films, such as *Traffic*, *Crash*, and *Babel*, which allows him to point out their flaws and to Bovell's unique strengths.

The title of Vineberg's review is "The Art of the Segue," which works at multiple levels, and is not directly referenced until the review's paragraph. The term segue, which is derived from music theory and indicates the transition between two ideas whose relationship is not necessarily obvious, occurs as the subject of a central dialog in the play. The term refers to the discomfortingly transitory nature of our situations and relationships in life and also the inevitable influences the past holds for the future. The reader immediately realizes that segues have been significant structural and thematic elements of the play under discussion, which connects characters and scenes from widely different time periods. Moreover, the reader also sees that Vineberg is using Bovell's concept of the segue as a basis for his own review, showing that an artist's earlier work necessarily informs his present work, often in surprising and complex ways. Vineberg's review makes a story out of the evolution of Bovell's ideas and artistic style, suggesting that to fully understand the present work we must understand it as the culmination of a series of segues from the first work to the most recent.

Along the way, Vineberg accomplishes his appraisal of the work in question by employing several additional strategies.

- Discussing the translation of Bovell's past work from one medium to another (theater to film), which allows him to uncover the essential qualities of both the common narrative and the respective media. *Speaking in Tongues*, for example, is "a distinctly theatrical piece in which four actors share nine roles," while "by contrast, Lantana. . . is completely naturalistic" (p. 22).
- Exploring the complex narrative structure to see how its pattern suggests the themes at play in the work. "Broken parental-filial bonds are Bovell's main

theme, and as in *Speaking in Tongues* the actions of the characters—in this case over a period of nearly three-quarters of a century—echo each other" (p. 22).

- Making links to other art forms, drawing parallels between one of the older play's scenes and a poem by Robert Frost, comparing the effectiveness of the film adaptation to other films with similar themes, linking the current play to a past play by Guare and its dialog to that of film director Mike Leigh, etc. These linkages help to provide richness to the critique that might otherwise be missing, similar to the way the taste of wine is described in relationship to other fruits and foods and even non-food essences.
- Dissecting the sources for the total impact of the work by examining the acting, staging, and dialog separately. Vineland even delves into the careers of some of the actors and the theatrical director involved, helping to show the collaborative craftsmanship involved in creating the work.

Vineland's critical techniques reveal the connoisseur's broad scope of tools and willingness to reach across disciplines and forms to find strategies that will illuminate the analysis. In a way, connoisseurship almost *requires* comparisons with artifacts and experiences outside the object of study, since the richness of an experience is never understood in and of itself, but through comparisons with other life experiences.

Educational technologists might similarly allow their focus to blur slightly, allowing comparisons to experiences of other sorts besides learning (experiences with art, for example), looking for parallels that bring insights to their evaluations, research analyses, and designs. Another lesson that might be drawn from Vineland's work is the value of noting "the segue," of examining the evolution of educational technology for understanding its current status and its contemporary products.

Wine Tasting: The Everyday Guide to Wine (Simonetti-Bryan, 2010)

At first blush, wine tasting appears to be a field of connoisseurship radically different from drama criticism. It may seem that tasting wine is all about the ability to make fine discriminations of a finished, static product, with taste and smell (and sight, secondarily) as its sensual dimensions, and with little temporal unfolding and no dramatic arc in its nature. However, because all connoisseurship is about the experience of appreciation, and not simply the products appreciated, these temporal dimensions also emerge if one looks closely. As Simonetti-Bryan (2010) points out, wine tasting is something that can be enjoyed by anyone, and wine can be appreciated at many levels and with a wide range of expectations. But for the connoisseur, the process of tasting, the historicity of winemaking as a craft, and the fact that wine is so reflective of its time and place of origin add its narrative dimensions.

First, there is the wine tasting ritual itself, the prescribed methodology for inquiry into a wine's taste, as well as the gradual unfolding of that taste, that add narrative qualities. The ritual is not without a rationale. It is grounded firmly in the nature of wine as a complex organic substance and the multilayered human sensory system, within which senses reinforce one another. Seeing is the first step. One examines the wine's color while the glass is tilted such that one can examine a small pool of the liquid in the side of a clear, thin-sided glass over a white background, like a tablecloth. Color alone can tell of the wine's variety, age, and, if present, its faults. Then, one swirls the liquid to release its odor into the glass before proceeding. Once sufficiently swirled, sniffing is the next step, first with the glass held at the chest, sensing its distant aroma, then, at the chin, finding its more prominently emergent scent, and finally, with the wine glass fully engulfing the nose, when the powerfully imposing scent/taste becomes available, almost as immediate as liquid in the mouth. Sipping comes only after these previous steps, and it is still a cautious step for the serious taster. The wine can flood the tongue, but should not fill the mouth. It should flow over the tongue to reach all the taste sensors, but leave room to blend with the mouth's atmospherics. Here the wine's taste has its most powerful effects, but not its final ones. That is reserved for the savor, the residual sensations on the tongue and mouth that linger, if one waits for them, after the liquid has been swallowed (or ceremoniously spit out). It is the totality of these steps that accounts for a wine's "taste."

A serious wine taster has a sophisticated language to describe the experience at each of the steps in the tasting process—color terms, aroma terms that link to smells far beyond the world of grapes, and terms that describe tastes (sweetness, sourness, acidity, bitterness, warmth, and spice), and even behavior of wine in the glass and on the tongue (e.g., "legs," "length," "weight," and "finish"). Then there are terms that *describe* how all these elements play off one another and develop a coherence ("finesse," "coarseness," "complexity," and "balance"). The complexity of this tasting process shows that while the wine itself might be considered finished, its taste is an evolving quality that unfolds differently for each person experiencing it. This is true even among experts, although they will tend to converge in their opinions about key qualities due to the rigor of their technique.

The narrative qualities of a wine are also embedded in its genealogy, the time and place in which the grapes grow, and the processes used in transforming them into wine. All of these are considered by wine connoisseurs as critical to its taste. Experts are designated as experts based not only on their abilities to judge and describe a wine's taste on the basis of the terms used above, but also to locate a wine's place and conditions of origin (its latitude, region, year, and even vintner). When a connoisseur tastes a wine, an entire story unfolds with each smell and sip, one that begins with the history of the grape variety. Most grape varieties derive from a single European species, but show distinctive qualities, especially when they are converted to wine. They have developed further distinctions as they have migrated from the continent of Europe to the four corners of the Earth, so the wine expert can typically tell whether a wine made from the Sauvignon Blanc grape was grown in France or New Zealand or South Africa and understands that this difference is derived from distinctions such as latitude and other climate variables, as well as geographical distinctions such as soil type. An expert can further discern distinctions based on the *terroir* of the vineyard that grows the grapes. *Terroir* is French word with a complex of meanings, referring to terrain, topography, and microclimate, which determine qualities such as soil type and depth, water availability, and access to sunlight and shade. Even the flora and fauna of the landscape, including microscopic ones that live in the soil, can influence the *terroir*, as will horticultural techniques (Johnson & Robinson, 2007). To summarize the longer story that could be told, the final variables on a wine's taste are the weather experienced in the particular growing season, when the grapes are picked, and the wine production techniques used, including how and in what material the wine is aged.

The complexity discerned by the connoisseur in each taste of wine is clear, but whether this level of discernment is valuable to the average wine drinker is questionable, and this question often becomes a source of derision, as in the affectionate spoof and instructional film, Wine for the Confused (Cleese & Kennard, 2004). But one can see how, as in the case of the drama critic, a deep knowledge about the product serves to increase the wine connoisseur's appreciation of the experience, not diminish it, and does not tend to limit the range of wines appreciated. If anything, it extends that range.

For educational technologists, the lessons that might be found include the benefits derived from the rigor of the inquiry (tasting) process, the wide range of qualities actually being considered in the "taste," and the wealth of information (the *terroir*, etc.) that is considered as contributing to the totality of the experience. Learning experiences also have a *terroir* that makes not only each class or product unique but also makes the experience unique for each learner. Just as the taster's degree of knowledge and exposure to varieties of wine contributes to the wine tasting experience, the qualities that a skilled evaluator, designer, educator, and learner brings to the learning experience colors it in critical ways (Parrish, Wilson, & Dunlap, 2011).

Travel Writing: Travels with Herodotus (Kapuscinski, 2004)

Travel writing is not a traditional realm of connoisseurship, but because it is concerned with capturing the rich experience of a place (and time) rather than a product, it is perhaps a defining example. Up front I should draw the distinction between a travel guide book and a work of travel writing. The distinctiveness of Kapuscinski's *Travels with Herodotus* helps to clarify this difference. This work is a collection of essays from travels in Asia, the Middle East, and Africa over several decades, linked by the ancient Greek history text he carries on each trip for inspiration and for passing time. In the work, Kapuscinski is not attempting so much to tell how and what to enjoy about the places he visits as he is describing his own reactions to the radical differences he finds in the places far from his home and the cultures of the people he meets there. He is describing his *experiences* of traveling for the reader to ponder. Furthermore, he speaks of the psychological distance created by the act of traveling, the experience of being on the move, aboard planes or trains, and being forced into a time of reflection that helps to make travel a philosophical inquiry (if one is willing to forgo the portable digital entertainment).

Placing oneself in a foreign culture is a brave undertaking. This was especially true before the ubiquity of Starbucks and international hotel chains. Kapuscinski (2004) leaps into his travels not without trepidation, but with fully opened mind and senses and a discerning eye for details that exemplify the essential differences from Western expectations. In the chapter about his first visit to India as a young journalist, he quickly begins noting differences in gestures ("Her hands were arranged as if in prayer . . . a Hindu gesture of greeting," p. 15), aromas ("Eastern incense, Hindu herbs, fruits, and resins," p. 15), and unusual sights and sensations ("a broad white river vanishing somewhere in the blackness of sultry, sweltering night. The river was of people sleeping out in the open . . . on the bare asphalt and the sandy banks stretching on each side of it," p. 17). Kapuscinski sees his role as the reader's eyes, ears, and empathetic substitute, feeling from the center to the edges of the places he visits for us.

He provides details about the history of the places he visits, but only enough to inform his depiction of the present. At times, he provides more history about Herodotus and his writings than about the places visited. Drawing from Herodotus, he begins to see his work as a series of investigations, and his role as "an envoy, engaged to render an account" (p. 22). In a way, Kapuscinski is also an ethnological researcher, but one without a research question except to understand, and one willing to assert his subjectivity as an important tool toward developing his account.

In India, one of his first travels, his investigation is hampered by his limited knowledge of the English language. His budding English is enough to read a few signs, but he has to resort to gestures and to trust those who guide him. He speaks of language as a barrier, closing him off to understanding. He speaks of approaching India not so much "through images, sounds, and smells, but through words" (p. 22). He recognizes the powerful relationship between "naming and being," that a critical part of knowing is to be able to speak of a thing with its name. Thus, a major activity during his travels in India is gaining skills in English.

Kapuscinski can at times appear to be writing about a series of unrelated incidents and scenes, random anecdotes that, however, build into a rich depiction of place. His choice and elaboration of details are a critical aspect of his brilliance as a connoisseur of travel. He tells us that "half-naked, soot-covered men bustle about" tending to the cremation process for hundreds of corpses, that "the line of corpses has no end, the wait is long," that the "gravediggers rake the still-glowing ashes and push them into the river," and that "the gray dust floats atop the waves for awhile but very soon, saturated with water, it sinks and vanishes" (p. 25). The detail is unnecessary if he is just an envoy, the language is superfluous if he is an ethnological researcher, but they are just right for a connoisseur.

Conclusions

This brief look at a variety of connoisseur types has demonstrated that Belland's (1991) original categories of skills, tools, and principles of connoisseurship hold up well even across very distinct disciplines. These connections to Belland's categories are summarized below, followed by several additional observations about these particular connoisseurs, as well as connoisseurship in general.

- Each of these three disciplines requires fine perceptual, and conceptual, discrimination to observe and discuss their objects of analysis.
- Theater critics, wine tasters, and travel writers use concepts with indeterminate limits and overlapping boundaries to describe subjective experiences and judgments. Consider concepts such as *terroir*, *theme*, and *culture*.
- Especially in the cases of wine tasting and drama, the disciplines are based upon hierarchies of concepts that get at the qualities of the artifacts at increasing levels of specificity. This was discussed explicitly in the case of wine. In the case of drama, it can be seen in the use of groups of terms such as *theme*, *plot*, *scene*, and *dialog*, and *corpus*, *production*, *writing*, *acting*, *directing*, etc. In the case of travel, consider concepts such as *communication*, *language*, *naming*, and *gesture*.
- Theater productions, travel, and even wine production are constantly evolving along with the cultures they are embedded within, so the connoisseurship required of them changes with each experience. One never finishes learning about them.
- Courage is required to assert one's subjective opinions about each of these, knowing that each person will have a slightly unique response, or even a dramatically opposite one. The number of such connoisseurs who find an audience is limited; such roles are competitive.
- Theatrical criticism and travel writing, in particular, reach outside their disciplines and draw comparisons to other forms of experience to help express their opinions. Of the three forms discussed, wine tasting appears to have the most closed world of inquiry, with traditions in tasting procedures that are long-lasting. However, the terminologies used evolve and the general preferences in wine taste change with time.

The examinations in this chapter uncover several additional concepts or refinements worth noting for their application to appreciating learning experiences.

- Connoisseurs immerse themselves in their experiences. They give themselves up to the rapture of the moment of the experience, even while they also maintain a critical eye for features worth analyzing. Connoisseurship approaches to researching, evaluating, and designing learning experiences requires an empathy that allows one to become a learner as much as possible (Parrish, 2006).
- Connoisseurs examine the historicity of the object of appreciation, how the object under examination has evolved to its current state, based upon previous works or products. History is an integral part of the story of the current experience. The historicity of learning experiences is often ignored. The evolutions of instructional designs are not typically reported other than in results of action research projects. Past influences could be examined fruitfully for insight into design thinking.
- For connoisseurs, all details are critical—none can be considered ignorable under every circumstance. But in reviewing, the connoisseur also selects only those details that add up to a larger coherence that explains or describes the experience

from a particular stance, even though ambiguity may at times also be an integral part of that description. Instead of indicating narrow attention, careful selection and treatment of limited details reveal the wealth of detail still waiting to be mined by the connoisseur when appropriate. Educational technologists have myriad details worth exploring, including not just learning outcomes, but transfer, usability, message clarity, affective response, critical stance, political underpinnings, theoretical grounding, impacts on motivation, impacts on self-efficacy, and learning engagement—to name but a few. The trick is being neither too narrow nor too dispersed.

- Connoisseurs not only broaden their attention to myriad details, they are willing to take time to savor those details. They trust in their abilities to find the meaning that can arise only after a period of immersion and reflection; they trust that all is not revealed immediately, on the surface, or visible in hard data. They are willing to let details accumulate, mix, and blend into complex impressions. Educational technologists might develop rituals similar to the complex process of wine tasting to approach the learning experiences they study, exploring them at different levels of sensitivity, examining different qualities of the learning experiences in separate passes.

A connoisseur can be seen as a sensing agent, one who has purposeful engagements in particular types of experiences then reports to others with skills of discernment and clear communication of both objective and subjective details of the experience. Connoisseurship is Eros refined. Connoisseurs have learned to overcome the bias of enthusiasm, to tame it with discrimination and careful examination. However, this does not mean that they forego the joy of innocent appreciation, but they can bracket it out or sample it at will, just as any good qualitative researcher understands the need to bracket out presuppositions and biases, or else make them explicit. One substantial difficulty for connoisseurs of learning experiences is that while most connoisseurs have no difficulty in also being an audience, educational evaluators and researchers cannot also be learners so easily. That can require a higher degree of empathetic skill.

Because the subjective details are as important as the objective ones, it is not just knowledge about a particular discipline, artifact, or type of experience that is important to becoming a connoisseur. It requires substantial self-knowledge as well. Lack of this component breeds snobbery—the belief that those who lack disciplinary knowledge are not qualified to make judgments about their experiences. The reverse is actually true. Lack of understanding of one's biases and lack of open-mindedness to new qualities of experience based on expanding personal tastes places debilitating limits on a connoisseur.

Just as wine tasting is not only about taste, travel writing is not only about traveling, and critiquing theater can be about critiquing life itself at times, taking a connoisseur's stance in analyzing learning experiences is more than judging the achievement of learning outcomes. Connoisseurship is not just another research methodology for educational technology. It is stance toward the field that allows room for other concerns to emerge. It shifts priorities and suggests a different range of questions and concerns of practice for educational technologists. It is reflective of the broader range of considerations that arise once one appreciates the importance of the entire learning experience with its range of transactional qualities and individual and situational influences.

Furthermore, connoisseurship in education is a concept with implications beyond evaluation and research. It is not only for critics, but it can also be seen as a goal of education. The values or principles of a connoisseur—that one is never finished learning, one should maintain the courage that one's individual experiences and tastes are valid, and one must maintain an open-mindedness to adopt knowledge from other modes of inquiry for balance and constraint—are values that we want to instill in students of any discipline. One goal of education should be to develop students who are willing to approach each new experience with full attention to its available detail and an appreciation that it will be a unique experience, at least partly because they are there to experience it, and that it will be one worth noting and worth learning from. And in the sense that connoisseurship describes a capacity for deep appreciation and discriminating judgment, it provides a basis for expert practice in any field.

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Part II
Application to the Field

Developing a Critical Stance as an E-Learning Specialist: A Primer for New Professionals

Brent G. Wilson

E-learning is a nascent field just now emerging as a combination of educational technology and distance education. Educational technology historically brought innovation into a classroom by introducing a new technology. Distance education left the traditional classroom behind and offered education through entirely different delivery methods. In both traditions, quality and innovation have continued to be key constructs—adopting the latest technologies that over time help shape our notions of high-quality instruction, and then using those same technologies to deliver that instruction broadly to people who need it.

E-learning specialists are both *ideals* driven and *problem* driven, sometimes head in the clouds but most of the time responding to pressing problems on the ground. We value the mastery of practical skill sets like authoring tools and methods for design and assessment. But there is also a place for theory. Yanchar, South, Williams, Allen, and Wilson (2010) found that instructional designers valued theory in spite of difficulties staying current and applying it formally to their daily work. In practice, various theories, technologies, and models become lenses and tools in the hands of professionals trying to solve the problem at hand and negotiate through the complex systems encountered in practice. *How well* we do our jobs, though, has a lot to do with a broad knowledge base and general awareness of trends and local conditions, along with professional qualities such as adaptability, self-learning, and professional commitment. These professional qualities may matter more than the particular theories or models that we happen to use on a given day (Smith & Boling, 2009, pp. 13–14).

Today e-learning resources enjoy unprecedented outreach in classrooms and remote locations throughout the globe. This longer outreach should, in theory, serve to reduce the Digital Divide (between those historically privileged and others not so privileged—particularly different racial groups). Yet e-learning programs are not

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assured of having positive social impacts. Depending on the particulars of design and use, e-learning resources could actually aggravate social distance and worsen the achievement gap between privileged and non-privileged people. The same questions are relevant *within* a program or school or company—how are our practices impacting our students/employees differentially—who is benefiting and who is not benefiting? This is a legitimate concern that goes back to the reform impulses of the field's founders (Reiser, 2001). While convinced of the value of our work in delivering high-quality education to larger numbers of people, we do not want to aggravate the already serious social problems in our society.

Unfortunately, these issues have a way of being neglected in the face of more pressing problems like getting a product out the door. And theory itself is often narrow in character. The dominant paradigm underlying the field has been borrowed from psychology, first in behavioral terms and then in the form of cognitive learning theories. Yet psychology is of limited value in weighing social value and determining social impacts. To address social concerns, e-learning professionals need to look at a broader and more eclectic knowledge base—at the social sciences, the humanities, curriculum theory; at pop, youth, and gaming culture; at religion, politics, and social-justice theories such as critical race theory.

So where do e-learning students get introduced to these alternative ideas? How do new e-learning professionals learn to think beyond the immediate skill sets and competencies to broader issues and concerns related to quality, access, and impact? It is my position in this chapter that the dominant focus on cognition and technology needs to be complemented with a critical commitment, interrogating prevailing assumptions and scrutinizing values and impacts, while respecting the craft of practice and site-based, contingent reasoning. We explore below what it means to take a *critical stance* toward our work. Our primary audience is the new e-learning professional—perhaps a master's or doctoral student or early career professional in a company or school, well trained in the cognitive and technical models but newer to critical theory and cultural studies. But we caution at the outset: There is no magic bullet. E-learning programs have the best chance for positive impacts through the informed, intentional practices and commitments of individual professionals, aligned with a professional community that shares these values and encourages critical and reflective practice.

The framework outlined in Fig. 1 shows some of the component skills, knowledge, and values associated with a critical stance—intended to complement the more technical descriptions of professional competencies for e-learning specialists and instructional designers (e.g., ISBTPI, 2010).

Knowledge for Critical Awareness

There is no substitute for broad-based knowledge—and unfortunately, knowledge that might be relevant to a problem cannot be predetermined and objectified. If we knew ahead of time what knowledge would apply to a problem, then it would be a

Adopting a critical stance includes…	Questions to ask…
Critical awareness Raising consciousness about the social impacts of your work	What do I know about the world that will help me do my work better – and how can I become better informed through a lifelong learning agenda?
Core values Modeling and supporting universal human values	How can I achieve better social impacts in my work – reflecting values such as full inclusion, respect for diversity, and participatory decision-making?
Close readings Evaluating discourse and practice through habits of careful observation and reflection	How can I learn to look closely at my work, and notice relationships, problems, and impacts that might affect quality and access?
Systemic interventions Solving problems in a complex system, where any action can reverberate and create effects (the system-change dilemma)	How can I apply the technical problem solving models of my field, in a way that has encourages larger systemic change?
Constructive synthesis Creatively pulling together ideas to help model and solve challenging problems of practice	How can I be more creative in bringing knowledge to bear on problems of practice – reframing and combining that knowledge in productive ways – to enable constructive action and consensus among diverse interests?
Transformation Being open to personal, organizational, and cultural transformation and renewal	How can I contribute to deep and fundamental change in people (including myself), and my team, or organization, and the e-learning profession itself?

Fig. 1 Suggested components of a critical stance toward e-learning practice

technical issue of knowledge application, and the problem would be reduced to an exercise. In this section, we sample some ideas that may not be in your instructional-design textbooks, but which have a tie to e-learning if one looks closely. Note that these brief capsules are intended as a starting point for conversation, to illustrate the breadth of relevant ideas impacting e-learning practice. For further discussion, see Friesen (2009).

Modernism and Its Critique

In 1933, the World's Fair was held in Chicago, showcasing the achievements of nations in providing services to their citizens. Its motto:

> **Science Finds, Industry Applies, Man Conforms**

This motto captures well the confidence people had in their institutions and science and industry's capacity to deliver the Good Life—if not now, then soon. In the 80 years since, society has continued in its march of development—amazing inventions providing entertainment, comfort, and conveniences to billions of people. Yet the sense of optimism is tempered by a foreboding that for every new development, for every technological solution, a pride is paid and an unwanted consequence is unleashed upon the world. This hesitation about ongoing progress is part of the *postmodern* turn that takes a more critical stance to our views and practices, and challenges established institutions (Hlynka, 2004; Hlynka & Belland, 1991; Wilson, 1997).

Dignity of the Individual

Thinkers of the Enlightenment Era (1700s in Europe) championed Man as a standard of goodness and knowledge, and deemphasized Deity as the necessary controller of world events. The Judeo-Christian belief that each person is made in God's image contributed to reformed thought including democratic governments, free markets, and religious freedoms, and labor and antislavery reforms. Valuing the individual can highlight differences: competition, innovation, extraordinary accomplishment, outstanding contribution, etc.—but also the commonalities we all share, respecting the inherent worth of all people. These human values have become part of the liberal tradition of thought. We see this influence today in our views about racism, sexism, privacy, and the rights and privileges of citizens.

Division of Labor: Feeding the System

Following publication of Adam Smith's *The Wealth of Nations* in 1776, the emerging field of economics examined how markets for products and services behave. Karl Marx offered a critique of capitalism that saw human labor as a commodity that could be bought and sold. Capitalism depends on a division of labor with different roles for people, some doing very menial work and receiving lower compensation, others doing more valued work and receiving higher compensation. Of course, a free market would not have every job position doing the same work for the same compensation—rather, *differentiation* is assumed and required for the system to function. Applying this notion to education, we should understand that students coming through the pipeline are preparing for a finite number of jobs—not everyone *can* be an information worker, for example. The larger economic system requires certain numbers of workers of different kinds. Within schools, we can observe the same principles of divided labor through staff organization and also through student assessment systems and the resulting outcomes of screening, diagnostics, and tracking. All of this is part of a larger system of inputs and throughputs, feeding a capitalist system where differentiation is essential.

American Pragmatism: Truth as What Works

The American Civil War was a severe test to the nation, and changed the way people thought about life (Menand, 2001). The surviving generation, including Oliver Wendell Holmes and William James, developed a pragmatist philosophy to help them rebuild their lives. Their stance replaced a correspondence theory of truth (something is true if it matches some ideal or objective reality out there) with a pragmatist approach: truth can be determined by its consequences, whether it leads to good outcomes (Rorty, 1979).[1] John Dewey, the principal American pragmatist of the twentieth century, turned his energies toward education and sought to reform schools through authentic learning, problem solving, dialog, and collaboration, which would in turn help students thrive in a complex world. Dewey's impact on education can be discerned today in constructivist approaches to learning that place more attention on problem solving and inquiry processes, and less on acquisition of objective facts.

Power of Narrative

Jerome Bruner was a cognitive psychologist in the 1960s, when behaviorism dominated American psychology and a computer metaphor of information processing was just beginning to take hold. Bruner's brand of cognitivism differed though—he wanted to understand how people *constructed meaning* out of their interactions, and saw people not like computers with inputs and outputs, but as agents acting on the world and interpreting situations through language. Bruner and others stressed the important of *narrative* as a conveyer of knowledge and action. So much of our understanding comes through cases and stories, which can embody and illustrate principles and rules, and can also go beyond the rules, conveying a complexity and richness of the world as it is.

Critique of Technology

Ever since technology arose as a construct, critics of technology have warned of negative side effects (Carlysle, 1829). Philosophers of technology have shown that not only is technology a carrier of values and meanings, new technologies actively shape and influence the values and meanings—even identities—that we own (Edelbach, 2010). A relevant lesson from history is that technology *bites*

[1] The two great wars fought in the twentieth century had a similar impact on European thinking—hence the similarities between American pragmatism and continental philosophy as seen through the work of Heidegger, Derrida, and Foucault.

back: Whenever knowledge and technique is applied to solve a complex problem, unforeseen consequences emerge that require further knowledge and problem solving (Tenner, 1997). Our own history of technology in education shows the same pattern (Reiser, 2001). As experts in technology use, e-learning specialists should be more aware of these issues than our lay counterparts, and lead them carefully through the dangerous waters. If we are seen as mere cheerleaders for the latest tool and fad, we are sorely astray of our proper mission.

Privileged Binaries

Jacques Derrida (pronounced Dare-a-DAH) was a French linguist and philosopher who developed the notion of *deconstructing* difference—closely examining the meanings in our use of language, including what we do not say. His approach, drawing on structuralist linguistics, included two ideas: (1) Language is based on binaries—hot/cold, high/low, black/white, etc. Every construct has an opposing binary that complements it. (2) One of the binaries is privileged, and the other is recessive or weak. So depending on context, one side will tend to get noticed, talked about, used, and given privilege and voice—while the other side is weaker, with less privilege, voice, and use (see Wikipedia's entry on binary opposition). In education (and e-learning), *theory* tends to be privileged over practice, *abstract* over concrete, and *science* over art. Educators develop blind spots, where the prevailing way of seeing things masks an underlying reality that coexists but which is largely invisible to participants. The same principle applies to participants themselves—some people and their interests (or the groups they represent) can be virtually invisible in the process. Exploration of the silent or invisible or less noticed can be a fruitful inquiry leading to new insights into e-learning practice (for an accessible introduction see Collins and Mayblin [1996]).

Foucault's Critique of Power in Institutions

Michel Foucault (pronounced Foo-COE) was a French twentieth century intellectual who examined how behavior is regulated in modern institutions. He studied prisons and discovered how just a few officers could completely control the lives of hundreds of prisoners, without the overt use of violence. He found that the violence was institutionalized in the structures of the facility, the rules of behavior, and the routinized practices of both officer and inmate. Modern correction officers avoided physical violence, instead maintaining control through "disciplinary" punishment—an established regimen of everyday practice. He later analyzed schools in a similar fashion, with similar conclusions. Foulcault's analysis has implications for participants in e-learning programs, including teachers and students, and the power dynamics within the institutions, reminding us of the dehumanizing effects our institutions and policies can have on people we are meant to serve.

Education as a Political Act

Paulo Freire serving as minister of education in a Brazilian province came to see education as a means of helping indigenous peoples become empowered individually and collectively. By gaining literacy skills and knowledge of the world, these people were able to enter the political process and assert their voices in all aspects of their lives. In *Pedagogy of the Oppressed*, Freire (1970) articulated the way that education of oppressed peoples can help empower and emancipate them politically as well as individually. In e-learning settings, a Freirean would ask—how are we empowering and emancipating our students and giving them voice, to become more fully human and participate more fully in the marketplace and political system?

Summary

These short capsules illustrate the breadth of thinking that critical observers engage in. For a longer list of critical theorists, see Dimitriadis and Kamberelis (2006). But a critical stance rests not only on theories but also on our everyday knowledge about local situations—the kinds of knowledge David Perkins (1996, p. 45) calls "knowing your way around the neighborhood." Things make sense within a context—try to broaden your context as much as you can, and it will inform your practice. A former colleague would routinely ask candidates for employment or graduate-school admission: "What have you been reading lately?" The intention was to see if this person engaged in self-directed learning and professional reflection. Recently a manager of a medium-sized e-learning support department reported a successful hire:

> All of our candidates knew the standard theories and models. We hired Mike because he could put these in a context—he knew what was going on in the world and what people in different fields were talking about. We wanted somebody to push us and broaden our thinking.

There truly is no substitute for being a well-informed, knowledgeable practitioner.

Interrogation Based on Core Values

As outlined above, Western thought has evolved to a point of valuing people's inherent worth as individuals. Because education is seen as a key tool for individual progress, it is often a battleground for competing visions of society and resolving inherent tensions between freedom and equality. In e-learning, the issues may emerge in questions like:

- Who has access to e-learning?
- Who is it designed for?
- Who is paying the bill and what are their interests?

- Who are the gatekeepers to entry and participation—and how do they exercise their influence?
- What barriers/obstacles are in place that would prevent people from access, participation, and success?
- How can we equip more people to succeed in e-learning environments?
- What are some forms of resistance people might offer, and where are we seeing resistance happening?
- How do people from different nations or cultures respond to e-learning pedagogy—for example, self-disclosure to peers, challenging the instructor, and constant participation in dialog?
- How does e-learning change the narrative, the formula of winners and losers, the language that we use to describe our lives and ourselves?

An example may help. Three-dimensional tools are emerging now that can make e-learning environments even more immersive. Right now 3D displays require special glasses, with a certain number of people unable to use them because of headaches and other physical problems. So the question arises: What percent of a K-12 population are we willing to exclude from access to 3D content, in order that the majority might benefit from the 3D experience? Five percent? Two percent? And how would that school develop alternative content to serve those students who cannot participate? Questions like this arise in every setting—K-12 and postsecondary education, corporate and government work settings—even home and informal learning settings.

The Digital Divide is the term most often used to describe achievement disparities between races and language groups. Efforts to address performance gaps can come from widely varying ideological bases, yet all share some fundamental values—that people should have access to educational opportunities, regardless of race, language, or social class. A critical e-learning stance does not duck these issues, but continually looks for ways to use e-learning as a positive tool rather than further perpetuate inequities.

Close Readings: Viewing Practice as a Text

Germany was a center for Bible scholarship during the Enlightenment period. As scholars closely studied Biblical texts, they discovered that the text could be read in different ways from different perspectives, leading to startling conclusions—for example, that Moses could not have written the Pentateuch (the first five books of the Bible), as traditionally believed, because his own death was described in the narrative. Over time, these scholars developed a *hermeneutical* approach to interpreting texts that enabled them to make inferences about the writers, intentions, audiences, and circumstances of authorship—uncovering hidden stories behind the stories.

Critical theory adopts a similar stance toward analysis of things we do not normally consider texts: films, for example, or paintings. For our purposes, a session of a classroom might be considered a "text" to be read and interpreted, unlocking hidden meanings through a careful method of analysis and inquiry. For e-learning educators, a "text" could be an online course, a threaded discussion, an educational software program, a media-design tool, a portfolio, a podcast, or a wiki—all subject to careful reading, observation, and analysis (e.g., DeVaney, 1993, 1994). These careful readings open up meanings and interpretations—for example, how people construct understanding of a subject, how they systematically include or exclude others in their conversations, or how they choose to interact and participate together.

For scholars, close readings of practice (as a text) is based on careful method—otherwise readings can go off in tangential directions and lose a sense of coherence and discipline. In practice settings, the process is not so formal. E-learning professionals can develop habits of noticing and interrogating situations where values are revealed through our institutions, policies, strategies, and practices. Qualitative inquiry methods, both formal and informal, owe a great debt to the hermeneutic tradition and differ markedly from objective methods of educational research, with fixed treatments and standardized outcomes (Friesen, 2009).

Resolving the System-Change Dilemma

Educational technology is a curiously bipolar field. On the one hand, we stress how everything is systemically related. An intervention in one part sends out ripples and reverberations throughout the system. Systems theory pervades early thinking in the field and continues to the present day. On the other hand, we tend to frame these interventions in narrow, linear terms: straightforward goal-based programs, gap analyses, pre- and postmeasures, and technical fixes that seem impervious to the systems surrounding them. How do we reconcile our proclivity to technical problem solving while acknowledging the nuances and complexity of the situations we work within?

While surely some model can be proffered that would show these relationships, a critical stance would simply be cautious in intervening, keeping an eye out for participants in the margins, giving voice to unsponsored interests, and specifically look for unintended outcomes. Complex systems *can* change by finding the right leverage points, marshaling support from the "crowd," and broadcasting innovations throughout the system. Following the adage "think globally, act locally," a critical stance is not cynical toward technical fixes, but rather asks us to keep our gaze higher toward larger impacts and issues. Any effort to really change the larger system requires a particular configuration of favorable conditions, including leadership from management, buy-in from opinion leaders, incentives and supports, and a local culture that embraces change. A systemically minded e-learning specialist can analyze situations and address weak points in a support system, rather than toiling away at one piece of the puzzle.

Constructive Synthesis

The term "critical" carries an admittedly negative connotation. All of us are somewhat defensive toward criticism. Our approach includes an ability to bring together knowledge that relates to a problem, and creatively *synthesize* that knowledge into new formulations and representations. After all, having a broad knowledge base is of no value if you cannot apply the knowledge to the problem at hand in a useful way.

As mentioned above, a critical stance would value collaboration and inclusive participation in solving problems. Yet bringing diverse perspectives together in a meeting can be difficult—people can easily get stuck defending their positions and unable to see a common way forward. Have you ever known a colleague who can see diverse perspectives and formulate a way of including those perspectives into a solution path, enabling a way forward? I mention this with envy, because I have never seen myself as one of these people.

People who can synthesize practical knowledge may find audiences among the general public (popular theorists like Stephen Covey or Daniel Pink) or the profession (bloggers like Stephen Downes or George Siemens), or within your organization. Bringing an analytic framework to the front end of projects can be valuable—frameworks such as cost–benefits or return-on-investment analysis, performance improvement, systems or process modeling, SWOT or strategic planning, or simply framing a problem within a useful narrative. Or pulling a similar interpretative framework together at the end of an inquiry project can clarify action alternatives. Learning to think visually and constructing figures and diagrams to represent problems and solutions—these skills enable stakeholders to look more critically and constructively at e-learning problems and determine appropriate action.

Transformation

Transformation is meant to something of a mystery—if we understood how deep change happens, we would do it more often! A critical stance should be open to the possibility, however rare, of radical and transformative change, in individuals, teams, organizations, and whole professions (Wilson & Parrish, 2011).

Conclusion

A critical stance toward e-learning practice would be reflective and informed by multiple perspectives and competing values and interests. The critical practitioner would reflect on what's good and needed in practice and seek to organize their goals and activities in service to those values, always on the lookout to improve practice and increase awareness of choices and alternatives. A critical practitioner uses various theories and models in their work—but as tools, not as static descriptions of reality. The needs/demands of local situations and their participants speak louder than the abstract theories and generalizations learned in school.

Becoming a critical practitioner is not something you simply can learn in graduate school or even in the first years of professional work. It takes a life-long professional commitment to gaining new knowledge, reflecting on your work, looking for impacts and meanings. Adopting a critical stance need not radically change the *types* of tasks you do or the products you create—rather, by deepening your awareness, the *quality* of your work should improve. Through greater sensitivity to meanings, connecting to people, and meeting their real needs, the quality, accessibility, and impact of your work should improve. These are outcomes that will help us truly become a *professional* in the classic sense of the word: guarding a specialized knowledge domain and committing to an ethical obligation to serving our clients and students in the best way possible, we also seek the public good and the strengthening of the profession itself.

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Critical Theory and the Mythology of Learning with Technology

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Critical theory is generally defined as the diverse body of work produced by members and associates of the Frankfurt Institute for Social Research (or simply, the "Frankfurt School") between 1930 and the present. Among the most important of these individuals are Theodore Adorno, Walter Benjamin, Jürgen Habermas, Max Horkheimer, and Herbert Marcuse. In a broader sense, critical theory is also associated with the contributions of late twentieth century social and even literary theorists, such as Louis Althusser and Roland Barthes. The theoretical contributions of the original Frankfurt School members frequently focus on media and technology (e.g., Benjamin, 1968; Habermas, 1970), education (e.g., Adorno, 1981a), and the relationship of both of these to social change generally (e.g., Horkheimer & Adorno, 2004). Despite the fact that these areas are of clear relevance to research and practice in educational technology, this theory and associated methods appear little recognized in research in this field.

The central argument of critical theory is that all knowledge, even the most scientific or "commonsensical," is historical and broadly political in nature. Critical theorists argue that knowledge is shaped by human interests of different kinds, rather than standing "objectively" independent from these interests. (Even knowledge encoded in the form of scientific facts, like those of epidemiology or astronomy, has changed over time, giving varying meanings even to relatively unchanging natural phenomena such as the spread of disease or the movement of celestial bodies). Human interests are understood as multiple and sometimes contradictory; as a consequence, knowledge itself is also seen as fundamentally pluralistic and incongruous, rather than unitary and monolithic.

Critical theory singles out for criticism and critique knowledge that is marked by particular characteristics. It focuses on knowledge that presents itself as certain,

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final, and beyond human or political interests or motivations. Critical theory sees its central purpose as the destabilization of such knowledge. In its place, critical theory seeks to generate alternative knowledge forms, specifically, those shaped by social interests which are democratic and egalitarian. Critical Theory, in sum, seeks to "make problematic what is taken for granted in culture," and it does so in the interests of "social justice," especially in the interest of "those who are oppressed" (Nichols & Allen-Brown, 1996, p. 226). Its emphasis on critique may make critical theory seem similar to postmodern approaches; however, its grounding of this critique in the foundations provided by ideological and human interests, as shown below, make critical theory distinctly *modern*.

Jürgen Habermas, a younger member of the Frankfurt School and one of the most well-known of contemporary social theorists, provided a basis for a compelling and widely referenced way of classifying knowledge forms, or more specifically, of "knowledge-constitutive interests" (see Table 1, below). Habermas understands knowledge as constituted by human interests that are "technical," "practical," and "emancipatory" in nature. Each interest is associated with a particular type of knowledge, a particular medium or area of human effort and interaction (medium), and by a correlative science or specialized type of knowledge and study. *Instrumental* knowledge corresponds to technical human interests that are associated with work, labor, or production and with the natural sciences. *Practical* knowledge refers to interpretive ways of knowing through which everyday social and cultural human activities are coordinated and given meaning (hermeneutics being the methodology of interpretation). *Emancipatory* knowledge, finally, is the kind that critical theory itself seek to generate and is articulated in terms of power, control, and emancipation.

Critical theorists would maintain that these three forms of knowledge and interest are never entirely separate. Emancipatory, or more broadly, political knowledge and interests are seen as interpenetrating *all* knowledge forms—whatever their purpose or related interest. This all-pervasive character of political knowledge and interest is central to the critical-theoretical concept of *ideology*. Ideology, in this context, does not so much refer to all political or emancipatory knowledge in and of itself nor to extreme political orientations or programs. Instead, ideology refers to *any* kind of knowledge (whether technical, practical, or emancipatory), particularly that which *appears* to be purified or freed of political interest: knowledge that is presented as self-evidently factual, neutral, or objective. According to critical theory, it is precisely this kind of

Table 1 Three kinds of human interest and knowledge as identified by critical theorist Jürgen Habermas

Interest	Knowledge	Medium	Science
Technical	Instrumental (causal explanation)	Work	Empirical, analytical, or natural sciences
Practical	Practical (understanding)	Language	Hermeneutic or "interpretive" sciences
Emancipatory	Emancipatory (reflection)	Power	Critical sciences

Source: Carr & Kemmis, 1986, p. 136; used with permission knowledge that is actually most driven by interests. As Adorno describes it, ideological knowledge is characterized by an "overbearing matter-of-factness," as facts which present themselves as neutral, self-evident or objectively true, despite being strongly shaped by social interests (Adorno, 1981b, p. 126).

Ideology is also defined as "a systematic scheme of ideas, usually relating to politics or society, or to the conduct of a class or group, and regarded as justifying actions" (OED, 2007). Ideological beliefs or ideas are also generally "held implicitly or adopted as a whole and maintained regardless of the course of events" (OED, 2007). Ideology, then, is a set of ideas or a kind of knowledge that is used to justify actions of social and political consequence and that is considered so obviously commonsensical or natural that it is placed beyond criticism, "regardless of the course of events." Other ideas or ways of knowing, by implication, tend to be marginalized as nonsensical, radical, or as "ideological" (in the more common and polemical sense of the word).

The social acts that an ideology justifies are often closely allied with powerful social and economic interests. For example, in mid-nineteenth century England it was generally a matter of "common sense" that keeping children in factories and out of school was socially productive, even economically necessary. Other views—that children deserved special consideration or that education would bring greater benefits to society in the long term—were marginalized. One member of the British parliament at the time went so far as to claim that regulations *against* child labor would represent "a false principle of humanity" and "an argument to get rid of the whole system of factory labour" (as cited in Feenberg, 2002, p. 146). Of course, what was once accepted as common sense is now highly criticized and easily recognized as driven by narrow, vested interests.

When ideological positions and arguments are elevated to (false) principles of humanity or are said to endanger whole ways of life, when they eliminate even the slightest hint of reflection or doubt, then they gain the status of "myths." These are "explanations of the world as all or nothing," truths that possess a "false clarity," that acquire the status of absolutes or that are presented as inevitable or indisputably "natural" (Adorno & Horkheimer, 1997, pp. xiv, 24). In his book of cultural critique, *Mythologies*, Roland Barthes echoes and amplifies this understanding: Myth "purifies" things, "makes them innocent…gives them a clarity which is not that of an explanation but that of a statement of fact." Myth, Barthes continues,

> "is constituted by the loss of the historical quality of things: in it, things lose the memory that they once were made… A conjuring trick has taken place; it has turned reality inside out, it has emptied it of history and has filled it with nature." (Barthes, 1972, pp. 142–143)

Critical theory responds to mythical inevitabilities and ideologically charged "common sense" by undoing these emptying and conjuring tricks. It "denaturalizes" that which is seen as natural; it problematizes that which is plain and commonsensical. It does this through "ideology critique" or more, "immanent critique." Through these "critical" methods the researcher takes ideas or knowledge presented as commonsensical and self-evident, and compares them to the social and cultural conditions to which they pertain. The researcher places ideas in their historical context and situates them in the complexity of a larger social background. Using the term "philosophy" to designate this critical method generally, Horkheimer explains that this process begins first by taking seriously the significance or "truth value" of everyday claims or ideas:

> It should be admitted that the basic cultural ideas have truth values, and philosophy should measure them against the social background from which they emanate. It opposes the breach between ideas and reality. Philosophy confronts the existent, in its historical context, in order to criticize the relationship between the two and thus transcend them. (Horkheimer & Adorno, 2004, p. 124)

Immanent critique seeks figuratively to "measure" the difference between what is claimed in commonplace ideas on the one hand and what is evident from historical and other social sources, on the other (see also Held, 1980, 183–187). In the language of Barthes, this method seeks to restore to things their history and recovers "the memory that they once were made" rather than presenting things as though they have simply always been the way they are. Horkheimer sees these differences and contradictions overcome or "transcended" in the sense that immanent critique does not remain confined to either ideas or the background from which they emanate. Instead, in highlighting the contradictions hidden behind ideological claims, this critical method is also able to point to new ways of understanding circumstances which are otherwise taken for granted and it is, therefore, able to suggest new courses of action. Essentially, the denaturalization and problematization of critique is performed by bringing a multiplicity of forms of knowledge into play, comparing what is accepted as self-evident in one set of sources, one literature or discourse, and by comparing it with what can be found in different and often alternative sources of information.

To put it in slightly different terms, ideology critique is about asking questions of things that are otherwise considered too self-evident to be put into question. For any claim of social or political relevance, therefore, ideology critique asks: "Why is it being made as it is?" "In whose interest is it being made?" "What is its relationship to different knowledge forms and claims—especially ones considered radical or marginal?" Engagement with ideological claims in this way can then extend critical inquiry to questions such as, "How might it appear to be natural or commonsensical and how can this "naturalization" be undone?"

It is important to remember that the process of critique is *not* a question of replacing the deceptions of ideology with incontrovertible truths. Instead, as Adorno puts it, it is more a matter of disabusing ideology of "its pretention to correspond to reality" (Adorno, 1981b, p. 32). In doing so, ideology critique is able to show that beneath the veneer of the commonsensical or self-evident there exist contradictory or opposed knowledge claims or forms. Behind the "naturalness" of natural or obvious truths are clashing social and human interests.

It is not difficult to take the methods of imminent critique steps associated with critical theory, above and apply them educational technology (or to a related area), especially to statements and publications that are used to legitimate or promote particular priorities and perspectives in this field. The claims and ideas presented in papers, presentations, and proposals that are most obvious and least subject to dispute or disagreement in a field like educational technology can be subjected to critique—with the intention of highlighting their constructed or ideological nature. In the case of educational technology, examples of these self-evident truths or claims are frequently encapsulated in catchphrases or buzzwords that are relatively easy to find in the literature. Phrases like "knowledge age" (e.g., Scardamalia & Bereiter, 2003), the "digital generation" (e.g., Bourne, Harris, & Mayadas, 2005) or fixed, exponential "laws" of technological change (e.g., Jukes, McCain & Crockett, 2010) are salient examples. As will be shown, these slogans give economical expression to "self-evident" notions that we live in an economy driven principally by developments in knowledge, the Internet provides the possibility of ubiquitous education, or technological progress drives educational change. It is these "common sense" ideas that, in this chapter, will be subject to the "historicizing" and "denaturalizing" force of ideology critique. They will be shown to be shaped by powerful, entrenched and often conservative social interests. They will also be shown to simplify or obscure a complex social reality that is constituted by different and conflicting forms of knowledge and that can be interpreted variously, depending on one's interest or motivation.

The Myth of the Knowledge Economy

It is commonly asserted that "knowledge," "information" or more abstractly, "the networked" or "the postindustrial" are eponymous for our economy. As with ideological claims generally, these broad and often unquestioned assertions have significant social and political implications. In the case of educational technology, they bring with them urgent implications for all levels and forms of education—from the preparation of children as "knowledge builders," through to wider society, to promote "collective responsibility for idea improvement" (Scardamalia & Bereiter, 2003, p. 12). As a consequence we are presented with assertions such as the following: "In what is coming to be called the "knowledge age" [the] challenge [is to] get students on…a *developmental trajectory* leading from the natural inquisitiveness of the young child to the disciplined creativity of the mature knowledge producer" (Scardamalia & Bereiter, 2003, 1370; emphasis in original); and "The new economy has placed the acquisition of knowledge, and the role of higher education, at the center of national development" (Futures Project, 2001); or further, that in our "knowledge-driven era… education is a lifelong endeavor and may —only occasionally—be mediated by the traditional artifacts of our historical learning experiences" (Gandel, Katz, & Metros, 2004, p. 73).

Unsurprisingly, traditional educational artifacts—such as "classrooms," "professors," and "degrees"—are generally seen as being superseded in the new knowledge economy, specifically by more advanced information or knowledge technologies: by computer supported "knowledge-building" environments (Scardamalia & Bereiter, 2003), learning objects (Polsani, 2003), and other advanced technologies and approaches. The idea of a radically new social, historical or economic order centered around information or knowledge has an important and politically charged history. By examining this history and thus *historicizing* the idea of the knowledge economy, it is possible to show its gradual construction and its actual and possible contestation. This history begins with a paradigmatic "shift recognized as early as 1973 by Daniel Bell…the shift from an industrial to a knowledge economy…" (Gandel et al., 2004, p. 42). Bell, who is sometimes described as one of the fathers of neoconservatism (e.g., see Nuechterlein, 1990) is famous for his account of the "coming… postindustrial society." In fact, this phrase forms the title of a text by Bell, which arguably serves as the basis for much subsequent speculation on new social and economic forms for the twentieth century (e.g., Brzezinski, 1970; Toffler, 1980; see Mattelart, 2003 pp. 73–98). In his foreword to the 1999 edition of this famous text, Bell lists the characteristics of the coming postindustrial society and how they have become and continue to be manifest. Among these are four trends: First, Bell identifies a shift from "manufacturing to services" in the workforce and the economy (Bell, 1999, xv). The percentage of the workforce employed in the manufacturing sector in America, Bell points out, has shrunk over the past decades, and has been accompanied by an "extraordinary rise of professional and technical employment" (Bell, 1999, p. xv). Associated with this first shift is an important, second change, an increase in the general importance of education: "Today education has become the basis of social mobility," as Bell puts it, "especially with the expansion of professional and technical jobs…" (Bell, 1999, p. xvi). A third change listed by Bell is the increased importance of technological infrastructure, and what he refers to as "intellectual technology:" "These technologies," Bell explains, "form a complex adaptive system that is the foundation of the electronically mediated global economy" (1999, xvii). The combined result of these and other changes is effectively summarized in Bell's fourth trend or characteristic: The "knowledge theory of value:" "Knowledge is the source of invention and innovation. It creates value-added and increasing returns to scale…" (Bell, 1999, xvii).

This last point on the social and economic value of knowledge is perhaps of greatest importance in descriptions of the "knowledge economy." Bell makes it clear that his phrase, "knowledge theory of value" is a deliberate variation on Karl Marx's, "labor theory of value" (Bell, 1999, p. xvii). Marx understands labor—specifically physical labor—as being a unique force in capitalist economies in that it is the only one capable of "adding value" to commodities and products that can then be sold at a profit (Bottomore, 1983; 265). In a significant theoretical move, Daniel Bell as well as those following in his footsteps present *knowledge* as playing this essential generative, value-adding, profit-making function. This has substantial consequences for understandings of the generation, mobilization, and exchange of knowledge in educational and research contexts. These consequences and implications extend to the nature of knowledge itself, as well as to the multiplicity of knowledge forms posited by Habermas and others.

With this "knowledge theory of value" as Bell recognized early on, the "knowledge work" occurring in education and elsewhere appears as a process of unprecedented importance. Besides being "the basis of social mobility" (Bell, 1999), education takes its proper place, as Peter Drucker says, at "the center of the knowledge society, [with] schooling [as] its key institution" (Drucker, 1994, p. 2). The critical economic and social value of these key educational institutions rests not so much in their function of social reproduction or in their potential to contribute to individual autonomy and responsible citizenship. The value of educational institutions rests instead in their role as a means of generating and reproducing knowledge as a value-creating productive force. The paradigmatic form of knowledge in this context is applied, natural scientific knowledge associated with disciplines such as engineering, chemistry, and life sciences (to list just a few examples):

> The major problem for the post-industrial society will be adequate numbers of trained persons of professional and technical caliber… The expansion of science-based industries will require more engineers, chemists, and mathematicians. The needs for social planning…will require large numbers of persons trained in the social and biological sciences (Bell, 1999, 232).

When evaluated in terms of the postindustrial knowledge generation and creation, however, the educational institution in its current form appears as woefully inadequate, hopelessly or even fatally outmoded. In the literature of educational technology and reform, schools and universities alike are characterized as following an outdated "industrial paradigm" (as opposed to a "postindustrial" model; Gilbert, 2005) as being "cottage industries" (Newman & Couturier, 2001; Smith Nash, 2005) or more generally as being "stuck in the past" (e.g., Lucas, 2003):

> in very fundamental ways, education is stuck. It doesn't know where to move and it doesn't have the tools to move with. The dialogue, both within and outside the education profession, does not advance. The same blunt statements (including this one) are made over and over. The tools education needs, of course, are conceptual tools. In this so-called Knowledge Age [sic], that is the first requirement. (Bereiter, 2002)

Not surprisingly, this same author goes on to emphasize the importance of computer, Internet, and other high-tech tools that correspond to these conceptual tools (e.g., Bereiter, 2002; pp. 460–462; Scardamalia & Bereiter, 2003).

A second implication of the knowledge theory of value is that it privileges some characteristics of knowledge over others. When knowledge is understood as a productive force, for example, it is not the role of knowledge as an instrument of enlightenment or of democratic decision making that is brought to the foreground; instead, knowledge tends to be characterized as a kind of service, utility or good to be bought and sold, used, enhanced, and reused. It becomes a kind of "super commodity" that has market value like physical commodities and that also transcends the products of physical labor. Mason, Lefrere, and Norris, writing specifically of "e-Knowledge," describe it as being "both a thing and a flow" that has the capacity to be "'atomized,' repurposed, updated, recombined, metered, and exchanged" (Norris, Mason & Lefrere, 2003, p. 1). Unlike physical goods, however, this commodified knowledge can be readily "mobilized" and "unbundled to take account of the location of users and their needs at [any] location" (Norris et al., 2003, p. x). And when such knowledge or "content is modularized and coupled with learning objectives," these same authors explain, "it is typically referred to as 'learning objects'" (5). In the context of a "knowledge society" in which knowledge as an economic force and commodity is paramount, it takes its paradigmatic form in education as a learning object. These "learning objects," which have received much attention in the literature of e-learning, refer to modular, exchangeable, digital resources that are able to be combined and configured with other digital objects.

A third ramification of the "knowledge theory of value" is that when conceptualized as a kind of "super-commodity," knowledge becomes something quite different from the way it is understood by Habermas and critical theory—as being contestable, multiple and derived from different human "constitutive interests." This multiplicity and this motivated or "interested" character of knowledge is effectively suppressed or erased. Instead knowledge is judged by a single and sole criterion, specifically, its "*performance*" (Polsani, 2003; emphasis in original). Writing about this performative knowledge, specifically as it is manifest in learning objects, Polsani explains:

> Before the advent of the postindustrial age in the 1960s, Enlightenment and post-Enlightenment ideas determined the purpose and use of knowledge. The European Enlightenment defined the human being as a subject whose destiny is the realization of its full potentialities through reason. The goal of acquiring learning was the realization of spirit, life, and emancipation of humanity and the purpose of production of knowledge was the moral and spiritual guidance of a nation. However, in the contemporary conceptualization of knowledge, its purpose is no longer to realize spirit or emancipate humanity but *to add value*… The legitimacy of performative knowledge is no longer granted by the grand narratives of emancipation, but by the market. (2003)

This notion of a purely performative and productive knowledge that is privileged above any other knowledge forms is also described in other accounts of the knowledge society. Again it is Daniel Bell, in his *Coming of the Postindustrial Society* (1999), who provides an early and powerful distillation of this "knowledge age" phenomenon. In this text, he describes the generation of productive knowledge as occurring paradigmatically in the "community of science":

> The community of science is a unique institution in human civilization. It has no ideology, in that it has no postulated set of formal beliefs, but it has an ethos which implicitly prescribes rules of conduct. […] As an imago [an ideal or subjective image], it comes closest to the ideal of the Greek polis, a republic of free men and women united by a common quest for truth (Bell, 1999, p. 380).

This "universal" and "disinterested" scientific knowledge enables what Bell refers to as "technical decision making" (Bell, 1999, 34). This form of technological management or administration is an application of knowledge, as Bell explains further, that "can be viewed as the diametric opposite of ideology": Technological decision making is "calculating and instrumental, [while ideology is] emotional and expressive" (Bell, 1999, 34).

Of course, it precisely these kinds of claims that Adorno, Horkheimer, Barthes (and other critical theorists) would see as being ideological in the extreme, as exemplifying myth in its critical sense. When knowledge claims deny their relation to human interests of any kind, their "pretention to correspond to reality" becomes absolute. In this context, simply having shown—in the preceding paragraphs—how these ideas originated and how they continue to evolve undermines their claims to natural or self-evident truth.

As emphasized earlier, however, the task of critical theory is not simply to engage in "criticism" for its own sake. It also seeks to generate emancipatory forms of knowledge able to provide alternative and progressive ways of thinking and acting. These can be found by looking to sources of information that stand as alternatives to those usually referenced in e-learning or research and development in ICTs. One simple example of this kind of source is provided by information that is supplied to people who are unemployed or who find themselves, as is euphemistically said, "in-between jobs." Imagine yourself looking for a job as a student or considering the possibility of a new area of employment (as millions of people do every day). As a part of your job search you go to the US Department of Labor Web site and look at the "career advice" section available there. Under the heading "Career Changers," this web site lists the top ten highest-growth industries in the USA and shows the total number of jobs that will be created in each by the year 2014. Based the way that the "knowledge economy" has been described above, you would think that jobs in research, high tech, and information technologies would be at the very top of this list. But this is not the case. The first three industries or areas of employment listed are "hospitality," "health care," and "retail." Together, these three categories will provide more new jobs than the remaining seven job categories, combined. These top three sectors are predicted to produce over 15 million jobs in the USA by 2014. After this top three come the financial services and construction industries. These top five industries hardly suggest that your best chances for a job would be to become a "mature knowledge producer" who would manage and produce knowledge or direct and meter knowledge flows. You would be more likely to conclude that future career choices can be found in the area of *service*: Working in a Wal-Mart (retail), a Holiday Inn (hospitality), or perhaps more optimistically as a hospital worker or care provider (healthcare).

Indeed, Daniel Bell and other sociologists and economists have given significant emphasis to this *service* component of the postindustrial economy. They sometimes describe the current social and economic order as being *both* a knowledge *and service* economy, highlighting the postindustrial specifically as entailing a shift "from manufacturing to *services*" (Bell, 1999; xv; emphasis added). This particular emphasis has much more ambivalent and problematic implications than the more single-minded emphasis on knowledge or information that is likely familiar to those researching ICTs. Obviously, service jobs do not hold the long-term attraction or bring with them the income, status or stability associated with terms like the "information worker" or "knowledge producer." Also, service sector employees generally require only "short- to-medium term on the job training" (Henwood, 2003, p. 73), with obvious and baleful implications for education and higher learning.

Perhaps the most important implication of the postindustrial economy as one reliant on *services* is social and economic polarization. Management guru Peter Drucker, for example, distinguishes between a *knowledge class* on the one hand and a *service class* on the other. It has been part and parcel of the new economic order that the rich are getting richer by (among other things) taking advantage of economic changes related to knowledge and technology to increase their wealth, and that the poor, disadvantaged by these same changes, are getting poorer. A rather dire picture of where this all may lead is also provided by Drucker:

> This society, in which knowledge workers dominate, is in danger of a new class conflict: the conflict between the large minority of knowledge workers and the majority of people who will make their living through traditional ways, either by manual work, whether skilled or unskilled, or by services work, whether skilled or unskilled. (Drucker, 1994, p. 67)

Thus, beneath the simplicity of the slogans about the "knowledge economy" and its imperatives for educational change, lurks socio-economic developments that are fraught with conflict between economic classes and clashing political interests. The myth of the knowledge economy obscures this clash by generalizing the situation of one class or group within the "knowledge economy," "knowledge workers"—to the population as a whole. To simply state that "children need to be placed on a trajectory" leading to knowledge work is to ignore the fact that other, marginalized and less celebrated forms of work are also structurally necessary in a "knowledge and service society." To recognize this is also to recognize that education must instead actively cultivate a range of skill sets germane to different economic fates. In other words, educators must prepare students for work in the service economy as well as more celebrated positions in the knowledge sector.

Of course, given its inescapable involvement in knowledge in all its forms, e-learning, and education have a further responsibility to recognize and engage with knowledge in its many forms and in terms of its multiple human interests. Education and e-learning need to move beyond understandings of knowledge and of its construction and reproduction as a "universal" and "distinterested" productive force that is measured and valued only in terms of its performance. With regard to knowledge or learning objects, critical theory teaches the importance of moving beyond their conceptualization as interchangeable modules or "black boxes" of knowledge, separated from the contexts and interests associated with their use. Using critical theory, educators generating and reproducing knowledge are able to open up this black box to ask whose knowledge might be inside, in whose interests this knowledge might be constructed and about the possible and multifarious implications and contexts of its use.

The Myth of the Digital Generation

The "net generation" (also known as "generation y," "millenials" or "digital natives") has been defined as those born in industrialized nations between 1980 and into the first years of the twenty-first century—with some variation on beginning and end dates. Given this timeframe, what is clear is that as members of this generation have grown up, they have been exposed to technologies such as personal computers, the Internet, video games, and mobile phones. These young people are characterized as valuing these new media over the old, and as being more familiar with videogames and texting than their parents and teachers. In *Grown Up Digital: How the Net Generation is Changing Your World* (2009), Don Tapscott cites studies which show that in many countries, vast majorities of net generation members would prefer to lose access to television rather than to the Internet (p. 43), and that they use their mobile phones for email and instant messaging regularly (p. 51).[1] Tapscott also showcases remarkable innovations and initiatives of teenage Sri Lankan, Chinese, and Argentinean entrepreneurs (among others) who he met at a Western Economic Forum meeting in Davos. These facts and examples are then used to argue that these innovations, media uses, and preferences reflect the way that a generation as a whole communicates, interacts, and thinks and even the way their brains develop. Their use of this technology is said to accelerate their reaction times, shorten their attention spans, and multiply the tasks they can undertake simultaneously:

> Today's generations operate at twitch speed due to constant exposure to video games, cell phones, handheld devices, hypertext, and all of the other experiences that reflect an increasingly digital world, together with an expectation that they will have far more experience at processing quickly than our generations have, and they're better at dealing with high-speed information [sic]. (Jukes et al., 2010 p. 36)

The conclusion that follows is that education must adapt to these changes and engage with this generation on its own high-speed, multi-channeled, and hypertextual terms. In this context, current educational methods can only be portrayed as hopelessly outmoded.

> The model of education that still prevails today was designed for the Industrial Age. It revolves around the teacher who delivers a one-size-fits-all, one-way lecture. The student, working alone, is expected to absorb the content delivered by the teacher. This might have been good for the mass production economy, but it doesn't deliver …for the Net Gen mind. (Tapscott, 2009, p. 122)

Different authors draw different conclusions from such arguments, with some recommending, for example, the integration of video games and simulations to teach conventional curricula (e.g., Prensky, 2001), and others asking for a more broad transition "from broadcast to interactive learning"—including problem-based and active "question and answer" approaches (Tapscott, 2009, pp. 121–148).

The arguments behind the generational labels and slogans work in similar ways to those associated with the "knowledge economy." Both sets of claims paint a picture of simplified economic or generational coherence that obfuscates a polarized and contested social reality. Instead of one class being designated as representative of an entire economy, the net generation myth relies on a stereotype of a particular *kind* of young student that is substituted for youth as a whole. Technologically competent, and sometimes remarkably gifted people from kindergarten to university are seen as being representative for most or all younger learners, and are associated with ways of knowing and learning that are uniform across the generation as a whole. Only the most promising or accomplished members of the generation are taken to be representative of it. Just as the slogans of the knowledge economy fail to recognize different economic sectors and realities, the slogans used to designate the net generation do not take into account the complexities of generational development and interaction, and of intergenerational educational processes themselves.

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[1] Data provided by Tapscott shows that large majorities of this generation in various countries "text messaged, e-mailed on mobile/cell phone in the past month" (p. 51).

It is, therefore, not surprising, then, that empirical research does not back up claims of the mainstream net generation literature. For example, a study (Pedró, 2009) of "new millennium learners" in some of the 30 OECD countries concluded that "students tend to be far more reluctant in [the use of emerging media in education] than the image of the new millennium learner would suggest." Students may use texting and Facebook on campus and at home, but this does not translate into demand for the use of similar technologies in the classroom. The study also reports that the majority of the students surveyed "do not want technology to bring a radical transformation in teaching and learning, but would like to benefit more from their added convenience… in academic work." These students, like at least some of their teachers, are inclined to see new media as a way of enhancing what occurs in classrooms or other in established educational settings, rather than as supplanting them. Reeves and Oh (2008) survey a wide range of studies on generations, technology use and learning styles, and come to a similar but more general conclusion:

> Generational differences are weak as a researchable variable in a manner similar to learning styles … The bottom line on generational differences is that educational technology researchers should treat this variable as failing to meet the rigor of definition and measurement required for robust individual differences variables. The gross generalizations based on weak survey research and the speculations of profit-oriented consultants should be treated with extreme caution in a research and development context. (p. 303)

Reeves and Oh's conclusions about "gross generalizations" and the exercise of "extreme caution" are echoed by other researchers that have looked at this same issue. David Buckingham, a leading researcher in media and literacy, speaks specifically of Tapscott in making the following point about the quality of internet use by net generation users:

> Tapscott's approach… ignore[s] what one can only call the banality of much new media use. Recent studies… suggest that most children's everyday uses of the Internet are characterized not by spectacular forms of innovation and creativity, but by relatively mundane forms of information retrieval. (Buckingham, 2006, p. 10)

Underlying the myth of the net generation is a pattern already familiar from the myth of the knowledge economy: The habits and preferences of one, privileged group (in this case, those involved in "spectacular forms of innovation and creativity") is substituted for an entire social category (all children or youth). Social differences associated with race, ethnicity, and class end up being obfuscated by the net generation myth—just as these same differences are ignored or distorted in the myth of the knowledge economy. These forms of stratification have greater discriminatory and predictive power than the relatively weak stratification between generations. Differentiations of class, race, and ethnicity would appear as bold, black lines, running across the relatively soft gradations as one generation blends into another. The net generation myth operates making these intergenerational gradations seem much more obvious and urgent for education than the harsher realities of differences in class, race, and ethnicity—created as they are by painful histories of colonization, conflict, and inequity.

Technology Drives Educational Change

The third and final myth to be considered here is not associated with a single catch-phrase or slogan in e-learning but this makes it no less powerful and pervasive. This myth is registered instead in ways of talking about technological and social change. More specifically, it appears in connection with technological *impacts on* society, particularly in statements that present technology as single-handedly achieving change in education or even as "driving" educational change. In its most extreme form, this myth is encapsulated in so-called "laws" of technically driven progress and change, which are found with surprising frequency in literature promoting and discussing e-learning and other high-tech subjects. Examples of these laws include Moore's law (the regular doubling of capacity of computer processors; Moore, 1965), Kurzweil's "law of accelerating returns" (positing the exponential nature of technical innovation; Kurzweil, 2001), or Gladwell's "tipping point" (a mathematical model of "epidemic" dynamics of change; Gladwell, 2000). According to this myth, technological progress is independent of other social conditions, and it has the power to change professional practices and priorities irrevocably or even, to render them obsolete. As a result, technology—as the word "impact" suggests—can be said to have decidedly "traumatic" repercussions on the individuals and institutions with which it comes into contact (Hilton, 2006; Pannabecker, 1991). During the dot-com era—when "education" was seen as the Internet's "next killer app" (Chambers, 1999)—people were predicting that it would turn traditional campuses into "relics" (Drucker, as cited in Lenzner & Johnson, 1997), and make the earlier explosion of email "look like a rounding error" (Chambers, 1999). Technology, in other words, is made to appear as the "destiny" of education and even of society as a whole.

As an example, Jukes, McCain, and Crockett combine Moore's law with similarly exponential developments identified by Kurzweil and others to arrive at the conclusion that "we live in exponential times"; and following from this, they insist:

> So what can be done? First, teachers must adapt to a new paradigm for teaching and learning. They must adopt new behaviors for what, where, when, and how they teach students. They must strive to bring their thinking into the twenty-first century, keeping what is still valid and important while abandoning that which no longer applies. (2010, n.p.)

According to the authors, it is essentially a matter of combined, exponential technological developments that determines the future of education and the fate of educators: "There will be many winners and losers… the key to being a winner in the emerging digital culture of the twenty-first century is to make a radical shift in… mindset or paradigm" (Jukes et al., 2010, n.p). Educators, in other words, are not seen as being particularly active or influential in the determination of the future of their profession: Instead, they can either be a winner or a loser, make a radical shift in mindset or be left behind. Technical progress—manifest in terms of processing capability and other developments—is presented as inevitable and autonomous in its effects.

Of course, technology as a force that drives social and educational change is not always expressed in such a direct or portentous manner as it is in the example, above. At the same time, implicit understandings of technologies as something that single-handedly and directly cause or force social change are detectable in a great deal of research on innovation. This is illustrated by investigations based on Everett Roger's model of the diffusion of innovations (Rogers, 2003). This model understands these innovations or technologies generally as being diffused or disseminated throughout a population as ready-made artifacts that are absorbed by a largely passive group of users. This generally allows for only two responses: "Adoption" or "resistance" of varying intensity. Rogers uses labels for degrees of adoption or resistance that are rather telling: "innovators," "early adopters," "late majority," and "laggards." The character of these labels leaves little doubt as to how various responses are viewed in this model. In e-learning research, as it happens, the population that is often studied and categorized in this way is composed of university faculty members (e.g., Bull, Garofalo, & Harris, 2002; Mahony & Wozniak, 2005; Giani, 2010).

An imminent critique of this myth can be undertaken simply by looking to alternative sources of information on technology to the work of scholars in the history and sociology of technology. Research and scholarship in these kinds of studies warn of the trap or fallacy of *technological determinism*: "the belief that social progress is driven by technological innovation, which in turn follows an 'inevitable' course" (Smith, 1994, p. 38; see also Chandler, 1995). There are, of course, different forms of technological determinism. The understanding of technological change implied in a great deal of e-learning research would fit well under what scholars have called "hard" rather than "soft" determinism, and also would fit under "optimistic" rather than "pessimistic" determinism. In the case of "hard" determinism, as Smith and Marx explain, "agency (the power to effect change) is imputed to the technology itself…with the advance of technology lead[ing] to a situation of inescapable necessity" (Smith & Marx, 1994; xii). As indicated in the example cited above, technology is indeed given the agency of a power or force of change. Technology (in this case, computer and Internet technology in general) is seen as being capable of acting on its own to produce significant social and educational transformation. What makes this determinism *optimistic* is that the "positive" aspects of this technical change are generally emphasized over "negative" ones. For example, faculty members who do not adopt technologies are seen as "laggards," as refusing the obviously "positive" potential of technology, rather than as being the last or wise few to resist its "negative" or destructive consequences.

The recent history of e-learning itself provides some powerful counterexamples that refute this overriding optimistic, "hard" deterministic bias. One example is provided by the emergence and entrenchment of "learning management systems" such as WebCT or Moodle in traditional educational institutions since the late 1990s. In this case, the rapid emergence of the Internet as a popular medium did not mean that it simply washed over the educational landscape, doing away with existing institutional and business models (as Drucker and others predicted). Instead, through a complex series of developments, interactions, and "negotiations," this technology was reshaped, adapted, and appropriated through the development of web-based software. In many instances, these software systems originated directly from universities themselves, in the form of individual or community projects of faculty and other university developers. These systems, moreover, have been designed and adapted in clear conformance with the interests and management structures of large educational institutions: they are centrally administered, meaning that they can be serviced and supported by network or computing services units already in place in these institutions; and they explicitly define "roles" (via system login options) and thereby reinforce traditional functions and identities of university personnel, teachers, students, and administrators. The adaptation of Internet technology, as a result, seems to have had the end effect of reinforcing rather than disrupting many conventional educational practices and functions.

By introducing a vocabulary that makes use of terms such as "adaptation," "negotiation," and "interaction"—rather than casting technology in terms of "impacts," "laws," and "inevitabilities"—the relationship between technology and education appears as much more complex. Technology itself is no longer an unstoppable force that inevitably determines the future of society in general and e-learning in particular. It becomes, as Andrew Feenberg describes, "an 'ambivalent' process of development" that is "suspended between different possibilities" (Feenberg, 2002, p. 15). "On this view," Feenberg concludes, "technology [itself] is not a destiny but a scene of struggle." (Feenberg, 2002, p. 15). When it is viewed as the result of complex, multicausal processes of social construction and negotiation, technology emerges as something very much *other* than the destiny of either education or society as a whole.

Conclusion

Critical theory, a methodological orientation familiar in many areas of social research, has clear relevance to e-learning as one example of a field of applied research into ICTs. This relevance has been demonstrated in this chapter by applying ideology critique to a number of basic and even self-evident notions and understandings in literature and that promotes, describes, and investigates e-learning. At their most extreme, these notions—of a knowledge economy, a digital or net generation, inevitable, technology-driven change—can be understood in critical-theoretical terms as "myths." The point of critiquing these myths, however, has not been to assail what is essential or axiomatic to e-learning or any other field, but rather, to provide a corrective: to show that economic, technical, cultural, and historical conditions central to the use of information and communication technologies are complex and need to be interpreted and investigated in new, different and above all, interdisciplinary ways.

Such an explicitly interdisciplinary approach is indispensable for providing a more realistic and balanced basis or set of starting points for undertaking research in educational technology and likely in other fields as well. Research becomes compromised or even misdirected if it is based on presuppositions that are fallacious and oversimplified. Alternatively, when myths, like those listed above, are clearly identified and their repetition avoided, the realization of alternatives and broadly progressive research designs becomes easier and more natural. For example, recognizing that many contemporary economies are oriented to the provision of service at least as much as to knowledge or information will surely affect how the contribution of ICT projects to the economy are conceptualized in research designs and proposals. Understanding technology as a scene of struggle rather than as a destiny or *fait accompli* might also help to guide the exploration of metaphors other than "impact" or "dissemination" when inquiring into the relationship between technology and changing institutions and practices.

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Habitus, Scaffolding, and Problem-Based Learning: Why Teachers' Experiences as Students Matter

Brian R. Belland

Recently, I wrote a paper in which I challenged a common line of thinking about the failure of many teachers to integrate technology (Belland, 2009). According to a predominant view, teachers' failure to integrate technology results from barriers (e.g., lack of beliefs in the value of technology for teaching, lack of incentives) that emerge after teachers enter the field (Ertmer, 2005; Hew & Brush, 2007). Using the sociological theory of *habitus*, I argued that teachers' experiences as students in classes in which technology was not integrated built dispositions to teach without technology and in a teacher-centered manner (Belland, 2009). In short, I argued that the lack of technology integration cannot be solved by simply helping teachers overcome "barriers" such as espoused beliefs about the value of technology. Rather, the root of the problem goes much deeper than that, and by applying the critical theory of *habitus*, one can reenvision the problem and craft appropriate solutions.

Despite evidence that it can help students learn higher-order thinking skills and gain deep content knowledge (Belland, Glazewski, & Ertmer, 2009; Finkelstein, Hanson, Huang, Hirschman, & Huang, 2011; Gallagher, Stepien, & Rosenthal, 1992; Pedersen & Liu, 2002–2003), problem-based learning (PBL) is not deployed on a large scale in K-12 classrooms (Ertmer & Simons, 2006; Hmelo-Silver, 2004). Good administrative support, of course, is crucial to successful implementing PBL. But teacher support is of paramount importance, because without teachers supporting learners, PBL would be impossible (Goodnough & Cashion, 2006; Hung, 2011 Lockhart & Le Doux, 2005; Stefl-Mabry, Powers, & Doll, 2005–2006).

While some authors attribute the limited use of PBL to post-teacher education challenges (e.g., Schraw, Crippen, & Hartley, 2006), this may not tell the whole story. In this chapter, I apply the lens of *habitus* to examine why PBL is not applied

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more widely in K-12 classrooms. Consistent with the aim of this book, in this chapter, I employ Pierre Bourdieu's sociological concept of *habitus* to take a step back to apply a critical eye to the research on the implementation of PBL.

Problem-Based Learning

Definition

PBL is as an instructional approach in which authentic, ill-structured problems drive student learning (Barrows & Tamblyn, 1980; Hmelo-Silver, 2004). Authentic, ill-structured problems can be defined as problems

- With unclear descriptions and more than one possible solution and solution path (Driver, Newton, & Osborne, 1998; Jonassen, 2000)
- That relate to students' future lives (Barab & Dodge, 2008)

For example, middle school students can adopt stakeholder positions to develop and defend ideas for using a grant to extend the Human Genome Project such that all people benefit (Belland, 2010; Belland, Glazewski, & Richardson, 2011).

In PBL, students work in small groups to

- Define the problem
- Determine learning issues to further understand the problem
- Determine an appropriate solution
- Defend their solution on the basis of evidential support (Belland, Glazewski, & Richardson, 2008; Hmelo-Silver, 2004)

While small groups in medical education usually consist of 6–8 students (Barrows & Tamblyn, 1980; Lohman & Finkelstein, 2000), small groups in the K-12 context usually consist of 3–4 students (e.g., Belland, et al., 2011; Sandoval & Reiser, 2004).

Self-Directed Learning

In PBL, students learn new content as they engage with the central problem of the unit. In this regard, PBL contrasts sharply with traditional forms of instruction in which students learn content and then apply the knowledge to a practice problem. Central to success in PBL is self-directed learning, defined as students' ability to formulate and pursue learning goals, and evaluate the adequacy of their learning processes (Loyens, Magda, & Rikers, 2008). Self-directed learning emerges as students identify learning issues they need to pursue to solve the problem. This stands in marked contrast to traditional, teacher-centered instruction, in which teachers (a) tell students information or what information to find and how to find it and (b) evaluate students' learning or process.

Scaffolding

As Loyens et al. (2008) noted, self-direction does not mean that PBL is "do-it-yourself learning" (p. 416). Rather, teacher guidance is crucial to student success in PBL (Hmelo-Silver, Duncan, & Chinn, 2007). Scaffolding can be defined as support provided by a teacher or more capable other that allows students to complete and gain skill at tasks that are beyond their unassisted capabilities (Wood, Bruner, & Ross, 1976). Scaffolding has been classified according to the intentions it works toward and the means by which it reaches the intentions (van de Pol, Volman, & Beishuizen, 2010).

Scaffolding Intentions

Scaffolding helps instructors work toward the following intentions

- Recruitment
- Direction maintenance
- Cognitive structuring
- Reduction of the degrees of freedom
- Frustration control (van de Pol et al., 2010, pp. 276–277)

Recruitment refers to enlisting student interest in the task at hand (van de Pol et al., 2010; Wood et al., 1976). Direction maintenance helps students maintain effort toward their learning or performance goal (van de Pol et al., 2010). Cognitive structuring means providing students models by which they can organize information and predict phenomena (van de Pol et al., 2010). Reduction of the degrees of freedom can be defined as simplifying those elements of the task that are not directly related to instructional goals (Wood et al., 1976). Frustration control refers to reducing frustration such that students persist in their efforts (van de Pol et al., 2010).

Scaffolding Means

Scaffolding can take the following forms:

- Feedback
- Hints
- Instructing
- Explaining
- Modeling
- Questioning (van de Pol et al., 2010, p. 277)

For example, teachers often *model* expert thinking to students to help *reduce the degrees of freedom for* (simplify) solving the problem (Pressley, Gaskins, Solic, & Collins, 2006). Teacher-provided scaffolding needs to be contingent on student performance characteristics and teachers need to work toward a transfer of responsibility to the student (van de Pol et al., 2010).

Computer-based tools have also been designed on the basis of students' expected difficulties to share the scaffolding burden (Hannafin, Land, & Oliver, 1999). For example, Explanation Constructor is an epistemic scaffold that helps middle school students engage in argumentation as they learn about the evolution of finches on the Galapagos Islands (Sandoval & Reiser, 2004).

Problem-Based Learning and Standards

Curriculum standards are an important part of the American K-12 schools. It is important to note that PBL is not proposed as something to be done in addition to teaching to the standards, but rather can serve as one vehicle to meet standards (Barron et al., 1998; Finkelstein et al., 2011). Within PBL, students learn content such as scientific theories. But they also learn how scientists construct knowledge about the world. For example, in the past, science standards largely specified the scientific "facts" that had been discovered and that students needed to know (Duschl, 2008). But more recent science standards reflect a growing consensus that science is a process of meaning making rather than a basket of facts (Duschl, 2008; McComas, 2008). As such, more recent science standards emphasize the importance of students learning how to investigate complex scientific phenomena (Duschl, 2008). Similar shifts in standards can be found in other subjects such as language arts, in which the common core state standards now emphasize argumentative writing (Beach, 2011), and social studies, in which recent standards emphasize that students need to be able to construct historical knowledge from reading primary source documents (Brush & Saye, 2009).

Central to students' ability to investigate complex scientific phenomena is their ability to engage in argumentation, defined as their ability to support claims with evidence and counter the evidence of others (Driver et al., 1998; Osborne, 2010). Through scaffolding, students can gain skill in argumentation while they argue about complex scientific phenomena (Belland, 2010; Belland et al., 2011; Jonassen & Kim, 2010).

Laying the Groundwork for PBL: Teacher-Provided Scaffolding

As noted previously, teacher-provided scaffolding takes the form of feedback, hints, instructing, explaining, modeling, and questioning (van de Pol et al., 2010). This chapter only discusses scaffolding in the form of feedback, questioning, and modeling, because these are the forms that have clear counterparts in traditional instruction that are radically different. In this section, I illustrate the differences regarding how questioning, feedback, and modeling are employed in traditional, teacher-centered instruction and in teacher-provided scaffolding. To do so, I describe the intention and means (see scaffolding section) of the techniques in teacher-centered instruction and scaffolding.

Questioning and Feedback

Central to teacher-provided scaffolding is questioning. One of the primary challenges teachers face in implementing PBL is asking the right types of questions (Oliveira, 2010). Questioning is entirely different in aim and approach when provided in the context of teacher-provided scaffolding than during traditional instruction (Ertmer & Simons, 2006; Hmelo-Silver & Barrows, 2006; Torp & Sage, 2002). In problem-centered instruction, teachers often aim to elicit elaboration or prompt further investigation from students (Hmelo-Silver & Barrows, 2006). For example, in a PBL unit on the Human Genome Project, a middle school student might ask the teacher how many people receive bone marrow transplants per year. Rather than simply providing students a number, the teacher would direct the question back to students. She may, for example, ask students why it is important to know how many people receive bone marrow transplants per year. She may also ask where such information can be found. The cycle of students asking questions and the teacher using questioning to elicit elaboration or further investigation may continue for several more turns.

Intention

Teacher-centered instruction is designed to transmit information from teachers to students. The intention of questioning in traditional, teacher-centered instruction is fundamentally to help students rehearse the new information and assure that students properly encoded information provided by the teacher (Chin, 2006). Feedback is intended to inform students whether they were correct. In short, questioning and feedback in teacher-centered instruction primarily serves to aid in encoding and provide formative evaluation of instruction.

To the contrary, the aim of questioning in teacher-provided scaffolding is promoting and sustaining student inquiry (Ertmer & Simons, 2006; Hmelo-Silver & Barrows, 2006; Torp & Sage, 2002) and construction of knowledge (Chin, 2006). Rather than ascertain whether students can produce the right answer, the goals of questioning in teacher-provided scaffolding include provoking new ways of thinking about the problem and eliciting elaboration (Chin, 2006; Hmelo-Silver & Barrows, 2006; Zhang, Lundeberg, McConnell, Koehler, & Eberhardt, 2010). Feedback is further intended to promote additional new ways of thinking about the problem. In short, teacher-provided scaffolding employs questioning and feedback as a catalyst for further student discussion and construction of ideas.

Means

In the traditional, teacher-centered approach, teachers engage students in a triadic dialog, in which (a) teachers ask students closed-ended questions, (b) students answer (and since the questions are closed-ended, the answers are brief), and (c) teachers provide feedback on the veracity of students' answers (Chin, 2006; Hmelo-Silver & Barrows, 2006). As part of authoritative discourse, triadic dialog helps teachers transmit expert knowledge to students (Chin, 2006). When students do not give the correct answer in a triadic dialog, they are informed of being wrong and either provided the correct answer or an explanation of why the answer was wrong.

In inquiry-oriented instruction, teacher questioning and feedback takes an entirely different form. Teacher questioning begins with a teacher question, but the question is open-ended (Chin, 2006; Zhang et al., 2010). Students cannot respond with a short answer that can rapidly be deemed correct or false. Rather, the question could be answered appropriately in a multitude of ways. For example, if the PBL problem relates to brucellosis among elk in the intermountain west, a question could ask students what are similar problems to which students could look for possible solutions. There are countless "correct" answers, but students will not likely come up with a good answer right away. In all likelihood, they will advance an idea, the teacher will provide feedback in the form of another question to further prompt student thinking, students will respond, and this process can continue for several turns (Chin, 2006; Hmelo-Silver & Barrows, 2006; Zhang et al., 2010). But it should be noted that feedback in scaffolding does not need to be preceded by a teacher question–student response sequence; rather, feedback can be offered as students are working independently if the teacher sees an opportunity to broaden students' thinking about the problem (van de Pol et al., 2010).

Modeling

Modeling is deployed with different intentions and takes different forms in traditional, teacher-centered instruction and in teacher-provided scaffolding. In this section, I explore those differences.

Intention

In traditional instruction, modeling is focused on helping students learn procedures. In traditional instruction, teachers might model the procedure used to perform a whole task. For example, a chemistry teacher may model how to perform a chemistry experiment by in fact carrying out an entire experiment. The intention, and correspondingly, the measure of success in this case is that students could imitate the teacher.

The purpose of modeling in scaffolding is twofold. First, it is meant to get students going. In the first application of the term scaffolding to education, Wood et al. (1976) described the role of tutors in helping infants learn to build pyramids with building blocks. One aspect of the scaffolding process was to model how to put two blocks together. But then the tutor stepped back and allowed the children to explore. The intention in this case was to get students going in their exploration of the pyramid game. The measure of success was not students imitated the tutor, but that students got going. Second, it is meant to expose students to expert thinking processes such that students can learn to think in a similar manner (Collins, Brown, & Newman, 1989).

Means

Modeling in traditional teacher-centered instruction takes the form of a demonstration of procedures, e.g., exactly what students are supposed to do. For example, in a traditional chemistry class, students are told chemistry "facts" and provided demonstrations of chemical experiments (Rickey & Stacy, 2000). Certainly there is a place for the demonstration of a procedure, as demonstrations are particularly effective for procedural learning (van Merriënboer, Clark, & de Crook, 2002).

In teacher-provided scaffolding, modeling will often consist of experts telling students how they might think about a similar problem—what considerations they would make, what references they might consult, and so on (Collins et al., 1989). For example, elementary and middle school teachers can model (a) how they would access and apply prior knowledge to solve a presented problem and (b) how to evaluate ideas (Pressley et al., 2006). Elementary school teachers can model the process of meaning making while reading (Wollman-Bonilla & Werchadlo, 1999).

Current Implementation of Teacher-Provided Scaffolding

Teacher-provided scaffolding is unfortunately rather rare (van de Pol et al., 2010). Most teachers have difficulty managing inquiry-based classrooms and asking the type of questions that promote student inquiry (Oliveira, 2010). Even after receiving training on how to scaffold student learning, PBL tutors who were content experts engaged with students in a didactic manner (Papinczak, Tunny, & Young, 2009). Lee, Penfield, and Maerten-Rivera (2009) provided an ongoing professional development program for one school year to third-grade teachers focused on scientific inquiry and practices to improve science instruction for ELL students. At the end of the study, participants reported on average that they promoted student scientific inquiry in most lessons. However, discrepancies between what the teachers reported doing and what actually happened (as indicated by observations) were found. In the fall "students did not engage in inquiry" (Lee et al., 2009, p. 850). In the spring, "students conducted scientific inquiry (i.e., generating questions, designing and carrying out investigations, analyzing and drawing conclusions, or reporting findings) within the bounds of a scripted lesson, as they primarily received and performed routine procedures for the inquiry" (Lee et al., 2009, pp. 850–851). In short, teachers on average did not provide scaffolding (Lee et al., 2009).

Furthermore, even when scaffolding is provided, it may be skewed away from teachers' stated teaching philosophies. For example, elementary school teachers who stated that they believed that reading instruction should be focused on comprehension rather than phonics provided scaffolding to students from ethnic minority and low-SES backgrounds based on the phonics approach (Mertzman, 2008). It appears that something is driving these findings since the research indicated that the teachers knew what scaffolding was for and how it could be implemented.

Potential Explanations for Minimal Implementation of Teacher-Provided Scaffolding

Teacher Beliefs

One explanation for the lack of effect of teacher education might be that teachers simply do not believe that having students construct knowledge is a good idea (Ertmer, 2005). According to this line of reasoning, teacher beliefs simply need to be changed to promote the construction of knowledge by students (Ertmer, 2005). However, it does not appear to be this simple (Belland, 2009). First, research in a variety of contexts often indicates that beliefs explain very little variation in practices (Fishbein & Ajzen, 1975). Also, there is not a direct path from belief to practice (Fishbein & Ajzen, 1975). According to Fishbein and Ajzen's model, people's attitudes about a practice or thing are informed by their beliefs about the practice or thing. Then their attitudes inform their practices (Fishbein & Ajzen, 1975). However, the strength of the relationship between attitudes and practices is very weak. For example, Fishbein and Ajzen (1975) reviewed research that showed that college students' "attitudes towards participating in psychological studies only explained 2.89% of the variance in study participation among college students" (Belland, 2009, p. 355). Espoused beliefs do not explain much more of the variance in teacher use of constructivist strategies (Andrew, 2007; Ravitz, Becker, & Wong, 2000) and technology (Anderson & Maninger, 2007). By digging deeper, one might discover the true root of the problem of limited use of PBL.

Inadequate Teacher Education

An alternative explanation is that teachers just do not know how to facilitate PBL because teacher education on PBL facilitation is not effective. While it is undoubtedly true that no professional development is perfect, inadequacy of professional development does not likely tell the whole story. Research that examines what happens when teachers gain knowledge of the benefits of problem-based instruction and of how to facilitate it, indicates that in such cases teachers often still do not implement PBL (Belland, 2009). For example, Windschitl and Sahl (2002) provided in-service education to teachers in a laptop initiative middle school. The in-service program was designed to help teachers learn how to structure instruction such that students used laptops to construct knowledge. Out of three teachers included in Windschitl and Sahl's (2002) study, the students of only one teacher ultimately used technology to construct knowledge even though all three teachers learned why it was important that students use laptops in this way and how to structure instruction such that students could do so. In another example, teacher education students learned constructivist mathematics teaching strategies (Ensor, 2001). As evidenced by journals, students learned the techniques and believed in the value of using such techniques. However, once teaching, they did not implement the techniques, insisting that the nature of their students' learning challenges did not allow for the use of constructivist techniques (Ensor, 2001).

Teachers' Habitus

An individual's *habitus* can be defined as his/her set of dispositions to do things in a particular way (Bourdieu, 1979). For example, one's *habitus* can influence favorite hobbies, career choices, and favorite foods. The *habitus* emerges from a set of life experiences. Individuals of similar social classes and similar life experiences will tend to have similar *habitus*. A person's *habitus* is formed throughout life. Immediate family members predominantly influence the *habitus* (Bourdieu, 1977). It is important to note that human volition is still possible. A *habitus* simply creates strong tendencies to do certain things (Bourdieu, 2004).

Teachers' practices have also been explained by their *habitus* (Belland, 2009). For example, preservice teachers who were taught a reading comprehension instruction method that involved popular texts did not use that method if their *habitus* disposed them to believe that popular texts could expose children to inappropriate material (Marsh, 2006). Preservice mathematics teachers taught to engage students in whole class interactive methods simply taught the way they were taught as children (Noyes, 2004).

So how could a teacher's *habitus* affect their implementation of PBL? Teaching is the only field in which most people who enter training to enter the profession have a lifetime of observing members of the profession (Belland, 2009). Students have observed how their teachers modeled procedures and engaged students in questioning and feedback. For most teacher education students, their observations were of teacher-centered modeling, questioning, and feedback practices (Belland, 2009). When they are asked to model, question, and provide feedback in a new way, they have difficulty overcoming the dispositions developed through observation of their own teachers. These dispositions would push the teachers to employ modeling, questioning, and feedback to further the same ends that their teachers sought using the techniques. Also, the types of questions that they ask and feedback that they provide will tend to be similar to that which they received as students. Even while teacher education students, they likely were lectured about how to employ constructivist methods (Palmer, Rowell, & Brooks, 2005). Finally, students have likely not engaged very extensively in self-directed learning during their own school careers (Belland, 2009; Ertmer & Simons, 2006). Rather, they were provided information by the teachers and expected to reproduce that information.

Changing one's *habitus* is extremely difficult, and it is naïve to think that one course, no matter how outstanding, will do so. When students receive instruction that goes against their *habitus*, it is received as symbolic violence, and thus is resisted (Bourdieu & Passeron, 1990). To change the circumstances so that it is not resisted, teacher education regarding PBL facilitation needs to be of longer duration, incorporate modeling, and include practical experience (Belland, 2009). It may seem obvious, but lecturing teachers on how to facilitate PBL is not the best idea, not just for conjectural reasons, but because such instruction will be resisted (Belland, 2009).

Suggestions for Future Research

Clearly, more research needs to be done to determine the best ways to help teachers not only learn about scaffolding and PBL but also to actually implement the models in their classrooms. Based on the research presented in this chapter, the explanation that teacher's *habitus* are interfering with their implementation of PBL seems reasonably well supported. But the research base is not deep enough to state that all ambiguities related to teacher implementation of PBL are resolved. For example, most research on professional development of teachers focuses on whether teachers like the instruction (Lawless & Pellegrino, 2007). Little research examines whether professional development leads to changed teacher practices (Lawless & Pellegrino, 2007). If more research examined the practice of teachers after professional development related to PBL facilitation, it could be found that with greater knowledge, teachers implement PBL.

I could find very few papers in which the lifelong experiences of teachers before teacher education were examined as possible explanations for teacher practices. Indeed, it would seem particularly difficult and expensive to engage in such research. First, engaging in a longitudinal study of students from preschool through their careers as teachers is impractical, because it would be impossible to know which preschoolers will become teachers. Even if it were practical, it would be enormously expensive. Thus, research that examines lifelong experiences would likely have to take a retrospective tact, by asking teachers to reflect on their childhood and adolescent experiences. This, of course, relies on the accuracy of participants' memories of events that happened 20–30 years ago, which is no sure thing. Triangulation through examination of documents could likely be used to counteract this problem.

Conclusion

An emphasis on critical thinking is sorely needed in American K-12 schools. For example, on the Programme for International Student Assessment Science exam, US students scored significantly below average on science literacy (Bybee, McCrae, & Laurie, 2009). This score reflected questions related to explaining phenomena scientifically, using scientific evidence, and identifying scientific issues. One way to improve US students' performance along these lines is through the use of PBL activities (Belland et al., 2009; Finkelstein et al., 2011; Gallagher et al., 1992; Pedersen & Liu, 2002–2003). But PBL is minimally implemented in American schools (Ertmer & Simons, 2006; Hmelo-Silver, 2004). By using critical theory to reexamine the reasons behind the minimal implementation of PBL in K-12 settings, one learns that lifelong experiences as a student likely lead teachers to form dispositions to teach in a teacher-centered manner. Even carefully crafted professional development may not be enough to help teachers both receive effectively and put into practice PBL implementation instruction. Through a careful examination of the theory behind *habitus*, one can learn how to craft teacher education that is well received by teachers and leads to the widespread implementation of PBL in K-12 settings.

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Aesthetics and Game-Based Learning: Applying John C. Belland's Connoisseurship Model as a Mode of Inquiry

Michele D. Dickey

Seeing what appears obvious is not always easy

Eisner (1998)

One of the most popular topics in the realm of educational research is the design, use, and application of games and game-based environments for teaching and learning. Games have always been part of the spectrum of educational media, but because of programming limits and even exposure to computer and video games, there was a relatively small group of researchers conducting research about using and designing digital games for teaching and learning. However, as technology improved and became more accessible, digital games became more sophisticated and began to cultivate a larger and more diverse population of players. Digital games are no longer the domain of children, but have become an increasingly popular form of entertainment among adults. The growing popularity of games has helped spark greater interest in the use of games for teaching and learning. Educational games have changed since the days of *Oregon Trail* and have become a popular media for research and academic scholarship. In the late 1990s and early 2000s, educational researchers such as Bruckman (2000), Dede (2003), Gee (2003), Prensky (2001), Rieber (1996), and Squire (2003) ushered a new era of research into the educational use of games and game-based learning and the burgeoning field of serious games.

Much has been written about the potential of games for teaching and learning, in regards to both the design of educational games and the implementation of off-the-shelf games for learning. While this growing body of work argues for the *potential* of digital games to transform learning and reshape learning environments, research to support these claims is limited and only beginning to emerge (Annetta, Minogue, Holmes, & Cheng, 2009; Barab & Dede, 2007; de Freitas & Neumann, 2009; Dickey, 2011a, 2011b; Jamaludin, Chee, & Ho, 2009; Ke, 2008; Ketelhut, Dede, Clarke, &

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Nelson, 2007; Kim, Park, & Baek, 2009; Paoasterious, 2009; Squire & Jan, 2007; Tüzün, Yılmaz-Soylu, Karakuş, Inal, & Kızılkaya, 2009). While much of this work contributes to our knowledge about educational games and game-based learning, most relies upon science-based methodologies to document, describe, and investigate what are essentially dynamic aesthetic experiences. Science-based methodologies provide a means for gathering and analyzing data, but they do not allow for the designer/technologist to "get inside" the experience.

Art in Contrast to Science

While science-based modes of inquiry are certainly important and illuminating, the foundation of digital games, like other forms of educational media such as educational films and television, was primarily established as an entertainment medium. With entertainment media and many forms of fine and performing arts, connoisseurship serves as a means of evaluating, judging, and validating works based on deep understanding. Hlynka and Belland (1991) argued that criticism offers a third paradigm or a "critical paradigm" not based on statistical-based methodologies (quantitative research) or anthropological or sociological models (qualitative research), but instead moves beyond what Guba and Lincoln (1981) describe as "one kind of science vs. a second kind of science." Hlynka and Belland (1991) asserted that this critical paradigm reclaims Guba and Lincoln's original dichotomy of "art in contrast to science" (Hlynka & Belland, 1991, p. 6).

Aesthetics in Games/Game Aesthetics

The notion of aesthetics in games is an ambiguous concept representing different and intersecting aesthetics. In game-based learning, aesthetics are overlooked or relegated to a surface discussion of visual design viewed through the lens of science. Visual design is certainly a component; however, aesthetics in game environments encompass complex and intersecting aesthetics which play an integral role in shaping experiences. These intersection aesthetics include art work or the artistic elements in game design such as the visual and narrative design. Yet the aesthetics also include the interface and the elements of a game that evoke emotion and feelings in a player. Finally aesthetics also construct the broader context of interacting in and through a machine/screen and the *culture of simulation* perpetuated through the point-of-view positioning of players. When cultivating a connoisseurship in game-based learning, it is important to understand the intersecting aesthetics that shape the experience.

Aesthetics and Art Design

Aesthetics in games is often used in discussions and instructions about the artistic aspects of games. In some of the earliest digital games, visual representation was limited to text (*Adventure*), but advancements in computers, computer graphics, and the advent of consoles have ushered in an era of digital graphics and sound design that is both appropriated from other forms (animation, film, motion picture special effect, music, and sound design), but is also a unique aesthetic. Game art is an important aspect of contemporary games. The construction of graphics, color, texture, 2D and 3D objects, text, storyline, dialog, and character design, along with music and sound effects, creates and supports the mood, tone, feeling, and sense of immersion of the game. It both constructs the environment design while also communicates to the user by signaling changes or events within game play.

Aesthetics and Interface Design

Aesthetics also refers to the emotional design, interactive design, interface design, and narrative design. LeBlanc (2006) defines game aesthetics as the "emotional content" and the desired emotional response that players have when they play. LeBlanc contends that a game's aesthetic emerges from the game's dynamics (behavior) and how the behavior of the game evokes responses from the player.

While LeBlanc (2006) focuses on the how the game evokes player emotions, other game designers and theorists focus on the interactive elements of games in their definitions of game aesthetics. Mortensen (2009) examined the crucial role of the game interface as being a main element in game aesthetics. She points to two key areas of interface design, usability (ease of use) and plasticity (the affordance of allowing users to modify the interface to suit their unique needs). Mortensen also addresses the aesthetics of immersion and interactivity and how the game structure (genre and mechanics), interface design along with the narrative and visual design support both immersion of the player in the experience and the interactivity between the game and the player. Similarly, veteran game designer and theorist, Chris Crawford (2003) maintains that interactivity is the essence of a digital game. Crawford stresses the importance of a game aesthetic that is process intensive vs. data intensive because it would promote more organic interaction rather than the activation of predefined scripts, actions, and routines. Myers' (1990b) also defines game "aesthetics" and being the result of interactivity. According to Myers' "A computer game 'aesthetic' cannot be based solely on game content but must consider player–game relationships as well—and further detail the interactive process of play."

The term aesthetics is also used in reference to games as an artistic medium. Theorists and designers have discussed the importance of cultivating the aesthetic of games, not just art games, but games *as* art (Crawford, 1984, 2003; Aarseth, 1997; Costikyan, 2002; Rollings & Adams, 2003; Mortensen, 2009). Costikyan's seminal discussion about games as art argues for the need to cultivate an aesthetic unique to the medium. These arguments have been echoed and championed by theorists and designers who argue that although games incorporate aesthetics from literature, film, and animation, games are essentially interactive environments that share commonalities with existing medium, but nonetheless, are a unique medium and not to be compared or held to standards of other mediums.

Aesthetics of Interaction

Beyond the more apparent reference to aesthetics in games, the notion of aesthetics is part of a deeper level of design. Turkle (1995) examined the differing aesthetic design between Apple computers and PC computers. While initially this may seem to have little to do with aesthetics in game-based learning, digital games are games in which players interact with machines. Granted, many games console, online and mobile, allow multiple players to play together, yet essentially, players are interacting with machines. The same is true in digital educational games, serious games, and game-based learning—at the core of all the different layers of design, a learner is interacting through a machine and that machine is invested with codes, customs, and values. Turkle illuminated the differing aesthetics between these two computer systems and examined the cultures of transparency vs. opacity. Turkle argued that the type of operating system in a PC was transparent and that of an Apple computer, opaque. The Apple computer interface relied on simulations to support the novice user. Turkle contended that there has been a shift from the modernist tradition of seeing “beneath the surface into the mechanics” toward a culture of simulation in which the underlying mechanics are obscured and hidden. According to Turkle (1995), this culture of simulation is marked by a changing relationship between humans, and the computer “in which people are increasingly comfortable with substituting representations of reality for real” (p. 23). This analysis of aesthetics becomes important when looking at the educational use of digital games and game-like environments for learning. In an era of when students physically located anywhere in the world represented by avatars of their own creation, can take classes in a photo-realistic representation of their university situated in a game-like virtual world application, the aesthetic of simulation is fully realized. The aesthetic of simulation becomes an element of design and one for discussion in how it supports or challenges immersion, emotion, and perhaps even learning outcomes.

Perspective/Point-of-View

To illustrate how the aesthetics of simulation relates to educational games and game-based learning, there are two contending, yet relevant perspectives of aesthetics purported by virtual work theorists Brenda Laurel (1991) and Carol Gigliotti (1995). In Laurel’s seminal work, *Computers as Theater* (1991), Laurel argues for an Aristotelian model of narrative to immerse, engage, and evoke emotion from the user in interface design. The Aristotelian dramatic structure begins with an exposition, inciting incident, rising action, crisis, climax, falling action, and denouement. Laurel maintains that this model is pleasurable because it provides the audience with a cathartic experience as they travel through the various stages. It is designed to engage the user/viewer/reader by evoking emotion and supporting agency. As Laurel notes in her preface, “the notion of direct engagement opens the door to artistic considerations that are broader than the aesthetics of the screen.” In contrast, Carol Gigliotti (1995) advocates for a Brechtian aesthetic for the design of game-like virtual worlds. In the 1950s, German playwright, Bertolt Brecht criticized the Aristotelian model of dramatic structure for its goal of pleasure and engagement rather than fostering a model that helped teach and instruct audiences. As Curran (2001) states, "Brecht attacks Aristotelian catharsis as a kind of 'opium of the masses' arguing that empathizing with characters prevents viewers from reflecting critically on the social causes of human suffering." In Brecht's plays, the actors routinely address the audience out of character or "break the fourth wall" and interrupt the narrative to provide commentary on the action within the play. This interruption was to force the audience to think about the choices made by the characters and the impact of those choices. Gigliotti argues that the Brechtian aesthetic prevents the audience/viewer from entering the pleasurable immersion of the Aristotelian model, but instead places the audience/viewer in a more powerful position with the ability to reflect and to determine the action to be taken. According to Gigliotti, the Brechtian aesthetics are "vehicles for imparting knowledge, a means of understanding the context in which that knowledge is developed and the encouragement to act on that knowledge" (p. 297).

Laurel's Aristotelian aesthetic and Gigliotti's contrasting Brechtian aesthetic are important for the design of educational games and game-based learning because they represent two different, but important perspectives of design for fostering learning. Laurel's Aristotelian model places the player/learner in a first person perspective with the goal of immersing the player/learner in the environment, role, and action—yet it is a seductive model and one in which the pleasurable, cathartic, flow experience may impact the ability of the player/learner to reflect on knowledge and design a unique plan of action. In contrast, Gigliotti's Brechtian model is a more reflective aesthetic designed to cultivate knowledge and understanding. The immersive experience would be interrupted to prevent the player/learner from attaining the pleasurable, cathartic flow experience, but instead to contemplate and reflect on knowledge gained by the experience.

Connoisseurship in Game-Based Learning

Belland (1991) proposed the use of connoisseurship as a necessary element for both fostering instructional designers and educational technologists and as means of reviewing instructional systems without the need for elaborate mechanisms of qualitative or quantitative inquiry. Connoisseurship is as Eisner (1998) states "the art of appreciation" and an "act of knowledgeable perception." Connoisseurs use their vast experiences to gauge and understand the fine distinctions in their field of knowledge. The connoisseur has the ability to relate new experience to past experiences and articulate the nuances to understand different characteristics and distinctions. A connoisseurship model of inquiry would allow for looking at the interdisciplinary nature of game design and game-based learning design by encompassing insights, skills, and techniques from artistic disciplines and provide a new lens for looking at interactive media.

Developing connoisseurship in educational technology and media requires the development fine discriminations, a hierarchal system of concepts, organizing principles to structure the relationships among concepts, and finally, strategies to focus on the salient aspects (Belland, 1991). The following sections provide an in-depth discussion of each of these elements and how they may manifest in developing a connoisseurship for game-based learning. The purpose of this chapter is not to outline a definitive model for developing connoisseurship in game-based learning, but rather to initiate a dialog for developing connoisseurship and different modes of inquiry and assessment of educational games and game-based learning inclusive of the role of aesthetics in these environments.

Belland's (1991) proposal about adopting a connoisseurship model was reasonable in the time it was proposed (the early 1990s), however, educational media has changed a great deal in the past 20 years. Technology developments as well as media developments have extended educational media far beyond the scope of educational films and computer tutorials outlined by Belland in the early 1990s. Developing connoisseurship in educational films included becoming knowledgeable in different aspects of classic entertainment films. Any study of cinematography typically included at least one viewing of Welles (1941), similarly the study of film editing a viewing of Bliokh (1926) and the study of documentary filmmaking included Flaherty (1922). Developing connoisseurship in educational films is certainly time consuming and extensive; however, films are linear media typically 1–3 h in duration. In contrast, digital games are interactive environments that are not always linear and usually require a much greater investment of time. A typical video game may take between 1 and 30 h to complete and other games such as massively multiple online games may require an investment of hundreds of hours and continue without end. Is it realistic to foster connoisseurship in educational games and game-based learning? After all, games are not merely sensory experiences, they are interactive experiences. Yet, both film and digital games are entertainment media and both undergo reviews and criticism as the primary means of review. Developing connoisseurship in game-based learning would certainly require an investment of time; yet fostering this investment in developing connoisseurs may result in creating the type of educational games and game-based learning that actually fulfill the promise of games and educational media so often touted by educational theorists and researchers.

Perceptual Discriminations

Belland (1991) proposed that the first level of developing connoisseurship for educational technology is cultivating knowledge of perceptual discriminations. Perceptual discriminations center around sensory experiences and the fine distinctions of how elements related to sensory experiences operate. Belland uses the example of typefaces used in the design of print material. A novice may not see or understand how the fine distinctions of typefaces such a *New Century Schoolbook* can convey to a reader a sense of permanence and authority. Similarly Eisner (1998) notes the distinctions between fine characteristics of wine that a wine connoisseur may perceive whereas the novice might not notice. While Belland (1991) acknowledges that some sensory experiences may be beyond the capacity or sensory limits of some people, for most, discriminations can be fostered and developed. In Belland's example of typefaces, he suggests that the novice designer might sit with experts as they discussed typefaces and through peripheral participation, begin to develop knowledge of fine distinctions conveyed through the use of different typefaces. Belland further contends that instructional and learning designers move beyond the surface sensory experiences and examine differences "among production qualities, coding systems—including forms of discourse, metaphor, iconographies, symbolic, formal features of the medium(a), and exemplary practices."

Digital games are sensory experiences that may include visuals, music, interactive sound, audio dialog, motion, animation, and narrative, along with game mechanics. A connoisseur in game-based learning would need to understand the aesthetics of a game-based environment and how it supports the desired learning processes and goals. Although the notion of aesthetics in games is an ambiguous concept representing different and intersecting aesthetics, these differing and intersecting aesthetics can inform the design and critique of game-based learning. Turkle's (1995) aesthetic of transparency and opacity can provide a fundamental view. Certainly, Laurel's (1991) Aristotelian aesthetic of immersion and Gigliotti's (1995) Brechtian aesthetic of reflection provide a point departure for looking at point-of-view (POV) or how the player/learners is situated in the environment supports or impedes the learning goal. LeBlanc (2006), Mortensen (2009), Crawford (2003), and Myers' (1990a) respective discussions of aesthetics of interactivity and interface are informative for the selection of game genre's and mechanics. Finally, the aesthetics of game art design is relevant for how it reinforces the environment while supporting the learning goals.

A connoisseur of educational games and game-based learning would first need a comprehensive knowledge of game genre. Too often in game research, the term "game" is used as though it were a specific type of activity. In reality, digital games include a very diverse group of genres. Different genres include different types of aesthetics, mechanics, dynamics, and even cultures. There may be some commonalities between genres and even overlapping game mechanics, but there are also some very broad differences. For example, a first-person shooter (FPS) game such as *Call of Duty: Black Ops* is very different in game mechanics, actions, and even culture than an adventure game such as *Azada*. The end goals may be the same (to catch a culprit), but the mechanics, culture, and game elements are very different. It is important that a connoisseur be well versed in different game genres and have an understanding of the conventions in different game genres and how different genres could be used to foster different types of learning experiences. For example, the focus of an online role-playing game is on resource management. The player develops a character and through completing various tasks/quests, is able to enhance his/her character. Much of the focus of the design of online role-playing games (RPG) is on collaborative play in which players contribute to a common goal by working with other players—each contributing her/his characters' unique attributes toward the common goal. In contrast, the focus of an adventure game is to uncover a narrative storyline. Players are often cast in a predefined protagonist role and given the goal of uncovering a mystery. They are placed in a scenario and act as the character and interact with the game environment and nonplayer characters to uncover the underlying storyline. Understanding what different genres have to offer for learning is important. Both of these genres are used for digital games and can be found in different formats, but the types of cognitive skills and strategies of these different genre's may be very different. A connoisseur should also be open and aware of the emergence of new genres.

In addition to knowing about different game genres, the connoisseur would need to have a thorough understanding of the types of game mechanics commonly used in different game genres and understand how these different mechanics might foster different higher-order thinking skills. Game mechanics are the rules of the game and the types of interaction afforded and constrained by the rules. A connoisseur would need to understand the relationship between game mechanics and the types of higher order thinking that may be fostered in different game genres and by extension, game mechanics. For example, in an adventure game, players find and manipulate objects, negotiate through contained maze-like environments, remember key items in the environment, and solve puzzles. This would require the player to activate thinking skills in identification (items and places), recall, locate, compare, and analyze. In contrast, a simple arcade game may require a player to collect objects within a specified amount of time. This would require players to identify objects and activate psychomotor skills.

While a connoisseur would certainly have a comprehensive knowledge of game genres and the relationship between game mechanics, game-based learning is a broad term and is often used for more than just games. Game-based learning also encompasses environments that are not necessarily games, but include game-like elements such as virtual world environments. A connoisseur would also have to have considerable experiences with these environments to understand the nuances and fine distinctions in the affordances of the environments provided by different applications.

Developing Concepts and Concept Hierarchies

Belland (1991) acknowledged that the development of simple concepts is of limited utility in developing connoisseurship. However, he maintained that where the notion of concepts is useful is in indeterminate concepts that require an understanding of subtitles and nuance. He further asserted that the use of concepts becomes more relevant in the hierarchy of concepts. Belland used film to illustrate concept hierarchy by first denoting the broad category of instructional film, then the narrower concept of the narrative film, followed by the narrower concept of *stream of consciousness*. Concept hierarchy is particularly useful in game-based learning because hierarchy is a large part of the design of educational games and game-based learning. From the broad concept of game, to the narrower concept of game-based learning, then the narrower concept of genre, then narrower to POV, followed by the narrower concept of mechanics, environment, navigation, interface, and art integrated, the connoisseur would also need to have extensive knowledge about how these elements provided the scaffolding learners needs both for interacting with the game or game-based environment and for achieving the learning goals.

Too often research into game-based learning fails to acknowledge the hierarchy of concepts that constitute a particular game and game-based environment, but instead remain situated in the broad concept of an educational game without delineating a genre or point of view, followed by narrower concepts such as mechanics, navigation, interface, and art.

Principles

Belland advocates two main principles for developing connoisseurship: life-long learning and courage of one's convictions. The connoisseur should continually learn and draw knowledge from research, theory, philosophy, criticism, and experiences. This principle is certainly valuable for game-based learning. Game design is a field that appropriates, integrates, and weaves together a wide array of art and science-based disciplines. There is a wide body of discourse about games, educational games, serious games, and game-based learning from researchers, theorists, philosophers, designers, and artists. Games design encompasses many domains including programming, literature, psychology, fine art, graphic design, sound design, and music. Developing connoisseurship in game-based learning would encompass diverse knowledge in how these various fields manifest in games, along with experience playing games of all sorts (both contemporary and those considered to be exemplary and foundational). The connoisseur would also have to develop knowledge and experience with educational games and game-based learning environments—both first hand when possible and through research and reflections when the media is not available. Developing connoisseurship would require learning the history of games and game-based learning and an appreciation for the pioneers and trailblazers.

The second principle which Belland (1991) advocates for connoisseurs is "courage of one's convictions" (p. 35). Connoisseurs must believe that their experiences and judgments are valid even when they conflict with others. The connoisseur's convictions are altered only based on new experiences and not due to the persuasion or conflict with others. This is particularly important for developing connoisseurs in game-based learning. The experiences of game play are different experiences for different players. With a medium that historically has been designed for primarily male audiences, those who are outside will need to rely on their knowledge, experience, and courage of their convictions particularly to break with tradition in how games are discussed.

Strategies

Belland maintains that the intellectual strategies of the connoisseur are like *problem solving* inasmuch as the connoisseur must remain open to new ideas and experiences while applying recollections of previous experiences. He further contends that the strategies employed by connoisseurs also differ from *problem solving* because with connoisseurship the experience begs interpretation rather than being framed as a problem. According to Belland, connoisseurship strategies focus on: (1) maintaining "extensive and intensive" involvement, (2) interrelating new experiences with previous experiences, (3) insuring that critical dimensions have been observed and analyzed, and (4) reflecting on new experiences in relation to previous experiences.

Finally, Belland offers a list of actions to help foster the development of connoisseurs. At the risk of displaying great hubris, Belland's list of actions for developing connoisseurs in instructional and learning design has been appropriated and adapted for developing connoisseurship in game-based learning. I take this great liberty because Dr. Belland was my advisor and mentor and I believe it would have pleased him.

1. Connoisseurs need to experience the "classic" works in the field of games and game-based learning.
2. Connoisseurs need to review and critique all forms of games and game-based learning environments.
3. Connoisseurs need to interact with a heterogeneous array of individuals who are in various stages of developing connoisseurship for the field.
4. Connoisseurs need to read critical literature in the field as well as artistic criticism published in popular online press.
5. Connoisseurs need to develop courage to hold and express unique observations and analyses and be able to interact with others based on them.
6. Professors of educational technology/instructional designers will need to study the extent to which connoisseurship in game-based learning can be developed in order to prepare scholars.
7. Researchers will need to examine the extent to which connoisseurship in game-based learning will improve the gathering of data even under traditional experimentalist's paradigms (p. 33–34).

Conclusion

The purpose of this chapter is to examine and apply the connoisseurship model proposed by John C. Belland in *Paradigms Regained* as a means for critiquing and "getting inside" of game-based learning environments. The connoisseurship model advocated by Belland provides an arts-based alternative to the existing science-based paradigms of qualitative and quantitative research methodologies. Aesthetics is a broad and diverse term in game design, but it is a fundamentally important aspect of games that is greatly overlooked in discourse about game-based learning.

The model of connoisseurship proposed by Belland offers a way to understand differing aesthetics in games and the importance of how it shapes experiences. Developing connoisseurship in game-based learning would certainly require an investment of time, yet this investment in fostering connoisseurs may result in creating the type of educational games and game-based learning that actually fulfills the promise of games and education.

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Part III
Problem-Based Learning (PBL)

Integrating Metacognitive Prompts and Critical Inquiry Process Display to Support Development of Problem-Solving Skills

Wei-Chen Hung and James Lockard

Introduction

After more than two decades of evolution, problem-based learning (PBL) has become a general model designed and disseminated as a collaborative, learner-centered environment, and used to support the development of inquiry skills. The major learning approach of PBL, according to Barrows (1986), is to help learners recognize the issues involved, understand the context, see how their knowledge is dependent on that context, and know why they are choosing a particular way to solve the problem. In PBL, learners are encouraged to engage in free inquiry and construct their own understanding through group collaboration and problem reflection.

Numerous studies have attempted to generalize the problem-solving process into steps that support development of learners' inquiry skills in PBL (Barrows, 1992; Bransford & Stein, 1984; Ericsson, 2006; Jonassen, 1997; Koschmann, Myers, Feltovich, & Barrows, 1994; Livermore, 1964). By identifying these steps, specific instructional strategies can be incorporated to guide problem analysis, conceptualizing, hypothesizing, and strategizing during the problem-solving process. The steps also provide useful indicators for assessing the quality of learners' inquiry skills (Koschmann et al., 1994; Kuhn, 2005).

The challenge is to develop support for the process of problem solving in order to enable novice problem solvers (learners) to reflect on their own learning and to engage authentic practices through problem-solving activity and social interaction in a way similar to real-world problem solving. Learners often do not know what process to use or have difficulty to conceptualize the problem or issues to be resolved (Bereiter & Scardamalia, 1989; Cognition and Technology Group at Vanderbilt, 1993)

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and may lack knowledge or interest to think critically about the problem (Savery & Duffy, 1995; Weiss, 2003). Identifying methods of helping learners model the problem-solving processes of experts, such as their methods of finding clues associated with problems, their cognitive processes, and the reasoning processes they use in selecting solutions, becomes an important issue for supporting learning in PBL (Hmelo-Silver, 2004; Ge & Land, 2004; Gijselaers, 1996).

Scaffolding and modeling derive from the theory of cognitive apprenticeship that emphasizes the social context of learning and the interaction between experts and learners (Collins, Brown, & Holum, 1991). The purpose of scaffolding is to provide temporary support for those task aspects that learners have difficulty performing. The support can take the form of suggestions or direct help. Guidelines, prompts, and feedback are essential for the design of scaffolding (Quintana et al., 2004). Modeling offers opportunities for learners to observe an expert's practices through visual step-by-step instruction, live demonstrations, or video/audio (Jonassen, Mayes, & McAleese, 1993; Williams, 1992). Instructors can then monitor students' learning progress and provide appropriate scaffolding at critical times. Although scaffolding and modeling are different in instructional purpose and design approach, they share the same design objective—to support learners as they perform and improve their skill at complex tasks.

Incorporating scaffolding and modeling as an instructional strategy supports effective problem-based leaning activities. However, one major design challenge is to provide meaningful facilitation, regulation, and modeling features that emphasize development of problem solving and inquiry skills as opposed to conventional goal of mastery of content knowledge (Pea, 2004). This challenge recognizes that the pedagogical emphasis in problem solving is on the development of inquiry skills, rather than the mere acquisition of facts.

One approach to this design challenge, as suggested by Paris and Winograd (1990), is to provide a mechanism that enhances students' metacognitive processes throughout the process of inquiry. When students are given a task or a problem to solve, they need to work in a problem-solving environment that allows them to constantly self-monitor and self-examine their thinking and level of comprehension. This self-monitoring and self-examining process involves connecting new information to prior knowledge, deliberately selecting thinking strategies, and planning, monitoring, and evaluating problem-solving processes (Paris & Winograd). Metacognitive processing involved in problem solving has been shown to be a more important indicator of the successful transfer of problem-solving ability than the presence of content knowledge (Berardi-Coletta et al., 1995; Davidson et al., 1994; Hartman, 2001).

Students who are required to engage in metacognitive processing increase both their comprehension of text materials and their ability to solve problems effectively (Bixler & Land, 2011; Chi, deLeeuw, Chiu, & LaVancher, 1994; De Grave, Boshuizen, & Schmidt, 1996; Gourgey, 2003; Oldenberg & Hung, 2010; Sandi-Urena, Cooper, & Stevens, 2011). Furthermore, support of students' metacognitive processing during problem solving can be embedded in the instruction or learning environment using appropriate scaffolding and modeling strategies.

For example, Bixler and Land (2011) used metacognitive prompts, including questions and hints, to guide undergraduate students as they planned, monitored, and reflected upon their problem-solving process. Students who received the metacognitive prompts demonstrated significantly improved problem-solving capabilities in four metacognitive processing areas—problem representation, developing solutions, making justifications, and monitoring and evaluation. Sandi-Urena, Cooper, and Stevens (2011) required college students to respond to a series of reflective questions during a problem-based learning activity. These students learned to solve nonalgorithmic chemistry problems of higher difficulty better than students who experienced didactic instruction. Even after prompt removal, students showed an overall increase in their use of regulatory metacognitive skills when solving problems.

Traditionally, scaffolding is dynamically provided by the instructor. More recently, technology has enabled scaffolding and modeling to automate non-salient portions of tasks to reduce cognitive demands, model organization of problem-solving activities, and facilitate collaboration among learners (Quintana et al., 2004; Manlove, Lazonder, & De Jong, 2006). Scaffolding also supports students' readiness for new learning or tasks and focuses their attention on task or problem elements of particular importance (Reiser, 2004). Hannafin, Land, and Oliver (1999) suggested four different types of scaffolding strategies to support inquiry, reflection and self-regulation, modeling, and task completion. For example, a procedural scaffold may be a hyperlink through which learners can access further information or guidance to support task completion. Technology may thus provide a means through which students have immediate access to scaffolding (e.g., metacognitive prompts, critical problem-solving steps, an expert problem-solving model) to enhance their metacognitive processing.

Designing an Instructional Tool to Support Metacognitive Processing in PBL

To support students' metacognitive processing in PBL using technology, we developed a software system called *ActionOrganizer*, targeted at college students participating in problem-based learning activities either in online or face-to-face settings. The system was originally designed to support graduate and undergraduate courses in Educational Technology and Business but has recently been applied to Nursing Education and Geography. The ultimate goal of incorporating *ActionOrganizer* into PBL is to capture students' problem-solving processes to systematically study their development of inquiry skills. The system will also allows investigation into issues involved in how learning takes place when students engage in PBL activities aimed at fostering knowledge acquisition, collaborative learning, and problem solving. In particular, we seek to identify critical thinking and metacognition traits that are central to the process of acquiring domain knowledge and inquiry skills, as well as explore the ways in which learning and instructional strategies (specifically, scaffolding and modeling) may be better demonstrated, promoted, and assessed with the support of technology.

Development *of ActionOrganizer* began in 2006 when the senior author received an internal grant. An initial nonnetworked prototype was created, and then usability feedback was elicited from a group of first year medical students (see Hung & Lockard, 2006). Results were used to improve the system's interface and interaction.

Design Framework of ActionOrganizer

The design of *ActionOrganizer* was grounded in metacognitive learning theories and the scientific reasoning process. It combines database technology with a learner-centered graphical user interface. Major features of *ActionOrganizer* include: (1) graphical representations of an assigned problem to help students understand the relationships among interconnected elements of the problem, (2) a unified user interface that allows students to record, retrieve, manipulate, and synthesize data captured at various stages of problem solving, (3) priming of scientific reasoning strategies with metacognitive prompts, and (4) a student task-performance tracking function for the instructor to monitor and assess individual and group learning.

As shown in Fig. 1, our design incorporates Barrows' (1986) PBL format (group formation, problem analysis, problem follow up, and performance presentation) and Livermore's (1964) integrative scientific reasoning approach as the problem-solving phases. We then mapped a set of problem-solving performance indicators derived from Kuhn's (2005) metacognitive traits and Halpern's (1997) critical thinking inventory to each phase to help us assess the quality of students' metacognitive processing.

Next, we incorporated metacognitive prompts and cognitive cues in the critical inquiry process to stimulate and foster students' metacognitive processing and problem-solving strategies. Prompts assist students in planning, monitoring, and reflecting on their thinking (Kuhn, 2005). For example, during the problem analysis phase, a metacognitive prompt that guides hypothesis generation is: "Imagine that you are an expert in the problem area. What do you know and what can you do?" Cognitive cues or hints include instructional and explanatory information about each problem-solving phase (Harris, 2002). An example hint provided for problem representation is: "Your goal at this point is to structure the problem so that it can be understood and addressed. Expressing the problem as clearly as possible at the outset will provide a useful beginning focus."

Student Module of ActionOrganizer

The two major components of *ActionOrganizer* are the student module and the instructor module (described later). The student module provides a framework that

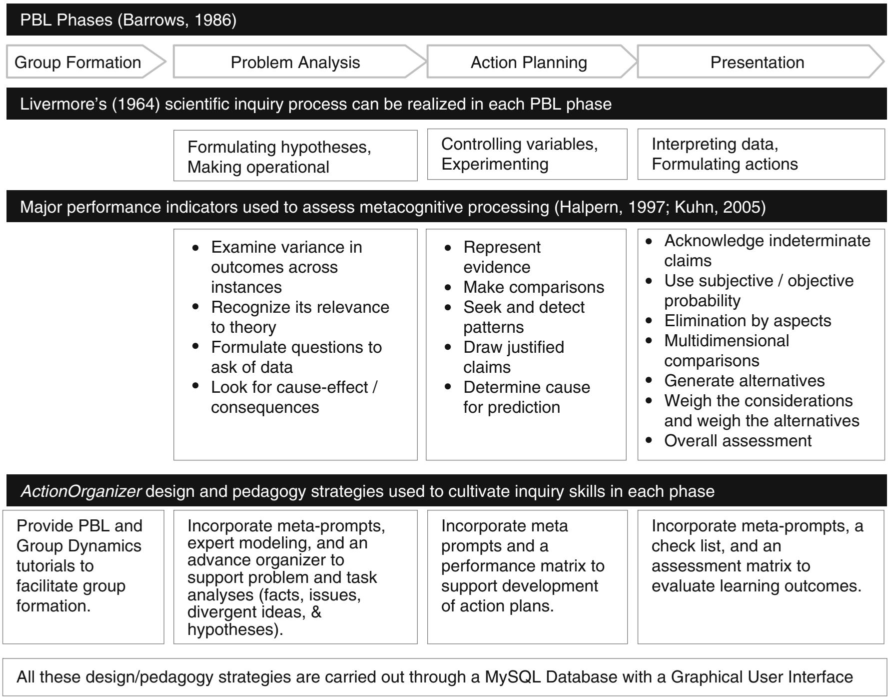

Fig. 1 *ActionOrganizer* design framework

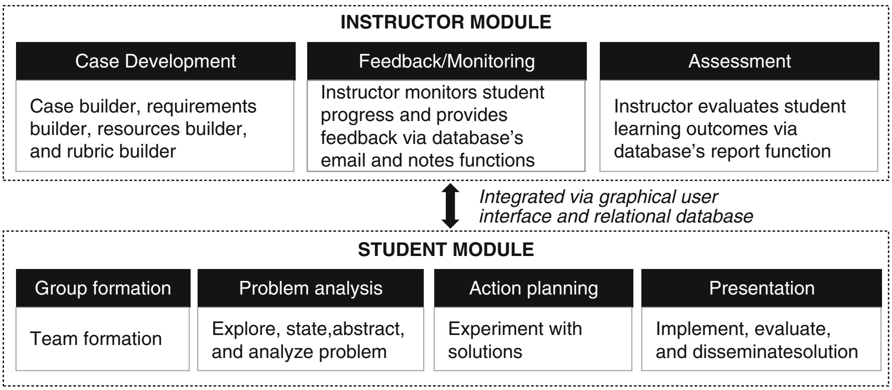

Fig. 2 *ActionOrganizer* working model: Integration of student and instructor modules

leads students through four problem-solving phases (See Fig. 2). Within the problem-solving phases, we identified seven reasoning steps that are essential to our design of modeling (explore problem—state problem—abstract problem—analyze problem—experiment with solutions—implement solution—evaluate solution).

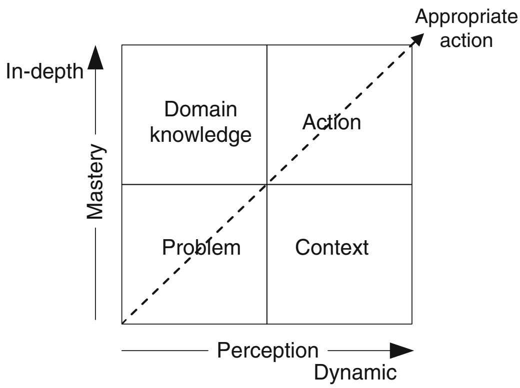

Fig. 3 2×2 problem-solving matrix conceptual framework

These seven steps are grouped under three of the four problem-solving phases: (1) problem analysis, (2) action planning, and (3) presentation.

In the problem analysis phase, students try to understand various dimensions of a complex, ill-structured problem given by the instructor. A typical problem could be to design a professional development workshop. Students propose a delivery platform (online, face-to-face, or hybrid) with recommended learning activities based on audience needs and existing facts. Students continue their problem-framing task and further refine their understanding of the problem through reading, brainstorming, and documenting and then organizing facts, ideas, issues, and hypotheses generated from discussions.

When the students are ready to identify possible solutions, they move to the action planning phase and use a 2×2 problem-solving matrix to experiment with the problem they are trying to solve. This 2×2 problem-solving matrix provides students a visual framework to guide them in the action planning process. As illustrated in Fig. 3, the assumption is that the appropriate action/solution derives from both domain knowledge and context.

Students start by reviewing gathered information (such as problem issues, facts, ideas, and hypotheses) and then propose a solution and action plan. To identify an appropriate solution, students must balance domain knowledge mastery and problem framing in context (i.e., situation specific requirements and constraints), through an iterative cycle of perception, articulation, and reflection. The matrix also contains probing questions that prompt students to determine the viability of their possible solutions.

Since the student module is built upon a relational database with a graphical user interface, students can query and cross-reference information entered at each problem-solving phase. They can also request a customized report containing any information they have recorded, such as one that displays a list of learning issues that require further research. Other system features in the student module, including data exchange and communication, are available for students to support their collaborative efforts.

Instructor Module of ActionOrganizer

The instructor module includes technical functions to support the three key tasks of case development, feedback and monitoring, and assessment (see Fig. 2). Instructors can select only the function(s) they need for building their PBL activities. They can use the *Case Builder* to incorporate simple text and/or rich, multimedia case materials into the learning environment, while the *Resources Builder* organizes additional resources. The *Requirements Builder* and the *Rubric Builder* support the tasks of specifying learning requirements and building assessment rubrics. Finally, the *Feedback/Monitoring* function facilitates students' learning performance and the *Assessment* function provides summative reports.

How ActionOrganizer Works

To illustrate how *ActionOrganizer* supports problem solving, screen captures of the software system are presented and explained below. This illustrated example was pulled from a case assigned in a graduate course.

Upon logging into the student module for the first time, students are prompted to enter their group's name, membership, and facilitator's name and email addresses (Fig. 4, left, Welcome screen). Sending this information to the instructor is a

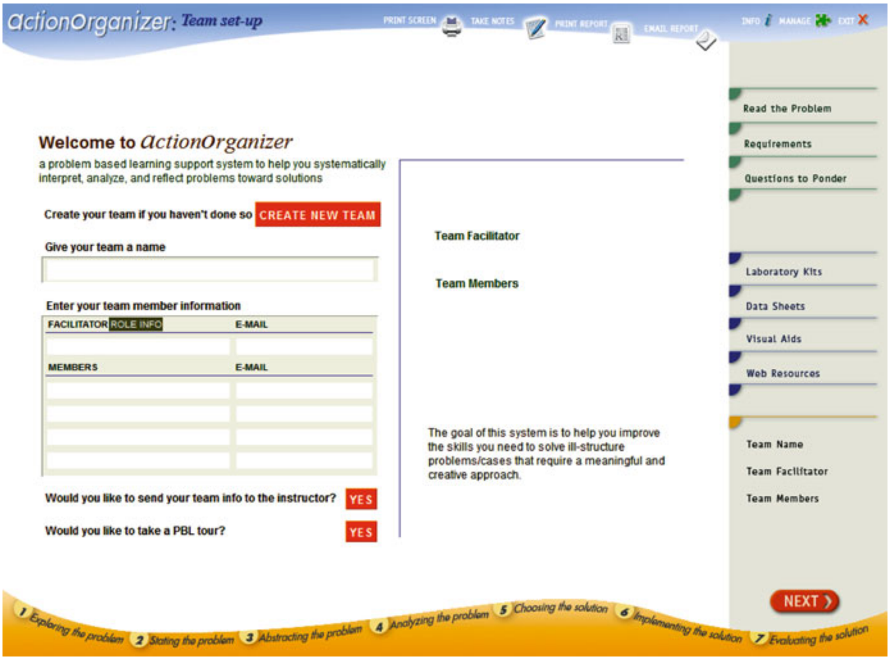

Fig. 4 Welcome screen and team set up

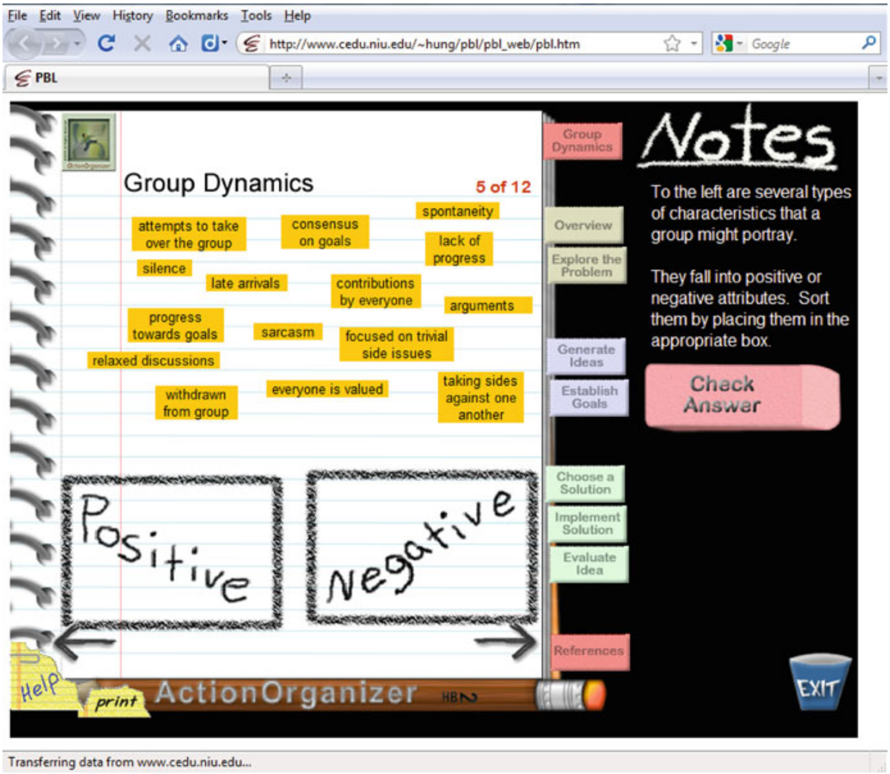

Fig. 5 PBL tour

one-time task. At the bottom of this screen, students have the option of viewing an online guide (PBL tour) describing the overall problem-solving process and strategies. By clicking a *Yes* button (Fig. 4, bottom), students will see the PBL tour. The PBL tour provides an interactive introduction to key topics such as group dynamics, problem exploration, goal setting, and solution implementation (Fig. 5). This guide is available as a reference tool from any component in the system.

After the PBL tour, a simple navigation instruction page is displayed to guide students quickly in how to navigate through the system.

In the problem inquiry and analysis work area, students click on the *Read the Problem* link (right side) to read text or access a multimedia file describing the problem (See Fig. 6). Each problem is supported by a scenario containing background material and a series of guides that set the problem context and give direction. Also available are assignment requirements, resources links, lab kits, visual aids, and the evaluation rubric, which support the problem-solving activity. In the next step, students articulate their problem definition and negotiate any differences of opinion within their group.

Students can also use the general toolbar located at the top of the screen to perform a variety of system functions such as printing the active screen for off-line

Fig. 6 Problem inquiry and analysis work area (with embedded audio annotation function)

reference, taking notes, generating reports, sending emails (linked with the database query functions), taking the PBL tour, and managing their PBL records.

In the *Analyze the Problem* section, students document problem facts, identify learning issues, and begin developing hypotheses. Students learn to use a systematic approach to seek and analyze information and to identify knowledge gaps. From problem framing to hypothesis building, students proceed in a manner that closely mimics the behavior of an expert.

Throughout the system, students can click on any one of the seven reasoning steps (Fig. 6, bottom) and a window containing a more detailed explanation opens (Fig. 7). The Hint button embedded in each text field displays metacognitive prompts to provide further guidance. These hints/prompts can be viewed at any time to help clarify problem goals, explore meanings and concepts, draw inferences, and monitor progress toward a solution.

When students have completed or partially completed the problem analysis, they can move to the action plan development phase (Fig. 8). In this phase, students converge and document possible solutions to solve the problem using a 2×2 matrix labeled “Solve the Problem.” A step-by-step tutorial (Fig. 9) is provided to show students how to use this matrix. The tutorial was designed to help students understand that problem solving is not always a clear-cut matter. Rather, ill-structured

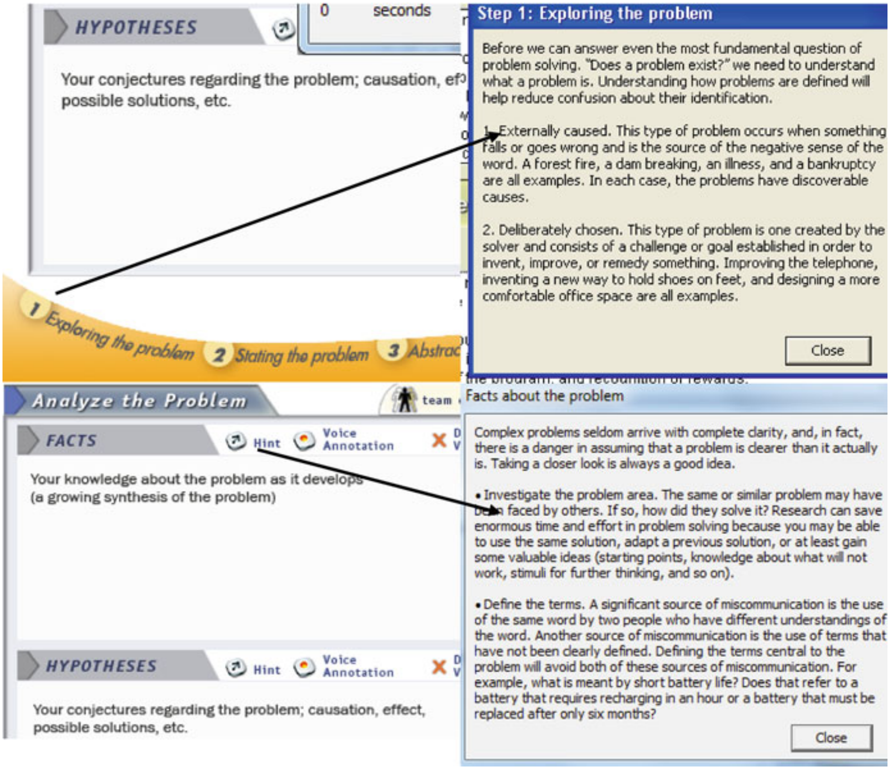

Fig. 7 Metacognitive prompts about the expert problem-solving process and problem analysis (via the *Hint* button)

problems involve interaction of multiple factors and cannot be solved in a linear fashion. The 2×2 problem-solving matrix enables students to experiment by continuously generating possible solutions to confront the complexity of the problem.

The final phase includes three steps: implementing, evaluating, and disseminating the solution. After generating a possible action plan (solution) for the problem, students conduct a final review of their plan using the criteria checklist to the right of the plan box and adjust their action plan as necessary, as shown in Fig. 10. Next, students provide a title for their action plan and enter references and resources used. They then compile a final action report and submit it for review by sending it as an email attachment, exporting it to html format, or simply printing it. They can also share the report with other group members to elicit additional feedback.

While action plan evaluation is the final PBL step, throughout the PBL process students can submit their work in progress to the instructor for comments and feedback via the e-mail and report functions, as shown in Fig. 11. The email function is preconfigured so that information students have entered into the *ActionOrganizer* database is automatically retrieved and sent via the email message without retyping.

Fig. 8 Action plan development phase

Formative Study of *ActionOrganizer*

The purpose of this formative study was to evaluate user perceptions of the updated design of *ActionOrganizer* and to identify any design issues that could potentially hinder user experience and performance. Specifically, we were interested in learning users' opinions about the system and whether it allows them to emulate the thought processes of experts when solving problems. Formative research has been characterized as a process of inquiry that employs analysis and synthesis to understand how an instructional product can be optimized (Dick, Carey, & Carey, 2009; Gagné, Wager, Golas, & Keller, 2004; Reiser, 1987; Sanders & Cunningham, 1973). Data collected at this stage can be used to determine which instructional features should be adopted or revised to make the product useful in a real-world setting.

Method

To study usage, constraints, and design features of *ActionOrganizer*, we recruited 11 graduate students from an introductory Instructional Design and Media course to use the software for 2 weeks to solve a science education curriculum problem. Determination of this sample size was based on Dumas and Redish's (1999)

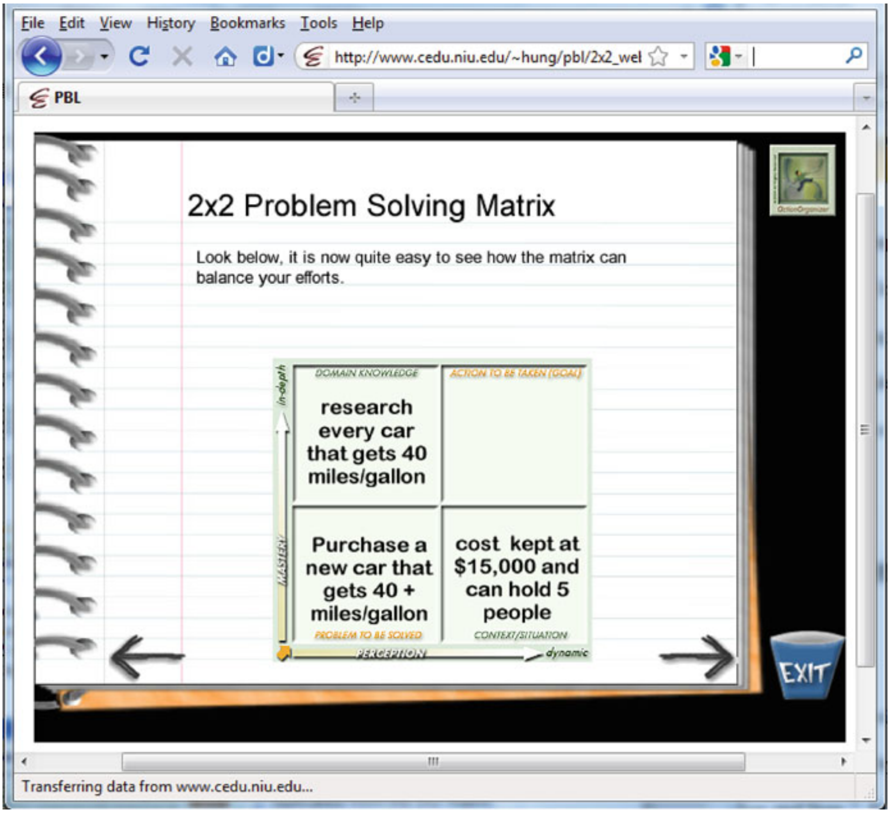

Fig. 9 2×2 problem-solving matrix how-to tutorial

evaluation guidelines, which recommend 5–12 participants to attain reliable usability information to validate a software system. Among the eleven participants, two were doctoral students and nine were Masters students, two were male and nine were female with ages between 30 and 50. All participants majored in Instructional Technology at the researchers' university.

Participants were randomly assigned to three teams. All team members knew each other already, but they had not worked together as a group prior to the study. Each team met face-to-face one time in the first week to become familiar with *ActionOrganizer.* After that, students were asked to work on an assigned case using the tool over the next 2 weeks, as often as they desired. The assigned case was to select a delivery format and design suitable instructional strategies for in-service teacher training in science curriculum development. Each team's task was to identify appropriate media, instructional strategies, and delivery mode for the training. After completion of the activity, a survey of user perceptions and focus group discussions were conducted to explore students' usage and opinions about the system's design features.

Fig. 10 Implementing, evaluating, and disseminating a solution

Survey Instrument

A survey was administered at the end of the study to elicit participants' opinions about *ActionOrganizer*. The survey instrument, *Students' Perceptions of ActionOrganizer Survey,* was developed and piloted by the senior author. The survey consists of 60 five-point Likert scale questions related to usefulness and students' perceptions of *ActionOrganizer.* There are four defined sections in the survey: Comparison (ten items) focuses on student opinions of the teamwork and communication functions in *ActionOrganizer,* as compared to traditional email and discussion tools; Concerns (ten items) focuses on student concerns about using *ActionOrganizer*; Interface (ten items) aims at understanding student reactions toward the system interface and orientation; and Perception (30 items) focuses on student perceptions of the system overall and its impact on their learning outcomes. Development of these sections started with Shackel's operational definition of usability (1986, as cited in Booth, 1989). Shackel identified four measureable usability criteria that any system should have—effectiveness, learnability, flexibility, and user attitude. These criteria served as the baseline to help us define areas of evaluation and develop indicators for survey questions. The usability test conducted on the early version of *ActionOrganizer* used this instrument and yielded an overall reliability coefficient of 0.90 using Cronbach's alpha (Hung & Lockard, 2006).

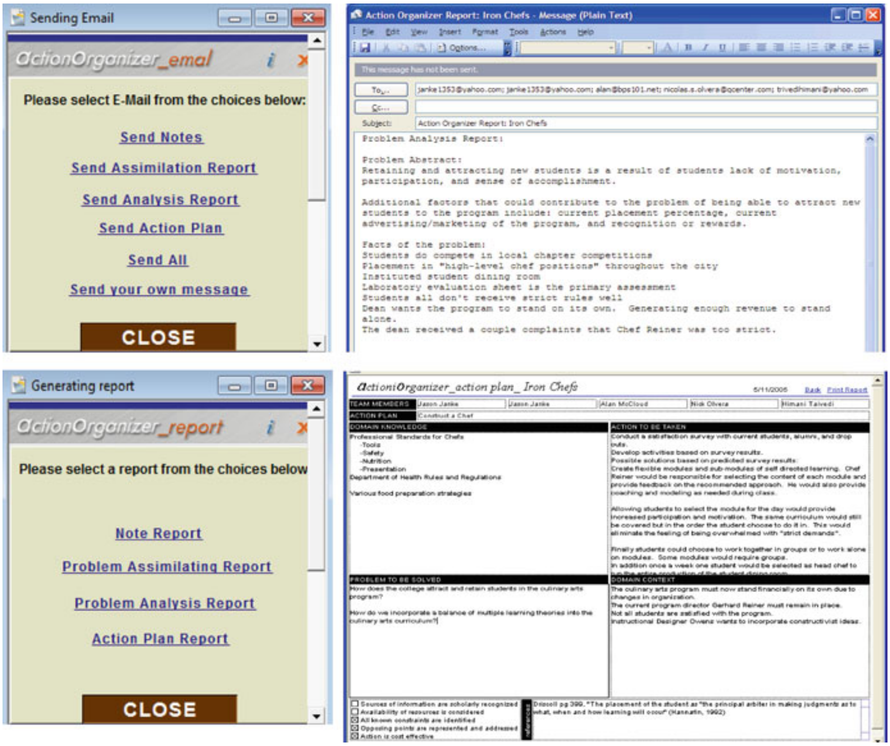

Fig. 11 Email functions and report generator

Focus Groups

Participants were invited to a focus interview to discuss usage, constraints, and applications of *ActionOrganizer.* All participants accepted and they were divided into two sessions. One session was conducted by the senior author and another session was led by the course instructor. Participants from all three groups were distributed as evenly as possible between the two sessions to ensure a diverse discussion. The discussion focused on the participants' learning experience with the support of *ActionOrganizer*. Both focus group sessions were conducted in a loosely structured format and guided with a set of open-ended questions about (1) the effectiveness of *ActionOrganizer* in promoting PBL, (2) students' perceptions of PBL and their ability to solve problems using a systematic approach, (3) the usefulness of *ActionOrganizer* from the students' perspectives, and (4) difficulties and limitations of *ActionOrganizer* in supporting PBL. Each session lasted approximately 25 min.

Results

Results are presented first for the survey, then from the focus groups.

Survey Findings

After scores for negatively worded items were reversed, internal consistency of the four sections was assessed using Cronbach's Alpha. Table 1 is a summary of each section's descriptive statistics and alpha value. The overall reliability coefficient of the instrument for the present study was 0.95. To understand the relationships among the four sections of the survey instrument, the sections were paired and correlation coefficients were calculated as shown in Table 2. No negative item-total correlation was found. The correlations, together with the Cronbach's Alpha values in Table 1, provide evidence of reliability and internal validity of the scores.

Table 3 summarizes the percentage distribution and mean score of responses to each item. Negative items were reversed during the analysis for scoring consistency. Higher scores indicate a higher degree of agreement with the item and, therefore, greater satisfaction among respondents. The survey revealed an overall positive attitude toward the usage of the system.

For the Comparison section, when asked to compare the system to traditional communication tools for group collaboration support (i.e., email and threaded discussion), the grand mean was 3.72 with a standard deviation of 1.03. Of the respondents, 82% agreed or strongly agreed with the statements: "easier for you to manage

Table 1 Section statistics and Cronbach's alpha values

Section	Mean	SD	Minimum	Maximum	Alpha
Comparison	3.72	1.03	2.91	4.36	0.87
Concerns	3.61	1.08	3.09	4.09	0.78
Interface	3.66	1.01	3.09	4.09	0.66
Perception	3.79	0.89	2.36	4.46	0.91

Table 2 Pearson correlation coefficients between assessment instrument sections

	Comparison	Concerns	Interface	Perception
Comparison	1	0.894**	0.807**	0.853**
Concerns	0.894**	1	0.629*	0.816**
Interface	0.807**	0.629*	1	0.708*
Perception	0.853**	0.816**	0.708*	1

* indicates $p<0.05$
**indicates $p<0.01$

Table 3 Distribution of respondents' responses ($N=11$)

	Response distribution (%) & mean					
	SD	*D*	*N*	*A*	SA[a]	*m*[b]
Comparison: Compared to using traditional email and discussion tools in problem based learning, do you consider *ActionOrganizer* to be:						
1. More time efficient for your learning activity	0.0	18.2	27.3	45.5	9.1	3.45
2. More convenient for you to use	0.0	36.4	9.1	45.5	9.1	3.27
3. More important for your group discussion	0.0	9.1	27.3	27.3	36.4	3.91
4. More fun for you to use	0.0	0.0	36.4	27.3	36.4	4.00
5. Easier for you to manage your reflections	0.0	9.1	9.1	18.2	63.6	4.36
6. Easier for you to interact with your group members	0.0	9.1	36.4	18.2	36.4	3.82
7. Providing better communication between you and your team members	0.0	18.2	9.1	36.4	36.4	3.91
8. Providing lower quality of discussion with your group members[c]	0.0	18.2	18.2	54.5	9.1	3.55
9. Attracting more potentially meaningful discussion within your group	0.0	9.1	9.1	54.5	27.3	4.00
10. Not compatible with my problem-solving approach[c]	18.2	18.2	27.3	27.3	9.1	2.91
Concerns: When thinking about *ActionOrganizer*, you feel:						
1. Lack of knowledge/skills related to the use of *ActionOrganizer*[c]	9.1	27.3	9.1	54.5	0.0	3.09
2. Lack of hardware/software stability/reliability	9.1	18.2	0.0	45.5	27.3	3.64
3. Lack of technical support[c]	9.1	9.1	36.4	27.3	18.2	3.36
4. Lack of instructional support[c]	9.1	9.1	9.1	54.5	18.2	3.64
5. Lack of group member support[c]	18.2	9.1	18.2	27.3	27.3	3.36
6. Lack of recognition[c]	0.0	9.1	36.4	45.5	9.1	3.55
7. Lack of confidence[c]	9.1	0.0	36.4	45.5	9.1	3.45
8. Lack of time to enter your thoughts into *ActionOrganizer*[c]	0.0	0.0	18.2	63.6	18.2	4.00
9. Lack of freedom to express your ideas[c]	0.0	9.1	18.2	45.5	27.3	3.91
10. Lack of creativity[c]	0.0	9.1	9.1	45.5	36.4	4.09
Interface: When using *ActionOrganizer*, you feel:						
1. Screen layouts were helpful	0.0	0.0	18.2	54.5	27.3	4.09
2. Amount of information that can be displayed on screen is adequate	18.2	18.2	9.1	45.5	9.1	3.09
3. Arrangement of information on screen is logical	0.0	0.0	18.2	54.5	27.3	4.09
4. Sequence of screens is clear	0.0	0.0	36.4	27.3	36.4	4.00
5. Next screen in a sequence is unpredictable[c]	18.2	9.1	27.3	36.4	9.1	3.09
6. Screen design is appealing	0.0	9.1	9.1	45.5	36.4	4.09
7. Secure and comfortable in interacting with the system	0.0	27.3	18.2	36.4	18.2	3.45
8. Terminology is clear and precise	0.0	18.2	18.2	45.5	18.2	3.64
9. Instruction is unclear[c]	0.0	0.0	36.4	54.5	9.1	3.73
10. More hints should be provided[c]	9.1	27.3	18.2	18.2	27.3	3.27

(continued)

Table 3 (continued)

	Response distribution (%) & mean					
	SD	*D*	*N*	*A*	SA[a]	*m*[b]
Perception						
1. AO helps me understand the nature of the given problem	0.0	0.0	9.1	72.7	18.2	4.09
2. AO helps me recognize the obstacles associated with the problem	0.0	9.1	9.1	63.6	18.2	3.91
3. AO helps me generate hypotheses about the problem	0.0	0.0	18.2	54.5	27.3	4.09
4. AO helps me reason the hypotheses that I generated	0.0	0.0	27.3	54.5	18.2	3.91
5. AO helps me identify the facts of the problem	0.0	0.0	9.1	36.4	54.5	4.45
6. AO helps me identify the learning issues for solving the problem	0.0	18.2	9.1	36.4	36.4	3.91
7. AO makes me feel I cannot solve the problem[c]	9.1	9.1	45.5	27.3	9.1	3.18
8. AO helps me have a clear understanding how I arrived at my final plan	0.0	0.0	27.3	45.5	27.3	4.00
9. AO provides me a better way to analyze problems	0.0	0.0	9.1	63.6	27.3	4.18
10. AO makes PBL easier to practice	0.0	0.0	18.2	54.5	27.3	4.09
11. AO prompts me to read the problem carefully	0.0	9.1	0.0	54.5	36.4	4.18
12. AO encourages me to identify the problem's critical features	0.0	0.0	9.1	54.5	36.4	4.27
13. AO prompts me to give many considerations	0.0	9.1	36.4	27.3	27.3	3.73
14. AO helps me apply my understanding of the problem to the action plan	0.0	9.1	9.1	54.5	27.3	4.00
15. AO offers me better management of my thinking processes	0.0	9.1	9.1	27.3	54.5	4.27
16. AO offers me better record keeping of my problem solving exercises	9.1	0.0	9.1	27.3	54.5	4.18
17. AO is mostly for people who know the concept of PBL[c]	18.2	27.3	18.2	27.3	9.1	2.82
18. AO is mostly for people who have a good understanding of computers[c]	9.1	36.4	27.3	18.2	9.1	2.82
19. AO is a tool suitable for PBL	0.0	9.1	9.1	72.7	9.1	3.82
20. Individual based PBL is not suitable for AO[c]	0.0	0.0	18.2	63.6	18.2	4.00
21. AO will improve the outcome of PBL	0.0	0.0	27.3	54.5	18.2	3.91
22. AO will weaken the teacher-student relationship	18.2	45.5	18.2	18.2	0.0	2.36
23. I feel AO provides inadequate guidelines to help solve problems[c]	0.0	18.2	18.2	36.4	27.3	3.73
24. I feel AO provides inadequate functions to facilitate discussions[c]	0.0	27.3	9.1	63.6	0.0	3.36
25. I feel AO makes sense	0.0	9.1	27.3	45.5	18.2	3.73
26. Discussions via AO often lead to frustration[c]	9.1	9.1	45.5	36.4	0.0	3.09
27. I believe there is more than one way to solve this problem	0.0	0.0	0.0	81.8	18.2	4.18
28. I would encourage others to use AO	0.0	9.1	0.0	36.4	54.5	4.36
29. I want more training on AO	9.1	9.1	27.3	54.5	0.0	3.27
30. I would like to continue to use AO	9.1	9.1	9.1	27.3	45.5	3.91

[a]*SD* Strongly disagree, *D* Disagree, *N* Neutral, *A* Agree, *SA* Strongly agree
[b]Item overall mean
[c]Negative item. Score was reversed

your reflections," and "attracting more potentially meaningful discussion within your group," indicating their positive experience with collaboration in a structured and guided problem-solving environment. On the other hand, 36% of respondents disagreed with the following statements: "more convenient for you to use" and "compatible with my problem-solving approach."

The Concerns section had a mean score of 3.61 with a standard deviation of 1.08. A large percentage of respondents (82%) disagreed with the follow potential concerns: "lack of time to enter your thoughts into *ActionOrganizer*" and "lack of creativity." Most respondents (73%) perceived that the system allowed them to express ideas, gave sufficient instructional support, and was stable and reliable. However, only 36% of respondents perceived that they had sufficient knowledge and skills related to the use of *ActionOrganizer*, indicating a probable training issue.

For the Interface section, the mean score was 3.66 with a standard deviation of 1.01. The large majority of respondents (82%) agreed or strongly agreed with the following statements: "screen layouts were helpful," "arrangement of information on screen is logical," and "screen design is appealing." Most respondents (67%) felt the sequence of screens was clear and terminology was clear and precise. In contrast, 36% of respondents felt that more hints should be provided and the size of the screen display needed to be increased.

When asked about the system's ability to support PBL, participants perceived the system to be useful in supporting their problem-solving activities. The Perception section had a mean score of 3.79 with a standard deviation of 0.89. 91% of respondents agreed that *ActionOrganizer* helped them (a) understand the nature of the given problem, (b) identify the problem's critical features, and (c) analyze problems and manage their thinking processes more effectively. Furthermore, a majority of respondents believed *ActionOrganizer* was suitable for PBL and said they would continue to use *ActionOrganizer* (73%), as well as encourage others to use it (91%).

In contrast, when respondents were asked about the *ActionOrganizer* technology, almost half (46%) perceived that *ActionOrganizer* was for people who already knew the concept of PBL and had good understanding of computers. Furthermore, 64% of respondents thought that *ActionOrganizer* would weaken the teacher–student relationship, an undesirable outcome.

Although the outcomes of the survey were limited due to the small sample size, their value lies in the knowledge gained concerning specific items in the instrument and issues that can be anticipated for the researchers in the further revision and implementation of *ActionOrganizer*. The survey yielded valuable formative data, with the goal of seeking optimality rather than validity in the instructional design and development process (Reigeluth & Frick, 1999).

Focus Groups

Both focus group sessions concentrated on the participants' learning experience with the support of *ActionOrganizer*. Findings are presented next under two summary themes: (1) participants' experiences solving problems using a guided approach and (2) potential areas for improvement of *ActionOrganizer* in supporting PBL.

Participants' Experiences Solving Problems Using a Guided Approach

Data collected from the focus group discussions indicated that *ActionOrganizer* provided an effective model for guiding users through their problem-solving process, although the process was deemed laborious. Participants were positive about the system's questions, prompts, and guided problem-solving structure, which enabled them to systematically and sequentially analyze and organize their thoughts and strategies that best fit the problem encountered, but only at what was perceived as a slow and potentially laborious pace.

The following are examples of how participants approached the use of *ActionOrganizer*.

> "I organize what we have concluded over group discussion. It takes time to organize it because I need to consider what my biggest concern is. In addition, I gained a lot of hints from the discussion. I categorized its elements based on my concerns and interests and according to the characters and their problems."
> "When I wrote my idea section, I felt many of my ideas were refreshed. I went back to the prior situation, thinking through all my ideas again but with more different ways and viewing them from different angles"
> "I feel the way of *ActionOrganizer*'s expression is very detailed. *ActionOrganizer* asks me to use very minor, little, or very detailed stuff (i.e., things, issues, topics, anything that happens in daily life) to compare to each other. I am not sure if I fully understand what AO wants me to do, or if I am doing it right…."
> "The final products were very, very different. And I felt that our final product had greater impact because of that."

The structure of *ActionOrganizer* was perceived by participants to help develop a shared understanding of the project process and nomenclature, which made both the task and communication easier. The following are examples of participants' comments on the use of *ActionOrganizer* during group collaboration:

> "I mean it's an action organizer. It just organized what elements I needed to have before I went to the next step. And each stage has an organized approach, especially with a group. It made a structure for us to use to follow and to input our group thoughts into and then build on those to the next step."
> "I think it [*ActionOrganizer*] did, in the group it did facilitate it [group collaboration] because I didn't have to explain my approach because there was an approach there that we were all working with."
> "I took mine that I did and they took theirs, and we could share from that single text file. That became very effective in being able to create a single one [result] that was reflective of our group experience."

Such structure also provided a reference point that group members reported using to determine areas or issues that needed to be either revisited or addressed:

> "It helped me evaluate where we were in the group process. Because I could see: Oh she's not getting this, or he's not getting that, or I'm not getting this and again we were all agreed that this was the format that we were going to do; that's what made it so effective. Also, the report that it produced really helped us evaluate where we were in the group process."

Students also perceived that *ActionOrganizer* provided an effective starting point for solving problems:

> "…each stage has an organized approach. Especially with a group. It made a structure for us to use to follow and to input our group thoughts into and then build on those in the next step."
> "I saw the tips and the hints and all that, then I would go back into, like, the case study and look for something similar to see if I could match it."
> "It made me think harder about what exactly the situation was, made sure I had all the facts."
> "The content and the terminology that it [*ActionOrganizer*] provided was very effective. And I think its style was extremely engaging. It had an engaging style."
> "It gives you the structure, the framework, the rules are there for you. Can we try this? See if it works. And gather the facts before I try these things. And those steps, I found that the tool [*ActionOrganizer*] helped me find those steps. Like I said at the beginning, organization isn't my strength; and so this, this gave me the edges of the road to stay within."

Potential Areas for Improvement

While participants had an overall positive reaction to using *ActionOrganizer*, they also noted certain limitations related to the system's interface design and problem-solving support functions. They expressed the need to have the system start where users left off, provide additional support to make the system navigation more intuitive, and include hints and prompts that are specific to the assigned problem:

> "I found that one of the frustrations was that I opened up the program and it took me through the same series of events instead of picking up where I left off. I had to go back to the beginning screen. I had to go back and say "I don't want to start a new one" and I had to go past the screen that gave me a little information on how to use it. It would have been convenient to have a way of skipping this."
> "I also got confused. I didn't realize that the tabbed interface … when I first used it, the very first time I had to have it pointed out to me that there was a tabbed interface…"
> "I felt that there needed to be hints on the research hypothesis. Because…we're not all at the same point in our studies. And those of us who have been through research classes, we knew what a research hypothesis might look like; but not all of my group members were at that point."

Although participants liked the usefulness of the guided design, they identified several areas for improvement. These include user adjustable screen and text box size, and integration with productivity software:

> "I would have preferred if it [screen design] would have just been whole-screen and that it would have just been boom, boom, boom one screen after another. I didn't think we needed to do the flipping…"
> "In the *ActionOrganizer* we had to scroll with the text and stuff, so instead of having these little tiny boxes I wanted to see the whole page of what I wrote."
> "The little tiny boxes [size of the text boxes], My gosh! What could you fit in there before you could start scrolling, 50, 60 words? That's just not acceptable if you want some content."
> "I found a way to bring two records in at the same time; but then, actually, I tried to bring three records in and it got even more complicated. It would seem to be nice to have an intuitive way to import and export records. Import them, delete them, manage them and then, like you were saying, be able to export them out to a Word document."

Finally, the system's problem-solving support functions conflicted with some students' existing problem-solving approaches, and they expressed concern for the time required to use the system effectively.

> "I have created my own approach to problem solving; and, so as a routine, I've relied on that approach. And this kind of interfered. I kept on transferring, you know."
> "I think as it stands, there would be a lot of learning for others to do before they would be able to use it."
> "I don't think it [*ActionOrganizer*] helped me. A different arrangement would have given me something. Uh, I think a flow chart from the beginning. 'Here's where we are, we're going to flow through and we are going to end up over here.' And that might have helped me visualize this [*ActionOrganizer's* guiding structure] a little better."
> "I didn't see it [*ActionOrganizer*] applying to problem-based learning. I saw it more holistic; that's how I'll use it in the future. And I'll borrow some of the terms and functions. That helped me out a lot. Because we create our own schema, but it may only make sense to us; and, so this was nice because now I can use the terminology that's going to be generally accepted, and I get more buy-in then."

Overall, it appears that the participants' experiences with *ActionOrganizer* were positive and most expressed their intent to continue using it, as well as to encourage others to use the system in PBL activities. In addition, participants found *ActionOrganizer* to be a practical system to assist with organization of their thoughts and strategies, development of shared understanding of the problem-solving process, and critical review of ideas and hypotheses. Nonetheless, there is a need to further improve the system's operability and collaborative functions, and increase the flexibility of its problem-solving scaffold to better address participants' needs.

Discussion

In this study, we employed educational software to support learners' metacognition during problem-solving activities such as problem analysis, group collaboration, and solution creation. A formative evaluation was conducted with two doctoral students and nine masters students majoring in Instructional Technology. Most participants reported that *ActionOrganizer* influenced their problem-solving processes positively as well as enhanced collaboration and communications. Participants reported that the system enabled them to clarify their ideas and viewpoints for solving the problem when going through the guided process. This finding is similar to studies conducted by Coombs & Elden (2004) and Lai & Calandra (2009), in that the system enabled participants to clarify their values, viewpoints, and ideas for solving the problem while making meaning of their problem-solving process.

As *ActionOrganizer* was used within their group, participants commented that the system created a shared dialog toward a common goal and helped them determine what would be the appropriate action for the assigned problem. This shared dialog, as reported by the participants, provided a means for group members to reflect on and evaluate their problem-solving process, such as how they derived the possible solutions and converged ideas and facts into working hypotheses. The data further suggested that *ActionOrganizer* has the potential to engage participants in examining the information they have entered critically and reflexively. Users can compare and contrast viewpoints, ideas, hypotheses, and possible actions before they are applied to the final group action plan. This suggests that *ActionOrganizer* may create a learning environment where meaningful and purposeful discussion can take place to enhance participants' metacognition (Kuhn, 2005).

While the system proved to be acceptable to the participants, several technical and design issues remain. Educational software creators have long focused their interface design on human computer interaction (HCI) where usability and graphical user interface design approaches play a major role (Alessi & Trollip, 2001). The requirements of a usable interface should be extended to include scaffolding related to problem-solving flow and metacognition. This will ensure that each problem-solving step can be meaningfully integrated to support learners' problem-solving processes and engage them in a unique learning experience.

Additionally, participants reported a desire for a system that provides greater flexibility in adapting to their own problem-solving approaches. Such a system may benefit learners more than would a system that follows a fixed, step-by-step process to develop actions for the problem. With this design concept in mind, the next iteration of *ActionOrganizer* could provide its users with an additional open inquiry module as a starting and connecting point, which the learners would utilize to record and process their own understanding and analysis of the problem and to determine which other system functions could be used to support their problem-solving processes.

Conclusion

This formative evaluation helped us to focus on design strategies as embedded in the *ActionOrganizer* system. Specifically, participants reported how they (a) used the system functions to help them solve the assigned problem, (b) approached the use of the system functions, (c) developed their action plans after using the system functions, and (d) how the system supported both individual and group problem-solving processes. The collected data will inform the next revision of the system.

From the perspective of system impact, we were able to acquire preliminary evidence that *ActionOrganizer*'s design approach provided a credible scaffold to promote students' development of inquiry skills. Its metacognitive prompt design gave immediate and meaningful guidance for students' inquiries. Although the purpose of this study was to determine which of *ActionOrganizer's* design features should be adopted or revised to make it more useful in a real-world setting, the findings begin to provide an understanding of a new technology, used for an instructional learning system, for which there is very little research data.

From the research perspective, a logical next step would be to go beyond self-report data to study the system's effect by comparing it with conventional tools such as threaded discussion and examining how a collaborative learning environment may be scaffolded to emulate the thought processes of experts when solving problems.

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Issues in Problem-Based Learning in Online Teacher Education

Brenda I. López Ortiz

Introduction

Problem-based learning (PBL) is an instructional method that was originally designed for face-to-face medical education. Over time, it spread to other educational levels and professional fields including teacher education (Hung, Jonassen, & Liu, 2007). PBL has also been adopted in online learning and has been characterized as one of its predictors of pedagogical excellence (Bernard et al., 2004). In considering the adoption in different contexts and for new audiences, fresh opportunities for research have arisen. The problems teachers face are different than those in the medical field (Jonassen & Hung, 2008). Distance education research has suggested that the technologies that support learning have an impact on the interaction of teachers and students (Carabajal, LaPointe, & Gunawardena, 2003; Gunawardena & McIsaac, 2004; Johnson & Johnson, 2007). Thus, the activities and processes originally developed for classroom-based PBL in the medical field may need to be modified for online PBL in teacher education.

The goal of this chapter is to present a critical analysis of the body of research that has emerged as a result of the adoption of PBL in online teacher education. To this end, the chapter will begin by defining PBL and online learning and strategies used for literature search and analysis. Next, the chapter will summarize findings of research organized by the issues related to implementing online PBL in teacher education. Finally, it will discuss implications for research and practice derived from a critical examination of the conglomerate of studies, which intersect a larger set of instructional technology issues.

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Definitions

Problem-Based Learning

PBL constitutes a radical departure from traditional teaching methods. The learning experience does not begin with a lecture followed by application problems. Rather, it begins with a practice or research problem that serves as the stimulus for learning (Barrows & Tamblyn, 1980). The corresponding increase in student responsibility aims at developing self-directed learning, a skill that is necessary for life-long learning (Barrows, 1998). Furthermore, the problem does not draw on discrete concepts or skills to discover a single right answer. It is an authentic problem that students would normally face in practice, and it cuts across whatever disciplines are relevant for the solution (Barrows, 1998). PBL has never involved individual problem solving, but rather has always incorporated collaboration. Finally, students evaluate and reflect on their learning in an effort to solidify learning (Barrows & Tamblyn, 1980).

Online Learning

The terminology used to describe learning experiences that occur when teachers and students do not share a geographical location and/or class time has varied over the years (Rudestam & Schoenholtz-Read, 2010). This chapter will use the term online learning to refer to the learning experiences described above. However, it will only focus on those in which access to information and communication occurs via Internet-based technologies (ranging from email and discussion boards to Web 2.0 tools).

Method

Literature Search

Research design literature provided guidance on article search and analysis strategies to ensure a systematic approach to finding relevant studies. The first step consisted of identifying keywords relevant to this survey (Creswell, 2009; Dolowitz, Buckler, & Sweeney, 2008; Machi & McEvoy, 2009; McMillan, 2004; Slavin, 2007). The main keywords were "problem-based learning," "online learning," and "teacher education." The next step focused on querying the thesauri of article databases to identify the best term match for these keywords. Finally, the archives of journals that focus on online learning (e.g., *American Journal of Distance Education*) were also queried. The search process continued until no new sources of primary research could be found. The search produced 34 sources including journal articles, dissertations, conference proceedings, and books.

Table 1 Number of studies per teacher education topic

Subject	Number of studies
Child development	1
General teaching methods	3
Learning sciences/educational psychology	4
Instructional technology	9
Special education	4
Vocational	1
Library and information sciences	1

Note: One of the studies examined online PBL in more than one teacher education area

Inclusion Criteria

The next step was to screen articles' abstracts (McMillan, 2004; Slavin, 2007; Wiersma, 2000) with two purposes in mind. First, the screening helped identify those that were central to the purpose of this survey (Creswell, 2009). Twenty-four articles met the criteria of describing research in PBL in teacher education. Then, the process of abstract examination focused on screening out nonempirical studies. Criteria for inclusion also included article date (2005–2011). The list was narrowed to 22 articles. The studies in this survey span many areas of teacher education. Table 1 describes the number of studies per topic.

The articles were evenly split between hybrid and online contexts with 11 studies each. Studies conducted in hybrid or blended settings (i.e., when some of the learning activities happened in physical classrooms during established time periods) were included inasmuch as the PBL portion of the experience was mainly conducted online. The research questions focused on design features of online PBL (e.g., problem design), implementation issues (e.g., the collaboration process), and online PBL effects (e.g., the development of critical thinking skills).

Analysis

The next step in surveying the literature was to summarize and analyze the studies (McMillan, 2004; Slavin, 2007; Wiersma, 2000). A "literature map" served to develop a sense of the broad picture of the literature (Creswell, 2009; Machi & McEvoy, 2009). For the purposes of this chapter, a spreadsheet was used to classify articles depending on format (hybrid or online), type of participants (students, teachers, administrators, etc.), sampling strategies, type of research designs (quantitative, mixed, qualitative), types of data sources (pre/post tests, documents, interviews, etc.), types of data analysis (content analysis, descriptive statistics, etc.), and the focus of the research questions (e.g., the design, the process, learning). The literature map served as the basis to write this survey.

The final step in surveying the literature of online PBL in teacher education was to integrate research findings in a manner that explained important issues (Machi & McEvoy, 2009; McMillan, 2004; Wiersma, 2000). The following section is divided into five subsections. The first presents issues that surface when transitioning to learning in online PBL (i.e., student characteristics and attitudes, access to necessary technologies, technology and PBL literacy). The second deals with issues related to collaborating via technology (e.g., group formation, student roles, communication, and technical support). The third examines the facilitation of online PBL. The fourth identifies assessment issues. The final subsection expands on issues that arise when designing online PBL for intensive courses.

Results

Transitioning to Learn in Online PBL

The design of an online PBL experience may incorporate the most effective strategies described in the literature, but that does not mean students will be able to spontaneously benefit from them. Considering students' knowledge, skills, attitudes, and access to tools is an important step in this design process. This section describes some of those along with suggestions on how to accommodate for them.

Engaging Students of Diverse Characteristics, Perceptions, and Attitudes

Overbaugh and Lin (2006) studied the interplay between learner characteristics and performance in two modalities of a course in instructional technology: face-to-face and online. They used a research-validated rating scale of learning styles to classify students. Introverted students tended to perform better in the online modality than the extroverted ones. Students who constantly needed more immediate feedback and tended to procrastinate were at a disadvantage during online courses. Designers can select either of two approaches to respond to these findings. They may guide students to identify their own characteristics and to understand whether the online mode is suitable for them. Alternatively, they may incorporate mechanisms to support diverse students regardless of learning styles.

Students are initially apprehensive about group work experiences online (López Ortiz & Lin, 2005; McLinden, McCall, Hinton, & Weston, 2006). Variables related to the diversity of student knowledge, skills and attitudes toward online group work and group dynamics (and how they can evolve online) are important here. Nelson (2007) discussed working styles, work ethic, and attention to communication as issues of tension. In their design of the online PBL experience, McLinden, McCall, Hinton, and Weston (2006) included induction activities to introduce students to principles of online learning. In spite of that, 40% of the students still failed to feel confident about this. The authors suggested the use of structure, especially toward the beginning of the experience, to scaffold student participation. In addition, they highlighted the need to provide guidance to course instructors to facilitate student engagement. In the research of López Ortiz and Lin (2005), course instructors encouraged students to explicitly share their prior experiences with online group work. The purpose was to acquaint students with issues that classmates considered important for the success of a group. Presently, newer features of online collaboration tools (e.g., the revision history of wikis) can also help assure students that individual accountability will be established. These features can help instructors to monitor the quality, frequency, and timeliness of individual student participation. Students' concerns can be minimized when they know that instructors appraise each individual's contribution fairly.

Accessing Supporting Technologies

The number of technologies available for twenty-first century education has grown exponentially. Along with this comes challenges in accessing these tools to support the learning experience. This is one of the initial design aspects to consider (Donnelly, 2006). The location from which students access course interfaces (e.g., home vs. work) and the type of connection (e.g., broadband vs. dial-up) may have an impact on the kinds of activities they can engage on a regular basis (McLinden, McCall, Hinton, & Weston 2006). Access may be available at work, but network restrictions and policies can prevent students from completing educational tasks. Derry, Hmelo-Silver, Nagarajan, Chernobilsky, and Beitzel (2006) elicited student responses to the activities and tools in the online PBL environment they designed. Students' responses were mainly positive, but a further analysis uncovered problems with the supporting technology. The authors indicated that the frequency of technology problems decreased over time as access to broadband connections became more widespread. The reliability of available technology is also a main concern reported in literature (Donnelly, 2006). Having access to the necessary technologies and being able to use them reliably represent challenges in online PBL for teacher education. Disseminating the technology requirements prior to student enrollment in a course as well as providing means for students to satisfy those requirements (e.g., download all necessary plug-ins) are ways to mitigate the effect of these challenges.

Knowing How to Use the Technology

Instructional designers are always looking for innovative technologies to support the learning process. Using technology for learning can help build literacy skills (Lambe, 2007; McLinden, McCall, Hinton, & Weston, 2010). However, when students are immersed in a learning experience, and technology is their only means of communication and access to information, a certain level of technology literacy becomes as much a prerequisite (McLinden et al., 2010) as a learning outcome. The result is an additional layer of challenge especially for the more novice technology users (Nelson, 2007).

McLinden et al. (2006) focused on computer literacy as an aspect of student interaction with mediating technology when participating in online PBL. Eighty percent of students had little or no experience with course management systems (CMS) or contributing to online discussions. Students also reported difficulties participating in synchronous communication events because of their keyboarding skills. This last finding is consistent with the research of Donnelly (2006). In other studies, while the researchers do not directly attribute low achievement to knowledge of supporting tools, they do consider the potential of the relationship between those two aspects (Jeong & Hmelo-Silver, 2010). Overbaugh and Lin (2006) found that online students needed more technical help than students in traditional classrooms, and this may require training on the supporting technologies (e.g., using a discussion board). In a study about multiple scaffolds supporting geography problem solving, Doering and Veletsianos (2007) found that the scaffold that provided guidance in learning the supporting technology (video tutorials) had a positive and significant relationship with problem-solving ability. However, it also increased students' self-reported cognitive load. Students felt frustrated because of their lack of knowledge of the tool and wanted additional time to solve the problem.

Another study provided evidence on how the lack of knowledge on working with the technologies and their novelty features can interfere with learning. Omale, Hung, Luetkehans, and Cooke-Plagwitz (2009) examined how avatars, 3D space, and bubble dialogue boxes affect the social, cognitive, and teaching presences of participants in 3D multiuser virtual environments (3D MUVEs). Briefly, cognitive presence refers to the ability of learners to construct meaning making through communication; teaching presence refers to design and facilitation of the learning experience; social presence relates to the ability of learners to project themselves as "real people" (Garrison, Anderson, & Archer, 1999). These researchers found that while 3D MUVEs can be engaging, their features can also drive learners off task. The ability to "see" each other and walk around a virtual environment was positive for social presence. Cognitive presence did not benefit as much due to students' lack of knowledge of the tool and the novelty of its features.

McLinden et al. (2010) interestingly noted that technology may be more ubiquitous on today's teachers' professional lives. However, this may not automatically translate to using technology for learning. The level of computer literacy skills of students has implications that must be taken into account in order to facilitate meaningful online PBL. A lack of familiarity with the online context in which learning unfolds can become a limitation of this environment, but literacy leads to confidence in using technology as a tool to support learning (Donnelly, 2006). A fine line may exist between introducing new beneficial technologies for learning and overwhelming students with the novelty. Designers of online PBL in teacher education must strike that balance to maximize benefits and minimize the challenges. Training, induction activities, and instructor guidance can help achieve this, and so the novelty wears off and students develop the necessary technology skills.

Understanding PBL as a Learning Strategy

Research studies have provided evidence of students' need to become comfortable with PBL so that they can succeed in their learning efforts. For example, McLinden, McCall, Hinton, and Weston (2007, 2010) requested student feedback with regards to the design of two consecutive problem scenarios. Students reported a preference for more tutor guidance and had difficulty navigating the first scenario, but not as much during the second one. The variation of student ability to navigate scenarios over time suggests the development of familiarity. An and Reigeluth (2008) also reported the need for "practice" as one of their guidelines for online PBL. Donnelly (2006) also found a positive effect in the use of explanatory materials as an induction to the PBL process and described it as a necessary design component. Similarly, students in the Derry et al. (2006) study reported difficulties with self-directed learning and collaboration. Self-directed learning in PBL is related to the initiative of students to direct the learning experience by engaging in activities such as finding instructional resources, evaluating their quality, controlling the pacing of and assessing their own learning (Barrows & Tamblyn, 1980). Derry et al. (2006) found students improved their self-directed learning skills as familiarity with the task increased. In this case, the authors designed an online PBL experience that utilized videos to present cases so that the students would apply knowledge and skills of learning sciences. The researchers found that student use of the videos changed over time. As students became more experienced in online PBL, they were able to notice important problem-related details on the first screening of the video, so they did not have to continually review it to further their understanding. In addition, students shifted from focusing on characteristics of the videos to those of the actual problems. These research findings point to the need to foster the progressive development of skill and confidence in working through online PBL experiences. The results are consistent with Björck (2002) in his descriptions of the need for readiness when working on online PBL.

Collaborating via Mediating Technologies

Barrows (1998) listed collaboration as one of the essential characteristics of PBL. The reason for this is the evident need for it in the twenty-first century workplace (Partnership for 21st Century Skills, 2004). The benefits of collaboration and the importance of the individual student contributions within learning groups have been thoroughly described (Johnson & Johnson, 2007). Teachers play an important role in helping students develop these skills. Experiential learning can help teachers develop collaborative skills themselves so that they can later guide their students in achieving this educational goal. In the online environment, collaboration is mediated by a variety of technologies with different features. As a result, it is important to consider challenges related to collaboration via mediating technologies when designing online PBL for teacher education.

There appears to be no etymological reason for establishing a difference between the words cooperation and collaboration (Merriam-Webster Dictionary; Oxford English Dictionary). Both describe the act of working together with shared purposes. What does exist is a difference in how students work together to achieve the common goals. Salomon (1993) characterized the difference as off-loaded vs. shared cognition. Off-loaded cognition refers to a division of labor. Different group members assume responsibility for discrete parts of the collaborative task and then stitch them into an artifact that becomes the group product. Shared cognition characterizes a truly joint effort during which all group members negotiate understanding throughout the process. This collaborative dimension of PBL has been identified as an important learning mode within teacher education (Lambe, 2007). It is said to yield more educational benefits to individual student cognition. The literature reviewed in this survey seems to favor shared cognition. For example, when Jeong and Hmelo-Silver (2010) studied the use of information resources in online PBL, they found that groups that gravitated toward shared cognition derived more benefits from using the resources. Yeh (2010) found a relationship between the degree of shared cognition and final grades indicating that a decrease in shared cognition translated into lower grades.

Despite hopes for encouraging shared cognition, scholars have found that off-loaded cognition characterizes group work more often than not (An & Reigeluth, 2008). The division of labor instead of the co-construction of problem solutions is part of the evidence that these authors provide to support this claim. An and Reigeluth (2008) identified the emphasis on product vs. process during student evaluation as a key contributor to this. They did report a case in which students switched from off-loaded to shared cognition upon realization of the need for the latter. The authors listed instructor facilitation as another guideline derived from their research to steer student collaboration patterns toward shared cognition.

Forming Groups

Collaboration in PBL implies the formation of groups of students who will work together in the resolution of problems. In their multi-case study, An and Reigeluth (2008) found that groups of four to five students were more beneficial to the discourse of the group than larger or smaller groups. The dialogue among fewer students may lose momentum at times. Continuous conversation in a small group has potential cognitive benefits that are associated with exposure to multiple perspectives at every step of the learning process. At the same time, an appropriate number of group members helps make the process of achieving consensus during decision-making efficient and should minimize the problem of social loafing. An and Reigeluth (2008) also suggested that designers consider the nature of the problem and the supporting communication technologies when determining the size of groups for online PBL. Group assignment is another aspect of collaborative work that researchers have examined. An and Reigeluth (2008) reported that voluntary group formation is aligned with the belief that student interest should drive this process. When this is the case, course designers should provide tools that (a) have the right features to enable students to become acquainted with potential group members, and (b) are convenient for students to access and use (Lin & López Ortiz, 2009).

Researchers have often resorted to instructor-led assignment of students to small groups using a variety of criteria. Nelson (2007) noted that this approach can be troublesome if characteristics like teaching experience and subject matter are not considered. Finally, researchers have considered the topic of group composition. Yeh (2010) found that more homogeneous groups (e.g., same major) were faster in achieving consensus than less homogeneous groups. A shared history among group members can help facilitate communication and collaboration (Duffy, 2000 as cited in Yeh, 2010). Group size, composition, and assignment have always been important variables to consider in students collaboration. The online context introduces communication challenges that need to be accounted for when design guidelines from face-to-face literature are adopted in this regard.

Assigning/Assuming Roles

Ideally, when a group of people undertake a collaborative task, each individual member should be equally responsible for the achievement of the collaborative goals. Whether students engage in off-loaded or shared cognition (Salomon, 1993), the contribution of each member of the group should be clearly specified. A design feature that was put in place in a study of online PBL was the assignment of student roles (chair and summarizer) prior to the beginning of the experience (McLinden et al., 2006). The chair was defined as the student in charge of coordinating group efforts, and the summarizer was the student responsible for incorporating group ideas into the problem resolution document. These researchers also allowed the rotation of roles with flexibility to change the rotation upon mutual agreement. All students strongly agreed or agreed that this was a useful feature. An alternative approach—to establish the roles simultaneously as the process evolves—may be less efficient because of the delayed nature of communication characteristic of the online environment. The result may be the inability of students to decide on responsibilities and concurrently fulfill them in a timely fashion (López Ortiz, 2011).

Communicating Synchronously and Asynchronously

At least two modes of communication exist when learners get together to solve problems online: synchronous and asynchronous. The synchronous mode resembles the traditional face-to-face approach of group meetings in that learners gather at the same time, although not necessarily at the same place. The asynchronous mode allows learners to contribute to the conversation over time and from distributed locations. In their most basic versions, CMS provide course information and access to both communication modalities. In a reflection about the potential of translating the PBL model for online implementation, the creator of the model pondered whether this is truly possible (Barrows, 2002). The mediation of technology in its synchronous and asynchronous modes was the cause for this concern.

A necessary step during the design of online PBL is to carefully think about the advantages and disadvantages of each approach and the tools that support them. This is because research has shown that there are differences in terms of the cognitive activities that different modes seem to support best (Hawkes, 2007). For example, Yeh (2010) contrasted the use of face-to-face communication with online discussion. The author found that students used face-to-face for in-depth dialogue and “multiple-perspective thinking.” They used online discussion more for coordination of problem-solving efforts, in preparation for face-to-face conversations, as a follow-up, or to make up when unable to meet in person. The nature of learning tasks also influenced the frequency of conversation. Nelson (2007) also reported that synchronous meetings served to push for completion of milestones, and that lack thereof had a negative impact on making progress. Greene (2005) described student use of the discussion forum to follow up on synchronous conversations.

Donnelly (2006) examined how blending the PBL methodology with the online environment could enhance learning. Her findings highlighted the capability of technologies to help support the sociocultural context in online PBL. Students reported increased ability to socialize and to contact each other online when compared to face-to-face communication. Donnelly (2006) also suggested that the archival nature of the online conversations was a beneficial feature of this modality. The reflective affordance of online asynchronous discussion was also contrasted with the immediacy of responses of face-to-face encounters. These findings are echoed in two other research studies: McLinden et al. (2006) and Edwards (2005). In particular, McLinden et al. (2006) reported that a majority of students responded positively with regards to access to and use of the discussion board for asynchronous conversation.

On the flip side, Donnelly (2006) cited the communication delays that may interfere with clarity of communication as a limitation of the online medium. Researchers have also reported that students still find asynchronous communication too impersonal or feel uncomfortable posting messages using their own names (Greene, 2005). In addition, students do not necessarily dedicate enough time in their asynchronous discussions to understand the problem or implement the solutions (Ng & Tan, 2006). Course instructors can engage students in induction activities like the ones described earlier to help them become adept at these stages of the PBL process via asynchronous communication.

Fewer students in the McLinden study responded positively to access and use of chat rooms for synchronous conversations. Two aspects of the nature of discussions via chat rooms may be intimidating for online students especially those with limited technology literacy skills. On one hand, discussion through this technology tends to be fast-paced (Greene, 2005; McLinden et al., 2006). Students with limited typing skills are at a loss not because of their ideas but because of their ability to share them at the same speed as their classmates. In addition, discussions branch out into threads within the same stream. Those can be difficult to keep track of in the fast-paced environment. Reducing the number of students in a chat session may ameliorate these challenges (Greene, 2005). Interestingly, at the onset of the experience, students expected that the chat room would be the main hub of communication under the assumption that it would resemble face-to-face discussion. The qualitative analysis of the data gathered by Doering and Veletsianos (2007) revealed that students used the chat room to seek and provide mutual support during online PBL. However, the quantitative analysis evidenced that there were negative although insignificant relationships between problem-solving ability and time spent in the collaboration zone. Other studies also discussed the negative impacts of synchronous work on online groups. Scheduling issues occur when attempting to incorporate synchronous communication to online PBL in teacher education (Nelson, 2007). Students choose online learning because of the flexibility of furthering their education without the requirements of being at a specific place at a specific time. Nelson also stated that life's expected and unexpected distractions (e.g., family events and even weather issues) also interfere with communication. Yeh (2010) reported that individual members felt disappointed when teammates could not be online for chatting as promised or when members were distracted during conversations (which is likely to happen when learners are home with their families). Yeh reported an increase in the need for face-to-face communication over time. This is perhaps because of the inability of online media to fulfill all of learners' communication needs during group work. Nelson (2007) reported students need face-to-face interaction because of response delays in communication and feelings of isolation. The lack of visual cues to gauge the effects of individual students' ideas is also another factor that contributes to students' preference for face-to-face communication (Greene, 2005). These results suggest caution in the incorporation of synchronous conversation for online PBL in teacher education.

In spite of the challenges mentioned above, there are still benefits to be reaped in the use of this technology. The research of An and Reigeluth (2008), Edwards (2005), and Wheeler, Kelly, and Gale (2005) provided a more positive perspective on student acceptance of the synchronous tools. The synchronous interaction resembles face-to-face communication, and students appreciate that when compared to the delay in communication of asynchronous tools (An & Reigeluth, 2008). From the instructor's perspective, An and Reigeluth (2008) reported that chat sessions were valuable during two stages of the online PBL process: at the outset (to enable student acquaintance) and during decision-making stages (to facilitate the process).

Edwards (2005) described the archival nature of synchronous communication as beneficial for the participants in her study. It allowed not only for the review of communication exchanges but also for catching up with class discourse when a student had not been able to participate in the conversation in real time. In addition, the chat functionality extended class time as it provided a place for the exchange of ideas beyond the physical classroom. Edwards (2005) stressed the fact that chat was a pedagogical tool. In other words, pedagogical needs drove the use of the tool. Other authors also reported on support of this tool for problem-solving, one-on-one or one-on-small group support and group development (Donnelly, 2006). Wheeler et al. (2005) arrived at similar conclusions with regards to video conferencing as a synchronous communication tool.

The study of technology to support online PBL has not been limited to mainstream course-management tools. In their study of 3D MUVEs, Omale et al. (2009) found that participants were able to engage in brainstorming, negotiation, and clarification, but were not equally able to agree on ideas and organize them to arrive at problem solutions. The authors stated that technical barriers were responsible for this, namely, the lack of embedded collaborative interfaces that could serve as catalysts for decision making. Participants used email to complement the virtual place to achieve consensus.

Ultimately, An and Reigeluth (2008) concluded that the use of a combination of synchronous and asynchronous technologies would allow students to reap the benefits of both approaches. The advantages consisted of the convenience of communication at a time when the student is ready and the expediency of the decision-making process. Perhaps the mission of "finding a harmonious balance" (Osguthorpe & Graham, 2003 as cited in Yeh, 2010, p. 1637) in obtaining convenient access to both information and human resources can be useful here. Yeh claimed that hybrid PBL (i.e., the combination of face-to-face and online conversation) contributed to the creation of a community. It is possible that as researchers and practitioners find themselves at the intersection of transitions between face-to-face and online, traditional, and PBL types of education, it is necessary to have a combination of media and methods to overcome the challenges of any single approach.

Supporting Students with Technical Problems

There are three layers of technology that mediate student learning during online PBL in teacher education: student computers, their Internet Service Providers, and the university systems. This will inevitably result in the need for technical support. Indeed, researchers have reported the presence of technical issues that have affected the learning experience (Nelson, 2007). Hardware malfunction has been occasionally blamed for failure to submit assignments (Yeh, 2010). McLinden et al. (2006) reported that about two-thirds of the students in their study had issues that required technical support. Twenty-five percent of these had to contact technical support providers. Regardless of the source of the need for support (the university's systems or the student's computer/Internet access), McLinden et al. (2006) emphasized the importance of a smooth experience where the technology does not interfere with learning. Lambe (2007) noted that in a blended/hybrid mode, occasional technical problems do not affect negatively the learning experience. The hybrid learning option will not always be feasible. Ensuring the availability of resources for technical support especially early in the process is one of the implications for practice.

Facilitating Online PBL

The transformed role of the course instructor is another of the essential characteristics of PBL (Barrows, 1998). The main function of the instructor is to provide guidance, not information. This is aligned with PBL's goal of developing self-directed skills in students. Barrows and Tamblyn (1980) went so far as to state "the teacher should respond to direct inquiry from the students only after he is sure they have exhausted their own logic or information base" (p. 108). Notwithstanding, online PBL in teacher education research has produced results that are at odds with this notion. Nelson (2007) described how students were initially uncomfortable with PBL because of the instructor's role as described above. Donnelly (2006) argued that the facilitator in online PBL needs to support students who have challenges when studying remotely, communicating without visual cues or without knowing their peers. Because of this, the author contrasted the role of the online learning tutor with that of the PBL tutor. Students reported appreciating the commitment and flexibility of course facilitators and their ability to (a) provide support when technology was failing, (b) guide the experience, (c) foster reflection by summarizing face-to-face activities, and (d) create group cohesiveness. In addition, the role of the tutor was crucial in fostering the use of critical communication structures that were in place online, but which would be underused otherwise. Finally, the tutor had an important role in taking the learning experience beyond the mere dissemination of course materials via online media, which was the original approach to the design of online learning.

An and Reigeluth (2008) studied online PBL in the context of three different cases. Using data from instructor interviews, observations, and document analysis, these researchers reported variations on how instructor participation was perceived. In one case, participants described instructor participation as insufficient. The instructor, though, was following suggestions from constructivist perspectives on learning by monitoring the conversation without participating in it. Students reported the need for more structure in the form of guidance from the instructor. The findings from another case illustrated how the instructor provided structure by making progress checklists available for student self-monitoring on a voluntary basis. The findings of this research point to the need for online PBL course facilitators to adjust guidance levels according to contextual circumstances. This is consistent with the findings of other studies. Researchers have described the evolution of the online PBL facilitator's role as moving from organizational to affective (Gressick & Derry, 2010) and from facilitating the process to playing devil's advocate during the discussion of issues (Lambe, 2007). The interplay between innovative educational methodology (PBL), unfamiliar learning context (online), and the technical challenges it brings with it may require that facilitators, at least initially, provide more guidance. A number of factors may make the case against waiting for students to exhaust their options. These include (a) the spread of discussion over longer periods of time because of communication delays, (b) the lack of visual cues, and (c) the dispersion of messages across a range of media with their idiosyncratic technical challenges and potential to add to the cognitive load.

Assessing Student Performance

Assessment in the context of PBL should be geared to verify the application of content knowledge and the development of problem-solving and self-directed learning skills (Barrows, 1998). As a result of their study of three cases of implementation of online PBL, An and Reigeluth (2008) proposed that the process be as much the subject of assessment as the product. The purpose of this is to drive student focus on engaging in shared cognition, thus obtaining the maximum benefit from the collaborative experience. The online environment has features that facilitate accountability by making explicit who participates in group work and to what extent (Donnelly, 2006). However, the challenge lies precisely in striking the balance between process and product. Instructors who are used to assessing content knowledge will find it hard to accommodate for grading of the process when they have designed the course grading to account for every piece of relevant knowledge of course topics. Grading the process could also potentially increase the time online PBL instructors must invest. This is plausible given the increased amount of time it takes to read student contributions (as opposed to listening to them during class time). Instructors who already grade weekly discussion would be in better shape to transition into the assessment of process. They could refocus those conversations by merging whole-group dialogue about course topics (the trend in online learning) with small group discussion about their application.

Implementing Online PBL in Short-Term Situations

Chen and Hsu (2005) designed an instructional design course that took advantage of both constructivist and objectivist strategies. Their justification was the intensive nature of the course: a 5-week, fully online summer course. A PBL approach was used to engage students in a meaningful, realistic technology integration experience. These researchers used the responses to online course evaluation surveys along with the analysis of student reflections and final submissions to evaluate their course design. In general, students responded positively to the design of the course. They particularly valued the authenticity of projects, instructor feedback, and technology. In addition, they performed well in their lesson designs with all students obtaining at least an A-. This led the researchers to believe that the combination of constructivist and objectivist strategies was successful in the context of a short intensive online summer course. Students were able to fulfill demanding learning goals without feeling the pressure of the time-consuming aspects of constructivist learning. The findings reported in this study support the adaptation of PBL to include traditional education aspects such as individual work and instructor guidance when planning intensive online courses. Designers, though, would have to come to terms with the idea of retaining characteristics of traditional education in a context that should be more open-ended.

Discussion

Implications for Research and Practice

It could be argued that the nature of the research surveyed in this chapter is consistent with the status of online PBL for teacher education: there is an incipient field of practice based on an emerging body of knowledge. Research illustrates that students now have to grapple not only with new content in a course but also with new instructional methods and new supporting technologies simultaneously. Questions related to increased course loads for both faculty and students have been examined before (Lefoe & Albury, 2006; Singleton & Session, 2011). Generations have been acculturated into an educational process as a transaction between a teacher presenting the content of one or more textbooks and a group of students taking notes on notebooks with pencils. Now, teacher education students and faculty are facing a shift on what the educational process entails. Course instructors are not just responsible for knowing and supporting students in their domains of expertise. They must now know and support students using innovative tools and educational methodologies. Savin-Baden's (2008) discussion of strategies to prepare faculty and students includes pedagogical and technical aspects. This is an evidence to illustrate that the shift is already taking place. A question that arises is whether cognitive loads can become unbearable for both teachers and students under these circumstances. Further study can help establish whether online PBL in teacher education is more suitable for students with specific characteristics or whether and how it can be successfully implemented for all. Research can also shine some light on ways that can serve to support students to become comfortable with new educational strategies and instructional technologies whether simultaneously or as a prerequisite of the learning experience. In an era when the time frames for course delivery have either remained consistent or shrunk (as with the emergence of intensive, short-term degrees) but have never lengthened, it is important to find the balance between the three types of literacies that students must develop.

With the transition to more student-centered approaches to learning, the incorporation of activities in which students take the initiative for their own learning has become a favored approach. However, true student participation in activities ranging from the design of a course to the negotiation of the work in small groups requires a level of coordination and exchange of ideas that may be prohibitive for online PBL in teacher education students. How can instructors support student decision making in light of delayed communication so effectiveness is not overshadowed by inefficiency? How can they balance the requirements of an extended exchange of ideas to ride on the waves of its cognitive benefits with the flexibility that students are seeking in online education? There seems to be another paradox here, or perhaps some really provocative research questions.

The initial fears associated with computer use were related to the isolation of people and their machines. Fast forward 25 or 30 years and the word *social* is tightly associated with the word *technology*. Early on, Turkle (1995) described the transition from a culture of calculation (as when individuals find themselves alone programming their computers) to a culture of simulation (where individuals interact with each other via the computer). A 180-degree turn in the evolution of information and communication technologies has helped shift the way they are perceived. Nevertheless, a few issues remain relevant. Yes, society is becoming more social, but some have posed the question of whether socialization is restricted to the technologically mediated world or whether it translates to the physical world. Evidence of student feelings of isolation still surfaced in the studies cited in this survey. These feelings may still be tied to students' individual characteristics. How can education professionals take advantage of the social capabilities of synchronous and asynchronous communication for online PBL for teacher education without inadvertently perpetuating its potentially negative consequences?

A widely studied trend in society has been identified as the shift toward product consumption. Concepts like "diploma mills" and the "mcdonaldization of society" (Ritzer, 2000) have emerged. Another paradoxical, although hopefully evolutionary reaction to this is the growing trend of advocating for the development of critical thinking, problem-solving, and decision-making skills in students which emphasize skill in conducting a process rather than preponderantly focusing on the accumulation of knowledge (i.e., acquiring a product). At least one of the studies reviewed in this chapter was attempting to balance meaningful learning through online PBL with the efficiency of short-term intensive time frames. With these two seemingly competing forces, how can online PBL researchers and practitioners convince students that the process is valuable so they invest the time and effort in it? What kind of evidence is necessary to define the amount of time that is ideal for students to efficiently engage in the process while making the most out of it? In the era of accountability and high-stakes testing, what is the role of assessment as a tool to reinforce the importance of learning about and engaging in the process as much as the product?

Conclusion

Authors have contemplated whether PBL for teacher education can be implemented online. The theme of adaptation continuously comes to mind. The designs examined in the research included in this chapter met most of the essential characteristics of PBL (Barrows, 1998). However, different types of technology and their particular affordances and constraints mediated collaboration, and this introduced issues that are important to consider when designing online PBL for teacher education. When those issues generate transformation on the processes that unfold, can we still use the PBL designation to describe the transformed PBL experiences in online teacher education? Is there an educational loss in such implementations? If so, what and how much of it is lost from the original PBL experience? Are the educational benefits worth the sacrifices? How can we balance that?

One more thought precedes the conclusion of this chapter. The range of technologies that support learning in the studies cited here includes Web 1.0 and some Web 2.0 technologies. Researchers and practitioners are barely understanding the educational benefits of learning mediated by one set of technologies when a new set emerges, blowing away the old technologies along with the understanding that was founded on their use. In discussing diffusion of innovation theory and its potential to inform educational research, Zaritsky, Kelly, Flowers, Rogers, and O'Neill (2003) proposed that studies focus on the variables that maximize the rate of adoption of innovations. Researchers should be able to communicate the perceived advantages of innovative tools and strategies if they are to promulgate the benefits of online PBL in teacher education. Will each new technology bring entirely unique affordances and constraints that will need to be examined anew in the context of this educational strategy? An affirmative answer to the question will profoundly impact this field if researchers can never fully understand its challenges because a new technology constantly supersedes an old one. After all, not all problems are created equal (Jonassen & Hung, 2008). Will this confine the field of online PBL in teacher education to an ever-emergent status?

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The Fallacies of Problem-Based Learning Viewed as in a Hermeneutic Perspective on Best Teaching Practices

Margaret E. Bérci

> *Tell me and I will forget; show me and I may remember; involve me and I will understand.*
>
> (Confucius)

The concept of best practice in teaching and learning takes many forms and is achieved through a variety of approaches. I claim that one such approach is through problem-based learning (PBL) processes. PBL has had a major impact on thinking and practice in higher education in the last five decades, implying that the PBL approach is more effective than traditional teaching models. Based on personal experience, as professor of education, I have observed that PBL is a challenging, motivating, and enjoyable way to teach and learn. Students appear to agree. However, the strengths of PBL relative to the traditional teaching approach is still unclear, and a number of disadvantages associated with a PBL curriculum have consistently appeared in the literature, raising the issue of whether education programs, at all levels, should adopt PBL.

To address this issue, the discussion aims to debunk the perceived disadvantages as fallacies—false or mistaken ideas or opinions that are misleading. To that end, I introduce the fallacies by providing a review of selected literature that identified six problems associated with PBL, each of which represents the tacit source of a fallacy. Then I briefly outline the principles of best practices in teaching and learning and propose that when viewed through hermeneutic lenses (Collingwood, 1993, 1998; Gadamer, 1977, 1999; Schleiermacher, 1998), there is a unique connection between the perceived PBL disadvantages and best practice principles. I proceed to outline the method of inquiry used for the project that produced supporting qualitative evidence for the claim that the disadvantages are fallacies. Finally, in order to justify the refutation of the fallacies, I engage in a discussion to explore each of the six fallacies in context of best practice principles. The discussion integrates selected literature and personal

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experiences, with the synthesis of written and oral narratives produced by teacher education students who experienced both traditional and PBL environments.

The Crucible for the Fallacies Associated with PBL

Though PBL has been studied extensively, very little research has systematically examined PBL's effectiveness (Dochy et al., 2003; Gijbels et al., 2005; Evensen & Hmelo, 2000; Newman, 2003; Smits, Verbeek, & de Buisonje, 2002). Five reviews of PBL outcomes are frequently cited (Albanese & Mitchell, 1993; Berkson, 1993; Smits et al., 2002; Van den Bossche, Gijbels, & Dochy, 2000; Vernon & Blake, 1993). Of these, Albanese and Mitchells' meta-analysis of the literature from 1972 to 1992 is perhaps the largest set of studies reviewed, and one most relied upon for foundational data by researchers.

Albanese and Mitchell formulated five questions through which they examined quality of learning achieved by medical students engaged in PBL. These five questions were: (1) What are the costs compared with those of lecture-based instruction? (2) Do PBL students develop the cognitive scaffolding necessary to assimilate new basic information? (3) To what extent are PBL students exposed to an adequate range of content? (4) Do PBL students become overly dependent on the small group environment? (5) Does faculty dislike PBL because of the concentrated time commitment required? In addition, another common inquiry that appeared in the literature was: How could faculty effectively evaluate/assess the learning that occurs within the PBL environment?

The philosophy of Robin George Collingwood (1993, 1998) maintained that every question represents a statement and exposes inherent suppositions, beliefs, and tacit knowledge when the question is read hermeneutically and underscored with the experiences of the reader. In reading hermeneutically, the reader, as the hermeneutic catalyst, makes a connection between the "what," the "how," and the "why" subsumed in the question (Smith, 1991, 1992). By asking questions, people make tacit connections with what they already know about a concept, how they know what they know, and why they need to know more. Taking the role of the hermeneutic catalyst, I posit that inherent in the above six questions is the tacit supposition that they each represent a perceived disadvantage/problem of PBL. I further claim that if I convert each question to its declarative form and view them through the lens of best practice principles of excellent teaching and powerful learning, then each declarative statement exposes a fallacy.

The Principles of Best Practice in Teaching and Learning

Best practice principles reflect the work of Zemelman et al. (2005) who reviewed the scientific evidence of effective teaching practices and discussed how these evolved in various disciplines. The expression, best practice, was originally borrowed from the professions of medicine, law, and architecture, where the term was an everyday phrase used to describe solid, reputable, work in a field. Professionals who follow best practice standards are aware of current research, up-to-date knowledge, technology, and procedures. Imported to the education field, best practice is the emblem of serious, thoughtful, informed, responsible, state-of-the-art teaching (Zemelman et al., 2005, p. vi).

There are 13 principles of best practice in teaching and learning, backed by educational research that draws on sound learning theory. Zemelman et al. (2005) grouped the principles into three main clusters. Best teaching and learning practices are as follows:

Cluster #1: Student-Centered, experiential, holistic, authentic, challenging
Cluster #2: Cognitive, developmental, constructivist, expressive, reflective
Cluster #3: Social, collaborative, democratic

Zemelman et al. (2005) identified what each of these clusters would look like when applied specifically to the various individual school subjects: reading, writing, mathematics, science, social studies, visual art, music, and dance.

What Is PBL and How Does It Relate to Best Practices?

The present discussion assumes a basic understanding of PBL; therefore I will only touch upon those definitional aspects that are relevant to the purposes set for the study. Boud and Feletti (1997) defined PBL as "…an approach to structuring curriculum which involves confronting students with problems from practice which provide a stimulus for learning" (p. 15). Much of the power behind PBL is located in the discussions that instructor and groups have as they work through complex problems that serve as the context for learning. Group participants present their own ideas as they listen to the ideas of others, ponder unclear issues and different points of view, go after references, utilize the expertise of the faculty, and learn from and help each other. Students summarize their findings in a culminating experience in which they test the solutions by applying them to real-world case. During the process, they develop skills in collecting, evaluating, and synthesizing resources. The instructor monitors the progress of the students and asks relevant questions to move the students through the problem-solving process (Barrell, 2007; Engel, 1997; Maudsley, 1999; Savery, 2006).

PBL originated as a teaching method in the McMaster University School of Medicine (Barrows, 2000; Pereira, Telang, & Butler, 1993). The strategy was intended to equip medical students with an extensive, integrated knowledge base that is readily applied to the analysis and solution of problems. Since its introduction, the effectiveness of PBL has been examined in other educational contexts and has become a major innovation in higher education practice across disciplines (Wilkerson & Gijselaers, 1996). It has been adopted as a process to educate students in law (Kurtz, Wylie, & Gold, 1990; Williams, 1992), architecture (Abercrombie, 1970;

Donaldson, 1989), business administration (Merchand, 1995; Stinson & Milter, 1996), economics (Garland, 1995), engineering (Cawley, 1989; Felder & Silverman, 1988), geology (Smith & Hoersch, 1995), nursing (Higgins, 1994), social work (Heycox & Bolzan, 1991), psychology (Reynolds, 1997), and information and communication technology (ICT) (Dirckinck-Holfeld, 2009; Miao, Holst, Haake, & Steinmetz, 2000; So & Kim, 2009). It eventually made its way into educational administration (Bridges & Hallenger, 1992) and teacher education (Kain, 2003; Knowles, 1975; Lambros, 2004; Levin, 2001; McConnell et al., 2008).

The desired outcomes of the PBL approach in the above fields evoke many of the principles of best practices (BP) in teaching and learning summarized above. Through engagement with PBL, students may:

- Develop problem-solving skills (BP Clusters #1, 2, and 3).
- Engage in self-directed learning while practicing team skills (BP Clusters #2 and 3).
- Assume a more active role in the creation of knowledge (BP Clusters #1 and 2).
- Develop an integrated (rather than discipline-bound) knowledge base (BP Cluster #1).
- Increase information retention through an exposure to field experience (BP Cluster #1).
- Create a less stressful experience as students examine concrete problems (BP Clusters #2 and 3).
- Use existing knowledge to construct, rather than receive knowledge (BP Clusters #1, 2, and 3).
- Acquire strategies to learn (BP Clusters # 1, 2, and 3).

Overall, PBL strategies exemplify BP principles by challenging the suppositions that teaching is telling and learning is listening; notions that are discredited both in K-12 settings and in teacher education. Indentifying the correlations between PBL and the BP was the first step in the goal to refute the fallacy contained in each of the declarative statements embedded in the six questions raised by PBL research.

Modes of Inquiry

Data Sources

Data on student self-perception and a single instructor's assessment of the quality of learning observed in two sections of a single PBL course, as contrasted with the quality of learning in numerous traditional courses, were collected. Specifically, several sources provided insights that were integrated with the literature to refute the six fallacies:

- The author's previous experiences as a K-12 classroom teacher, Social Studies K-24 curriculum developer, teacher educator using both traditional and PBL approaches, and researcher in the philosophy and practice of teacher development.

- The qualitative analysis and synthesis of narrative feedback, systematically recorded in personal course journals by participants in two graduate classes that used PBL as its strategy to conduct research into the curriculum and pedagogy of Secondary Social Studies.
- The transcripts of selected group sessions held by the instructor with the course participants.
- Comments on student course evaluations.
- Scores on the key course assignments.

Project Design

The project was an interpretive, holistic study, grounded in the phenomenological-hermeneutic theory of knowledge construction (Collingwood, 1998; Gadamer, 1977; Schleiermacher, 1998). Phenomenology is a philosophical paradigm in which the aim is to describe experience as it is lived. Phenomenology views human behavior, what people say and do, as a product of how people interpret their world. Hermeneutics involves the systematic study of texts—in this case, the narratives of the course participants, and the group discussion transcripts—in order to disclose embedded, tacit meanings. Study design and an analysis were informed by Gluck and Patai (1991), Yow (1994), McMahan and Rogers (1994), and Rowan and Reason (1981).

The Graduate Course Design

The course used PBL to teach PBL (Sage, 2001). PBL is particularly well suited to the study of Social Studies curriculum and pedagogy because, like PBL, Social Studies emphasizes the ability to make competent decisions as its primary goal. The curricular focus of the graduate teacher education course was to examine critical incidents, in the form of living cases, brought to the discussion group by in-service teachers who had experienced them in their own classrooms. PBL formed the core of the course curriculum and the PBL process modeled throughout the course followed the six steps advocated by Torp and Sage (2002) and summarized here by McConnell et al. (2008).

Step 1. Participants present/read the initial living case or problem.
Step 2. Engage the group discussion around the questions: What do we know about the scenario? What do we need to know? What are the hypotheses about the problem?
Step 3. Students, as a group, gather more information about the problem.
Step 4. Group Discussion focusing on: What do we know now? What do we still need to know? What are the revised hypotheses? Groups prioritize learning issues and assign research tasks.
Step 5. Conduct research (Internet, library, texts, or hands-on experiences).

Step 6. Group processing of research findings that includes a summary of the results, revisitation of learning issues, revision of hypothesis, proposal and defense of recommended actions, and plans for further questions and research.

In the role of PBL instructor, I asked challenging questions and required students to give evidence or reasons for their conclusions and opinions, and thereby facilitated development of their critical thinking abilities and inquiring dispositions (Browne & Keeley, 2011). The key assignments asked participants to research the theory and practice of PBL and to apply PBL as a viable strategy for teaching the Social Studies in the grade 7–12 setting. Working in groups of five, the in-service teachers applied the processes introduced during the course to create a curriculum map and a set of teaching units aligned to the standard Social Studies curriculum of a specific grade. PBL processes were also the basis for the instructional sequences in the teaching units. The units were assessed using a complex rubric that differentiated various intended outcomes: content knowledge, understanding of concepts, problem-solving ability, and the ability to transfer theoretical understandings to field work (Macdonald, 2005). The latter is often referred to as pedagogical content knowledge, which Shulman (1986, 2004) described as the intersection between content and pedagogic knowledge that allows teachers to select appropriate strategies for effective teaching of the school subject.

Participants in each course section met five times during the semester to share experiences. These meetings were in addition to group meetings that were part of the PBL process for researching curriculum and pedagogy problems. My intent was to adopt an unstructured format in these meetings (Bogdan & Biklen, 2002); however, I did use an opening issue statement to guide the interaction. These statements were open-ended and generated from themes that arose from participant exchanges during prior meetings and regular course discussions. The audio recordings of these group meetings were transcribed and added to the field notes of this study, and my analytic memos formed the basis for selecting the themes and issue statements for subsequent sessions. The group was also encouraged to use the Blackboard® discussion forum to provide peer support and to share possible solutions to problems they encountered.

Aside from working in small groups to explore the pedagogy problems, set tasks, etc., participants kept personal journals in which they recorded their observations, critical reflections, feelings, and thoughts on the PBL process. Participants shared these individual journals with me and, on a voluntary basis, with the rest of the group on a dedicated Blackboard® discussion forum, set up using insights from Savin-Baden (2003, 2009) for creating PBL online environments.

Participants

The two sessions of this course (that I had previously facilitated, on numerous occasions, using non-PBL processes) were offered in succeeding spring semesters. The participants ($n = 15$ and $n = 18$) were students who had previously taken non-PBL pedagogy courses (undergraduate and graduate) in which I was the instructor. Therefore, I was familiar with their work and could make comparisons in growth of understanding using the traditional model with that achieved using PBL processes. The participants, in turn, were able to compare their experiences in the PBL environment with those in the previous courses in which I did not model the PBL approach.

Analysis

The project emphasized data production, not data collection, since data were not "out there" waiting to be picked up, gathered, or in any other way brought together by some value-free research machine. Rather, data were constructed from participant-generated text by a human researcher, who has a history, ethics, interests, ideologies, values, and flaws; who asked some questions but failed to ask others; who used some methods but failed to use others; and who conceptualized problems and operationalized concepts in some ways but not others (Hammond, 1989).

The experiences on which participants reflected in personal narratives (written and spoken) represented unique primary sources that served as qualitative data for the findings. These narratives were the voices of students as they shared their perspectives on the transition from a traditional education preparation course to one using PBL. Narrative data, however, do not speak for themselves. Rather, they require interpretation, and the process of hermeneutic analysis is well suited to study topics that are rooted in time, place, and personal experience, in which the characteristics of the participants and the interpreter are important for the analysis (e.g., the effectiveness of PBL).

To adhere to hermeneutical principles of analysis, I also used a "backward design" strategy (Wiggins & McTighe, 2001) to analyze participant feedback, including the course evaluations that students filled out anonymously at the end of each semester. Rather than first developing a series of codes to use in identifying a set of themes that reoccurred in the data, I first identified six themes, representing each of the six fallacies, and *then* coded the data to reflect those six themes. Hermeneutic analysis followed the processes described by Clandinin and Connelly (2000), Lieblich, Tuval-Mashiach & Zilber (1998); Riessman (1993). The synthesis of the products of the project was the basis for the findings. It is important to note that no fallacy stands alone and the rejoinders for each fallacy are also interrelated, with each rejoinder influencing the rejoinder for the others.

Findings: Fallacies of PBL Debunked

Fallacy One: There Are Costs to Instruction Using PBL Compared with Those of Lecture-Based Instruction

Compared with traditional approaches, the PBL environment needs to incorporate additional resources for use by students, and since the success of the PBL approach depends on the functioning of the group, it requires an effective tutor who needs to be an expert facilitator as well as an expert in subject matter. Thus, one concern is the higher delivery costs of the PBL curriculum, both financial and in staff time (Albanese & Mitchell, 1993; Berkson, 1993). However, I have found that there is little evidence for this concern in the research and the claim remains theory- rather than evidence-based.

This fallacy also situates the educator exclusively in the traditional role of the expert. PBL challenges this idea of *sage on the stage* and replaces it with the *guide on the side*. Students must not be passive vessels filled by professors, but must become active apprentice learners to experts (Jones, Rasmussen, & Moffitt, 1997). Traditional lecture-based instruction often involves delivering as much information as possible as quickly as possible. The lecture, or direct instruction, method was one of the most effective and efficient ways to disseminate information prior to the proliferation of electronic resources. This type of instruction allowed students to be passive learners, relying on transcription, memorization, and repetition for learning. In recent decades, much has been learned from cognitive research on the nature of learning (Major, 2001). Students construct knowledge; they do not take it in as it is disseminated; and they build on the knowledge that they have gained previously (Cross, 1998). Research also demonstrates that students learn best through experimental connections (Cross, 1999).

PBL also assumes the existence of an unexplored knowledge base from which students operate, which Connelly and Elbaz (1980) identified as contextual, situational, theoretical, social, and experiential. These are in addition to inherent but implicit self-knowledge that PBL also endeavors to make explicit. In teachers' work, these manifest themselves as professional responsibility, command of subject matter, content-specific pedagogy, class organization and management, and student-specific pedagogy (Geiger & Shugarman, 1988). I have noted that in the preparation of teachers, PBL makes it possible to identify the student as the decision maker in all critical incidents. Participants agreed that the PBL process provides a way to extract these decisions, generalize them, and thereby make them accessible to their peers. PBL engendered respect for intellectual diversity and encouraged higher self-expectations and thereby higher self-esteem. These possibilities come with no costs to instructional goals.

The participants noted that although they were encouraged to search for their own solutions, the professor identified the various types of pedagogic objectives, prepared the discussion path, and generated the points that they felt needed to be covered. The participants felt that the PBL course supported most of the teaching and learning objectives that they needed in their own daily work with their high school Social Studies students. Specifically, these objectives covered informational knowledge (content), the basic skills, procedural knowledge, and dispositional knowledge. Basic skill competencies included the communication skills of writing, speaking, listening, reading; the functional literacies such as, learning skills, resource use, and information search and acquisition. Procedural knowledge or critical thinking skills included analysis, synthesis, interpretation, and evaluation, the necessary processes of problem solving.

In addition, the reflective processes of PBL addressed dispositional knowledge and made it possible to identify how they felt about their chosen disciplinary curriculum and its application. Students used their journals and the group sessions to reflect on how they thought about their schools, their sensitivity to different cultures, ethics, morality, their self-confidence, and the value of negotiations and compromise. The seeds for the themes of reflection, discussion, and communities of inquiry nurtured by PBL extended or transformed their thinking and perspectives and moved them outside the traditional box.

This was accomplished without accruing any costs in relation to the traditional instructional methods of covering such objectives and at the same time provided a greater amount of time on task.

This did not mean that direct instruction was abandoned altogether in the PBL environment. As Edelson (2001) suggested, I used the mini-lecture or benchmark lesson to present key information at the time that the students understood the necessity of that information and its relevance to their problem-solving and investigational tasks. Such direct instruction promoted knowledge construction and inquiry in ways that made content knowledge also available for future use in active contexts (Hmelo-Silver, Duncan, & Clark, 2007). Inquiry cannot be understood as engagement only with abstract knowledge, but requires active engagement with situations, and in action; this type of active engagement is difficult to achieve in the traditional lecture-based instruction. When engaging in PBL, most of the learning results from the process of working through the problem, as opposed to the simple obtainment of a solution. In the process, teaching becomes what Schön calls "knowing in action" (1983). This type of knowing can be acquired from the actions individuals undertake at each step of the PBL process.

The success of this strategy was evident on key assignment results. The PBL participants scored an average of 20% higher on their key assignments than students did in previous courses in which the assignment focused on similar objectives. Economists would call this an example of "opportunity costs," something that is sacrificed in the quest for a greater gain. In the present case, some passive teaching and learning strategies were sacrificed for the rewards that were reaped through active learning.

Best Practice Principle Evoked: Active learning experiences are the most powerful and natural form of learning. Students must be personally and deeply involved in the creation of knowledge instead of passively listening to a lecture.

Fallacy Two: PBL Students Do Not Develop the Cognitive Scaffolding Necessary to Easily Assimilate New Basic Information

The concept of scaffolding may take many forms. In the present discussion, it broadly refers to the range of services provided to assist learning, whether they are situated in the realm of the cognitive, logistical, or practical (Greening, 1998). An important feature of scaffolding is that it supports students' learning of both how to do the task and why the task should be done that way (Hmelo-Silver, 2006). Scaffolding presents learners with opportunities to engage in complex tasks that would otherwise be beyond their current abilities. Scaffolding makes the learning more tractable for students by changing complex and difficult tasks in ways that make these tasks accessible, manageable, and within the student's zone of proximal development (Vygotsky, 1978).

The fallacy that PBL does not develop cognitive scaffolding was advanced by Kirschner, Sweller, and Clark (2006) who argued that PBL is ineffective and inefficient because "rather than being presented with essential information, [PBL learners] must discover or construct essential information for themselves" (Kirschner et al., 2006, p. 1). Mayer (2004) demonstrated this assumption to be flawed. There is an extensive body of research on scaffolding in PBL environments, and researchers have developed theory-driven and empirically based design guidelines for incorporating effective scaffolding strategies to support learning (Collins, Brown, & Newman, 1989; Davis & Linn, 2000; Ertmer & Simons, 2006; Hmelo & Guzdial, 1996; Hmelo, 2006; Hmelo-Silver & Barrows, 2006; Reiser, 2001; Saye & Brush, 2002; Simons & Ertmer, 2006).

Participants indicated that while working with the PBL model, they developed their own expertise in a number of areas that together supported the overall problem-solving tasks and thereby allowed them to gain confidence in helping develop their students in these areas. Comments aligned with research that demonstrated that students appreciated the way the instructor guided through coaching, task structuring, and hints, without explicitly giving them the final answers (Hmelo-Silver et al., 2007). They noted that the PBL process also allowed the professor to introduce content knowledge in stages, at a time when that information was most meaningful. Of course, they also noted that at first they experienced shock (the first step psychologists associate with trauma) and would not believe that they actually had to solve problems before I would lecture on the concepts embedded in the problems. However, they quickly moved through the steps associated with trauma to successfully integrate the various stages of the new process and at the end wondered why they had trouble with the idea in the first place.

Best Practice Principle Evoked: Learning must be cumulative, integrated, progressive, and consistent. Learning occurs through a series of definable but not rigid stages that are encountered as whole, real ideas, events, and materials in purposeful contexts and not by studying subparts isolated from actual use. It is a way to provide a work environment that is developmental and expects that students will succeed.

Fallacy Three: PBL Students Are Not Exposed to an Adequate Range of Content

According to Albanese and Mitchell, about 20% less subject knowledge can be covered in a PBL course than in a conventional, lecture-based course (Albanese and Mitchell, 1993). That is, 20% of the time is spent with the processing skills.

However, the strength of PBL is that it is more than just another strategy to acquire content knowledge and the 20% is minimal in the light of the opportunity to draw on and develop a wide range of skills that form the elements of lifetime learning (see fallacy #1). I have observed that well-designed problems that are addressed using PBL can be the entry tools into standards, methodology, classroom management, and all the other components and content areas of an effective teacher education curriculum.

According to the majority of participants in this study, the content becomes authentic and not simply imposed from above as something that is necessary to know, it now becomes imperative knowledge from the standpoint of the teacher. In previous non-PBL courses, participants noted that often the documents used in the education classes remain unread or are not fully understood because they could not enter into them in some meaningful ways. This is not a phenomenon in the PBL course, since reading materials that cover the content needed are tied to the cases they are researching and are often materials that they themselves have found to be useful. I have also noted from the reference lists attached to assignments that the readings undertaken are much more extensive than those that I would have assigned in a traditional environment.

The use of PBL does not mean that facts, theories, and concepts are sacrificed. Problems with which the group engages are full of information and require that theory be applied to complicated real-world incidents. From my experience as instructor, this type of active learning promotes deeper understanding of concepts and theories, and improves retention of information. Engagement with abstract knowledge is therefore not only passive, but also actively aligned to real situations in the classroom. The participants are not expected to solve the problems at the onset; instead, the problems are used as stimulus for learning. Throughout the project, the participants worked through the higher levels of Bloom's cognitive domain (Bloom, 1956) as they dissected, analyzed, and then synthesized the problems they brought to the group, to see if they could understand the issues and the underlying values involved. If they could not, then they worked at locating relevant resources to obtain the information they needed.

Even in a lecture-based course, covering all the material is an impossible task. However, providing students with a basic framework of the area being studied enabled them to put their out-of-class readings and experiences into context, stimulated interest in the content area, and encouraged out-of-class research. The question was no longer, "Why do we need to know this?" but rather "What do we need to know?" Students became responsible for their own learning. One way that content was injected into the course was to provide at each session an overview, important terminology, and important references. This was not always necessary with each group and depended on the experience and expertise of its members. It was important to take care not to overly encourage the participants' reliance on such teacher-centered transmission of information. Participants appreciated that rather than having to perform on tailored assignments, they could decide how to proceed toward knowledge construction and were able to express themselves. There was less chance that students learned irrelevant detail.

In my experience at all levels of the education spectrum, I have come to realize that knowledge does not mean information. True knowledge implies understanding, and I have observed that PBL provides opportunity to foster understanding. As Schulman notes: “Aristotle was right: the deepest understanding one can have of any field is an understanding of its pedagogy [i.e. the ‘knowing-how’] because pedagogical knowledge understanding is predicated on the kind of multiple readings, the kind of contingent understanding that reflect the deep objectives of …education” (2004, pp. 400–415).

Although the initial content learning of PBL students may be less intensive than those taught conventionally, PBL students retained content knowledge much longer (Camp, 1996, p. 3). I compared final products of the non-PBL courses I taught with those developed by the participants in this study (in most cases they were the same students), and it was evident that the projects of the PBL course were of higher quality, incorporating greater content knowledge. In tasks involving integration of basic knowledge with pedagogical content knowledge, the participants also tended to do better in the PBL environment than they had in the traditional courses. PBL students were more accomplished at transferring learned concepts and content to new problems and explaining the causes of encountered phenomenon while working in the PBL course. This observation backed up the work of Capon and Kuhn (2004), who demonstrated that “students who experienced PBL instruction were able to integrate newly acquired concepts with existing knowledge structures that have been activated” (p. 74).

The course evaluations indicated that students committed far more time to the PBL course than their traditional courses. However, they felt that they walked away with a new awareness of learning and better understanding of what it means to teach. They suggested that the PBL model should be fully integrated into their whole program and not just in an isolated course. Such integration would help them synthesize fully the idea of deep approach to learning and reinforce ideas from other courses without the need for intense cramming of facts and definitions for an exam. Student course evaluations revealed that in the PBL course, students perceived themselves as learning less content than in their previous courses. However, they felt that they had the opportunity to develop advanced cognitive abilities such as problem-solving skills, communicating skills, and a sense of “personal responsibility,” thereby also strengthening pedagogical content knowledge that they did not feel they acquired in the non-PBL environments.

Judging by the quantity and quality of references cited in their final products, the less intensive content in the PBL course may have been only a perception. If it was not a perception, then any negative difference in the quantity of content was certainly outweighed by the depth of understanding of the “concepts” that a greater amount of content was intended to illuminate. An interesting but important phenomenon was that attendance was significantly higher in the PBL course than in the traditional courses. The implication of this phenomenon is that the PBL students had more opportunities to interact with content, simply because they were there more often.

Best Practice Principle Evoked: Students do not just receive content; they recreate and reinvent every cognitive system they encounter. These cognitive systems are mental systems consisting of interrelated items of assumptions, beliefs, ideas, and knowledge that an individual holds about anything concrete (person, group, object, etc.) or abstract (thoughts, theory, information, etc.). It comprises an individual's world view and determines how he or she abstracts, filters, and structures information received from the world around (Huitt, 2006). The most powerful learning comes from developing true understanding of concepts and higher order thinking associated with various fields of inquiry. One goal of best practice is to provide learning activities that exploit the students' unique learning preferences since not all students learn the same way.

Fallacy Four: PBL Students Become Overly Dependent on the Small Group Environment

This fallacy is based on the belief that students learn less in an environment in which they are only asked to fulfill a small portion of an assignment, relying on other members of the group to produce the other portions. However, the classic PBL model consists of five to eight students who need to consensually resolve a phenomenon or a set of events that require explanation. The blocks of learning are structured over a full curriculum to ensure exposure of each student to a broad range of problems and related information to become effective teachers.

The processes of PBL scaffold competencies that help students not only build further knowledge but also encourage interpersonal skills that find significant resonance outside of the university setting (see fallacy #2). Cooperation from all members of the group is necessary in order to work through the problem. Students soon realize that the divide and conquer mentality is not an effective strategy. Therefore, the members function as a group drawing on each other's knowledge and ideas. This is a true simulation of life in the schools, where teamwork is critical for the survival of the individual as a professional. Only a few people in education work in isolation. In my work with teacher education students, I have witnessed the benefits of collaboration both in disposition and in professional development. Researchers also suggest that students benefit from working together, and they learn best from teaching each other (Annis, 1983; McKeachie, Pintrich, Lin, & Smith, 1986). I found that encouraging competition at this level was not always the best way to model what educators need to know. PBL's less competitive atmosphere, where grades are awarded for the work of the group rather than the individual, results in higher product. It has long been noted that students who develop teaming skills, such as consensual decision-making skills, dialogue and discussion skills, team maintenance skills, conflict management skills, and tam leadership skills have a better opportunity to learn more than students who do not have these skills (Donovan & Cluer, 1994; Johnson & Johnson, 2008; Peterson, 1997).

The writing that was part of the PBL process, ultimately, resulted in reflection on reflection—a type of meta-reflection—a stage of consciousness that the participants would probably not go to normally. Meta-reflection is an activity of the mind during which the individual reflects not only within herself, but are also invited to reflect with others, which can deepen the reflection and help the individual to explore the self by moving outside of the self. The group support helped to eliminate the fear and risk of exposing the vulnerabilities of the self that often abound in traditional settings. The consensus was that, as teachers, they need to reflect on practice at each step of the process in order to develop the ability to reflect in practice, which is the act of making decisions in the midst of teaching (Schön, 1983).

Best Practice Principle Evoked: Students should work cooperatively to help each other learn. Participating in interactive and cooperative processes bring together students of all ability levels and enrich the learning environment, while helping to discover the complexities of human interaction. Learning is always socially constructed and often interactional.

Fallacy Five: Faculty Dislike PBL Because of the Concentrated Time Commitment Required

The problems inherent in any form of change are certainly present in the move to adopt PBL as a mode of learning. The common failing with PBL programs results from entrenched (non-constructivist) models of learning and power relations (Pereira et al., 1993). Many professors, as well as school teachers, view the PBL model of instruction as one that divests them of some of their effectiveness or influence. To the professorate, this means that they become only a facilitator and not the expert or fountain of knowledge.

Britzman (1987) suggested that the all-knowing teacher is a deep cultural myth, and from that has sprung rather immutable views of the role of the teacher and the way that teaching and learning become structured and experienced. The transition to PBL represents a disruption to these existing assumptions, which then results in resistance. The uneasiness is caused by the need to question the role of the professorate in higher learning. Teacher educators may have expertise in lecturing or delivering information, but they must revisit and update their expertise in what it means to learn. The professor role as PBL facilitator must emphasize such metaphors as coach, guide, mediator, co-learner, and co-investigator, while the student role emphasizes learning as problem solving, producing knowledge, exploring, and co-learning (see fallacy #1). This often causes anguish for professors.

Faculty need to transition to modeling the theories of learning, to move beyond the mere transmittal of information about learning. Adopting PBL requires that instructors develop expertise not only in subject matter but also in the pedagogy of PBL. They must acquaint themselves with the various strategies of PBL, experiment with differentiated instructional plans each semester, and ensure that students are engaged in relation to their own interests and strengths rather than aiming to engage the average student in passively taking in information. I have noted that if I wanted my students to endorse the PBL environment, and use their own time efficiently, I need to be thoroughly organized and prepared—clearly defining purpose, procedure, and expectations—before my first session with them. I am also convinced that PBL suggests that teaching itself should be practiced as a form of inquiry in relation to students. Administrators need to offer workshops to help develop their faculty's skills in facilitating and in managing group dynamics (including dysfunctional groups) (Sage & Torp, 1997).

When transitioning to PBL, it is no longer important that professors simply know content; rather, they must understand their students' learning styles and needs, and have a wide range of pedagogic strategies. They must admit that good educators can say that students are now working as if they did not exist.

Participants who were working on their MA thesis while taking the PBL course commented that one of PBL's advantages was that the processes aligned with how they interacted with their thesis advisors. They valued their thesis professors' skill in collaborating with them, in a one-on-one situation, to solve a problem. The PBL environment created an opportunity where the course professor used the one-on-one skills and was able to get more personally involved with students in larger numbers. PBL provided opportunities for their facilitator, mentor, coach, and instructor to assume the role that resembles that of a supervisor of graduate research students, while serving a larger group simultaneously within the time commitment of a traditional course.

It may be assuring to note that a survey by Zimitat et al. (1994) revealed that 70% of students in a PBL course found that the professor's role is still essential to their success in using this self-directed method. Although it is undeniable that the initial commitment to learn to educate for problem development and the time required for design of scenarios is considerable, the complaint is not so much about the increased time commitment, but the discomfort of change.

> *Best Practice Principle Evoked*: Students benefit if teachers provide the opportunity for a rich instructor–student interaction through many different types of in-class and outside-class activities.

Fallacy Six: A Curriculum Using PBL Is Impossible to Assess

This fallacy originates from the fact that students engaged with the PBL environment are free to choose the topics they want to study and the depth to which they choose to study such. In response to any given set of problems, any two students may learn different material. Instructors cannot test students on a predetermined list of content. Testing under such conditions means that instructors often struggle to create a meaningful, systematic strategy for observing whether students have met the learning objectives for the course. However, such work is not impossible to test; it is impossible only if the instruments used are not adapted to the process (Belland, French, & Ertmer, 2009).

While each PBL instructional environment is unique, and therefore merits its own unique assessment strategy, assessment used in PBL should seek to examine the level of integration of interdisciplinary knowledge, skills, and behaviors. Generally, principles set by the National Research Council (NRC) outline this integration. The NRC contends that there are three guiding principles to assessment: content (assessment reflects what is most important for students to learn); learning (assessment enhances learning and supports instructional practice); and equity (assessment supports every student's opportunity to learn) (Walters & McCracken, 1997). Macdonald and Savin-Baden (2004) also developed a set of useful principles to guide educators to think strategically about assessment for PBL. They also suggested various assessment forms that aligned with their principles. Essays and examinations that relate only to the content and contain no context should be avoided at all costs. Assessment needs to fit the philosophy of active learning encouraged by PBL processes and should always relate back to the types of activities undertaken in a PBL environment. Costa and Kallick (2004) emphasized that assessment must be authentic. Authentic assessment involves tasks that are similar to the tasks performed in real life (Walters & McCracken, 1997). Creating authentic tasks alone is not enough. Great care must be taken to ensure that there is a close relationship between the learning objectives and the authentic assessment tasks (Anderson, Reder, & Simon, 1996).

When creating an assessment tool for PBL, most of the work is done when the ill-structured problem or scenario is introduced. As students and facilitator explore the components of the problem and work out what would be required to present and support the solution, the tasks and the dimensions of the assessment plan are also identified. The assessment plan dimensions evaluate the same tasks that are part of the teaching/learning phases. Identify a problem, create a problem statement, develop a process with which to investigate the problem, create a solution, and test the solution. During the teaching/learning phase, students are confronted with new problems that arise from the original scenario, which requires the participants to demonstrate the desired depth of understanding of the particular concept that is under study.

Giving students the opportunity to evaluate and reflect on their own learning is a key element in assessment. Woods (1994) noted that assessment of students' activities in their PBL groups is also advisable. She recommended that instructors assess the group as a whole and that the group also needs to be encouraged to assess its own performance including its adherence to process, communication skills, respect for others, and individual contributions. Assessment methods that are adaptable to PBL, which itself adapts to diverse learning style, should also adapt to the needs of diverse student populations.

Participants were also required to judge their own work and reflect on such self-assessment in their journal entries. In this case, self-assessment meant that students were involved in identifying criteria to apply to their work and to judge the extent to which they met the criteria (Boud, 1986, 1987). Often there was a tendency for participants to assess what they meant to do, rather than what they actually achieved (Macdonald, 2005). I brought this to the participants' attention several times during the course, with the end result that the final self-assessment efforts were more objective about the extent to which they met the criteria we set collaboratively.

Upon reflection on how to align PBL instruction and assessment, several suggestions emerged. First, participants felt that I should realize that they are professionals in the field in which the issues they examined exist, and that I should assess them as if I was their supervisor, in which case the assessment was formative not summative. Second, the group was supportive of the fact that since course instruction was problem-based, the assessment was also similarly structured—that I did not undermine the creative process needed to develop their key assignments by assessing them with a multiple-choice or essay test. Third, they needed guidelines regarding my expectations without overly detailed goals and solution criteria. Participants valued the fact that they were instrumental in creating the criteria. Fourth, the fact that assessment was ongoing occurred throughout the course, and that I did not wait until the final draft of the key assignment was submitted, and helped them create a much better product.

PBL makes it possible for the faculty member of the group to give prompt feedback on ideas and to communicate high expectations. The participants agreed that the critical part of the assessment was the feedback at each phase of the process. This included feedback that they received from their peers, the detailed comments from the instructor about each student's strengths and weaknesses, and the suggestion for improvement.

Best Practice Principle Evoked: Students should be encouraged to self-monitor their thinking and have clear goals and criteria to tell them when they have achieved the goals. Empower the students to have some role in the assessment. Students should get prompt feedback about their performance.

Final Thoughts

MacKinnon (1999) summarized the benefits of PBL to be a pedagogic strategy that promotes students' confidence in their problem-solving skills and strives to make them self-directed learners with a sense of ownership over their learning. These benefits can give them an advantage in future courses and in their careers. I must also note that adopting PBL in teacher education led my students and me to the recognition of the equity principle evoked by Dewey (1916), who argued that democracy is actually a theory of education. In the PBL environment, professor and student have equal value in the learning process. In fact, addressing diverse leaning styles is a principle factor in the interest in PBL by the education community as its pedagogy supports every student's opportunity to learn.

From a purely fiscal standpoint, anecdotal comments from Ian Winchester may add yet another perspective to my discussion, albeit through a single, but powerful voice. Winchester has a background in medical education at McMasters University, and in 1995, in his capacity as Dean of Education at the University of Calgary, he transformed the traditional teacher preparation program into one based on PBL principles and processes. Twelve years after the transformation he noted that:

> …we actually managed with 20 less full time faculty than we had before (initially 80, after budget cuts, 60) to educate the same number of students as we had before we made the switch to an all PBL program. We used to have classes of 100 students or so and faculty taught six classes each. After PBL we still required the same number of hours from faculty, but now organized into 2 and 3 h seminars. Each faculty member had to do three of these in the professional program and three in the graduate program. Therefore, our 1,800 students (half professional, half graduate) amounted to a ratio of 30–1 compared to the university's normal 15–1. Yet we managed to teach in the new way with more or less no strain for anybody (Winchester, 2007).

When pressed to comment on whether the change and the cutbacks resulted in any loss to the quality of the program and to student learning, he offered that:

> There was no comparison in quality, in my view. Our present students get much better quality than any of their generations of predecessors. There was no quality in being a nameless one among hundreds, lectured to, having to take notes and write multiple-choice exams. Now we have no exams, but we see their work every week from multiple perspectives, and they never cram, they work together, and they are always in the school classroom or another educational site as well as in our classes. Of course, it is not just PBL. We also follow Sir William Osler (the great Canadian physician who wrote the first comprehensive textbook in medicine) in having them, so to speak, at the bedside all the time (Winchester, 2007).

This last comment highlights a unique component of PBL that makes it possible for students of teaching (undergraduate, graduate, and professorate) to spend a greater amount of time in schools (the field) than in university lecture halls.

I aimed to demonstrate that most problems associated with PBL are fallacies that can be dismissed if it is recognized that PBL embodies, capitalizes, and exploits most of the principles of how to improve teaching and learning. Therefore, if educators focus on the overall benefits claimed for PBL, evoke specific better pedagogic principles of learning and teaching, and superimpose them on the processes of PBL in context of the education of teachers, then the six fallacies actually stand as components of best practice principles. I encourage teacher educators to adopt PBL characteristics in their courses as a viable approach to developing best practice principles for teaching and learning at both undergraduate and graduate levels. In-service teachers are also encouraged to use PBL as an instructional strategy in K-12 classrooms.

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Part IV
Case Studies and Current Practice

Design for Media: Nurturing the Transition of Media Arts Students from Consumers to Producers Through Deliberate Practice

Charlotte Belland[*]

In 2006, in accordance with NASAD guidelines, The Columbus College of Art and Design reduced the graduation credit hours from 129 to 120 h. This reduction in credits allowed students to take classes in their majors during the second half of their freshmen year. But this early specialization led to students focusing too heavily on particular software packages and mimicking trendy techniques. In Spring 2007, the Media Arts department of the Columbus College of Art and Design (Media Arts) noticed a significant increase in fragmented portfolios—collections of small, investigative pieces, high in production quality but lacking in personal expression.

Having good technique but no clear personal expression is not desirable for artists. Thus, Media Arts embarked on a curriculum reform project designed to encourage students to develop their personal expressions through diligent practice with a variety of techniques and media. In Fall 2007, Media Arts implemented a Media-focused Design sophomore fundamentals course called Design for Media (D4M).

Theoretical Basis of Pedagogy of Design for Media

Learn by Doing

Much research has shown that students learn most effectively by doing rather than passively listening to an instructor telling them information (Schank, 2002, 2004; Schank & Langer, 1994). This appears to hold true in Arts Education.

[*]This chapter is lovingly dedicated to Dad

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Traditional Arts Education revolves around the transfer of technique principles from teacher to student. Students spend many hours watching, observing, and mimicking teachers' techniques. While art students need to learn technique, they also need to learn how they can leverage technique to enhance their own expression.

In D4M, technique is delivered nimbly (applied at needed), failure is celebrated (an understanding of why something did not work), and students are required to document their iterative processes (blogging). This mimics what students will encounter in the professional world. By applying the concept of Roger Schank's Story-Centered Curriculum (Schank, 2002, 2004), students are active participants in their desired careers.

Story-Centered Curriculum

Building a story-centered curriculum starts with defining five key factors (Schank, 2002; Schank, 2004). The first factor is a clear understanding of the career goals of the student. This has to be balanced with the realities of current professionals (not just the rock-star illusion of a fantastic career). Feedback from current professionals is crucial—a skill that was relevant a month ago might be obsolete. The second factor is determining the main activities of the professional. What tasks make up the daily routine of the professional? What are the rare tasks? The third is determining the key events that take place in the profession. What are the events that occur frequently? And infrequently? The fourth is to assemble this information into the story. What is the narrative? The fifth and final step is to determine the skills and experiences that are needed prior to entering the story. These experiences could be prerequisite skills or previous stories.

Story-centered curricula are goal based (Schank, 2002; Schank, 2004). There is a clear destination or series of destinations that allow students tangible feedback to gauge their success. By actively participating in the story, students engage the content and write themselves into the story. Through this participation students become task proficient. The skills are retained because the task was needed to tell the story.

Could This Be Applied to Arts Education?

Many teachers of art are highly skilled experts in their fields. These sages of craftsmanship share their skills though detailed workshops. They show a technique and ask their students to replicate it. While craftsmanship is an important element of art training, it needs to be paired with the reasoning behind the choices. Why did an artist opt for a particular technique? Was it a deadline? Was it a client? Framing the technique into a story and bringing the students into the story through simulation can allow the idea of story-centered curriculum to be applied to arts education.

How Would This Work in Arts Education?

Most private arts schools are engaged in storytelling as an end product (e.g., a series of paintings, an animation, an installation, etc.). By applying the tenets of story-centered curriculum to the classroom, the art student has an opportunity to understand the process of production as it relates to their intended careers. Teachers can simulate the career by constructing a simulation environment, complete with obstacles nimbly applied to afford a richer learning experience. Students can actively apply their skills within the context of the story. Learning becomes active.

Structure of Design for Media

D4M provides a forum of media investigation, allowing students to experience their proposed production pipeline. This 15-week course involves the exploration of potential Media Arts disciplines (e.g., animation), and the application of freshmen-year foundational knowledge into the realm of Animation, Cinematic Arts, and Photography. Grading is weighted toward effort not outcomes. This framework encourages students to explore a variety of areas before they make a formal commitment in their junior year. The structure of the course is informed by 10 foundational principles:

- Students should engage in deliberate practice
- Effort rather than final product should be rewarded
- Students should risk new techniques and media
- Failure is to be celebrated and encouraged
- Students should become involved in their professional communities through critique
- Individual attention is key
- Allowing students to make decisions is paramount
- Content, not tools, is the most important
- The traditional classroom structure is not always the most conducive to student development
- Students should be encouraged to break the rules.

Deliberate Practice

It is the individual's ability to develop an intentional, purposeful, strenuous and tedious practice routine that produces a successful artist (Brooks, 2009). Just like the athlete, daily calisthenics builds muscle memory and strengthens a foundation onto which new experiences can be built. An artist needs to practice every day. Unfortunately, the artifact, the final print hanging on the wall, often determines the success of the artist. As many Art Educators have experienced, sometimes a student who waits until the last minute can still produce a good product (emphasis on sometimes). But this robs the student of learning by doing because the focus in on the product, the project that is due the next day. The student does not risk a new technique because there is no time for experimentation.

Students need to visually document their current work through a public blog twice a week. This Creative Habit (Tharp, 2003) provides a framework for students to build on their knowledge bases and physically demonstrate the benefits of such practice. While the final project (video, photography, animation, game, etc.) is important, it is the continual practice that is paramount. Even habitual procrastinators are pushed to work continually at development of their artistic skills.

Reward Effort

To support deliberate practice, an educator must reward effort. Sophomore students are still at early developmental and experimental stages of artistic growth. Many students are just starting to make the transition from expert consumer to novice producer. For example, while students might possess a raw conceptualization of the colossal task of creating a feature-length animated movie, few enter D4M with prior attempts at animation.

As such the focus at this developmental stage needs to be placed on effort rather than product. When students compare their first attempt against modern commercial examples, a negative experience will be the likely outcome. Rather, students need to focus on the continual work and the corresponding incremental improvements in technique: acknowledgement of weekly/daily practice and identifying upward shifts in craft however subtle. By focusing students' attention toward their weekly/daily devotion and improvement in skill, the spotlight can remain on the individual, not the current "feature release."

Over 90% of the final course grade in D4M is based on the daily (weekly) documentation of effort. This method of grade weighting rewards students who actively engage in deliberate practice. While the final piece is important, it cannot carry the entire course. Students need to exhibit continuous, thoughtful attempts to have the possibility of passing the course.

Risk

Most art students are expert consumers. They know every detail of their favorite motion picture, game, or installation. They can point toward pages of artists' interviews, stacks of how-to books, and hours of "the making of" videos. Yet, students in the Media Arts department rarely enter into the sophomore year with any specific hands-on media experiences. They have not yet risked new media opportunities, resulting from the lack of access, non-exposure, and/or apathy.

D4M acts as a gateway for students to experience a new medium. With the majority of the grade based on effort, each student is free to try out techniques or systems without risking a bad grade. For example, a student who had desired to be an animator may find video to be a better fit. Effort, not product, is rewarded. The student can then switch his/her initial practice to video.

As noted by Rao, Sutton, and Webb (2008), "You do something that scares you, that's at the edge of your capabilities, where you might fail. That's what gets you up in the morning." College art is a time for exploration. By removing the grade implications of "final projects," the sophomore is able to take chances with new media. The Media Arts department needs for sophomores to try out and risk new techniques—otherwise, students will not venture out of their comfort zones. In brief, the comfort zone offers little room for improvement. Just like in sports, first attempts are expected to be awkward and a little painful. Similarly, the exploration into a new production style might be genesis of the next form of media.

D4M students who risk new media can make mindful decisions about what type of Senior Capstone Project they wish to pursue. They know what works through the lived experience of trying it. They also have learned what does not work which is equally of value.

Fail Fast, Fail Forward

Students are encouraged to try out new mediums. When learning a new technique, failure is the cornerstone of growth. Embrace mistakes—value mistakes (Capodagli & Jackson 2010). The faster students can fail at a particular technique, the faster they are able to begin the process of figuring it out.

Failure without reflection can be wasted energy. Biweekly posts are required for all enrolled D4M students no matter the outcome. Students must document what they tried, the outcome, and analyze the process. "Oh well, didn't work. Nothing to show" is not considered to be acceptable content.

The instructors of D4M have a concurrent course requirement of their own, to admit their failures with gusto. This can be related to a personal project, a particular client, or maybe a technical error during a demonstration. Either way, students who witness leaders celebrating their failure are more likely to do so themselves. As noted by Berkun (2005), "Wise people admit their mistakes easily."

Public Critiques

The sole delivery tool for D4M is the public blog. While the school does offer students private web-based portfolio space, this closed circuit system does not allow for public critique. It is too easy for the student to restrict access to just their teachers, excluding classmates and external professionals.

Likewise, D4M teachers use internal course management software called GoStudio. However while this is appropriate for sensitive content like grading and attendance, it is not conducive in facilitating a public critique process.

The three blogging sites utilized most frequently for D4M are Blogger, Wordpress, and Tumblr. The main D4M web presence is hosted on Wordpress. Through the utilization of public blogs, students take sole ownership over the process that begins with the individual selection of the blogging site they have chosen to use. The blogging site becomes the responsibly of the student to maintain.

The modern artist must embrace the notion of the working blog—a site devoted to the process and production of an artist's body of work. It is very rare to find a professional artist without a blog. The blog is the modern sketchbook, detailing not only process but also opinion and editorial views.

If the blog functions in the public domain, anyone anywhere can post a response to a student's blog (Jognson, 2010). This is an ever-flowing process in which a student is not beholden to a particular space and time to receive feedback. While traditional critiques are still employed throughout the semester, a blog can facilitate feedback from people anywhere in the world. Often, alumni will contact the department looking for ways to help and encourage current students as a way to give back to their community, the next generation of artists. The D4M catalogue of student blogs offers a direct connection. A blog response from a PIXAR animator or TIME Magazine photographer or industry storyboarder can go a long way toward encouraging the student to continue with his/her purposeful practice.

Individual Attention

Blogs afford a quick way to tailor individualized instruction. Requiring students post their documentation twice a week on their blogs maintains the opportunity for a strong dynamic connection between individual student and teacher. The student can see that his/her feedback is adapted to him/her. Similarly, a teacher is able to identify a student who is having difficulty and address these issues quickly.

Individual comments need to be brief and direct. Otherwise, a teacher may begin to feel overwhelmed at the notion of needing to post a lengthy response biweekly to each of their 20–30 students. D4M teachers facilitate this by learning to say more with less. The targeted purpose is to identify what is working, what is not, and provide a suggested course of action. As noted by Overby (2009), "The teacher is a facilitator rather than an authoritarian figure."

Emphasize Decision Making

Effort without goals produces frustration. D4M employs two methods for decision making: the artist's statement and the setting of small, short goals. Both methods play a pivotal role in students' abilities to make decisions and judge if these decisions are being reached.

The artist's statement is crafted to provide a written explanation and description of the current project. It is used as both a compass and an evaluation tool ("this" is what I will achieve with the production of this work and "this is how" I produced the work). D4M works with the short form: a one paragraph description of the what, why, and how. Students are introduced to concepts like the Elevator Speech and Log-Lines (the paragraph has to "sell" the idea). Often, students will spend many weeks writing and redrafting their artist's statements.

Often, students might encounter decision paralysis, in which they are unable to commit to a subject. When this occurs, D4M teachers strategically switch such students to art calisthenics. The goal is to send the students off campus (or any comfort zone) into an area of investigation. For some, it might be to the zoo to sketch and draw the animals. For others, it might be to photodocument a public rally on the statehouse lawn. As students post to their blogs, the teacher challenges them to form opinion about what they saw. If this sparks an idea, then the student is encouraged to try the artist's statement again. If not, the student is sent out for another strengthening exercise.

Setting small short-term goals is the second aspect of decision making. Usually, this is a brief statement on each blog post indicating what the class/teachers should expect on the next post. The catch for the D4M teacher is to regulate these small goals so that they stay small. Often, the eagerness of youth will set unrealistic goals, due primarily to the fact that many have not experienced a true production pipeline. Students have not yet developed a sense of the clarity of reach, as they are yet to encounter these experiences. It is the responsibility of the teacher to regulate and provide guidance.

A Superior Tool Does Not Create Superior Art

As expert consumers, students are keenly aware of specific software and hardware. For many students, the introduction to the Media Arts labs presents a massive world of both digital and analogue potential (the CCAD Media Arts department is privileged to have a wide array of digital tools, studio space, and multiple black/white, color, and photosensitive labs). Some students enter the department with a solid history of professional techniques. Either way, it is the role of D4M to promote transparent technology—this content is the most important element.

The junior year of Media Arts is reserved for technical skills development. It is during this time when students can narrowly focus on very specific techniques and skill sets that they will need for their senior years. During D4M, students have the opportunity to sample the different offerings. While sophomores have the option to focus on a specific technique, they are more often encouraged to try multiple options. While it is not rare for a student interested in photography to sample video and become hooked or for a student interested in 3D animation to discover that photography is what inspires him/her, the point is that a sophomore must have a safe zone to explore different options. Students need to be provided an opportunity to refine or readjust their focus, not being limited to a narrow set or choices due to initially picking the wrong major.

Along these lines, students who desire to work with a very analogue technique should be allowed to do so. While the student still needs to employ digital techniques for public review, the art-production tool can be analogue. A student should not be forced into using the highest-end hardware/software to produce art just because it is industry standard.

Nimble Grouping

D4M is planned so that each section meets at the same day and time. While this does pose some scheduling challenges for the occasional transfer student, the benefits for all students outweigh the challenges. This course design creates two meeting options: small, assigned “teams” (the actual class rosters) and one large critique/meeting group.

Each section has an assigned teacher. The teacher functions in the role of the “team leader” for his/her cohort of students. At the end of the day, this teacher is also responsible for the final word on his/her students’ grades. While a student might receive feedback from another section’s team leader, the assigned team leader has the grade-granting authority.

Each class meets at the same day/time. This structure allows for the flexible sharing of resources. Classes can dissemble and reassemble based on the current needs of the students. If there is a visiting artist, all students can assemble. If there is a demo on a particular software package, only students interested in that topic need to gather. Communication is the key to this nimble grouping. All groupings are posted on the D4M blog. If no specific event is posted, students are required to meet in their assigned classroom.

Happily Break the Rules

Set the stage for innovation by happily breaking the rules (Kelley & Littman 2005). This principle applies to both the class structure and student development. As long as each student is actively engaged in deliberate practice, teachers can modify the format to meet the emergent needs of the current class. Likewise, if a student creatively approaches a challenge with a new method, it is essential to let him/her try.

Future Plans

D4M will continue to evolve based on professional, alumni, current student, administrator, and teacher feedback. The illustration and fine arts majors have a parallel course, Design and Digital Application.

In alignment with Story-Centered Curriculum (Schank, 2002), D4M’s Core story encompasses the Senior year experience. As in many Art Colleges, seniors at CCAD engage in a capstone project in which they apply everything they have learned to date in a project that to a large degree mirrors what they will do after graduation. With D4M, sophomores are learning techniques and applying them in a similar manner as they would in their capstone project and beyond. Sophomores propose large-scale projects and begin to experience the Senior Story. They also begin to live the life of a professional artist, trying out new techniques, integrating those techniques into personal styles, and seeking feedback from the professional community through blogs.

The problem of students privileging certain techniques and media over content that led to the creation of D4M is by no means unique to Arts Education. Schank (2004) proposed the idea of a story-centered curriculum within the context of computer science. Many people assume that computer scientists simply need to know how to code in an algorithmic manner. Rather, they need to integrate techniques from computer languages into their own personal expressions to be successful. Only by doing that will they be able to apply the techniques of computer science to solve problems effectively. Similarly, writers can learn creative writing techniques from a teacher, but they would never be considered great or even good writers until they can integrate those techniques into their own personal styles and transform them. The same holds true for artists.

By making grading reflective of effort and documentation, Arts faculty can encourage the integration of techniques into personal style by removing the "danger" of a failing grade. Additionally, D4M mentors do not teach copious amounts of technique. Rather, mentors can focus on providing feedback on students' use of techniques in action. This reflects the senior year story—constant feedback on the capstone project from faculty, peers, and professionals and students are responsible for leveraging resources for learning technique.

A deviation from Story-Centered Curriculum is that D4M is focused solely on the individual. Questions and challenges could be posed that could only be solved by group effort. There have been several successful senior group capstone projects. These students had formed groups prior to their senior year. A question that needs to be asked is whether groups can be nurtured within D4M.

Within D4M, the obstacles are generated by the individual's missteps and errors. This deviation is important as it reflects the actual experience of the Senior Year Experience. While adding mentor-planned obstacles could add an additional level of challenge, it is very rare for a senior to receive feedback that would massively alter his/her project. This type of obstacle would have to be implemented at the start of a project, as this is where a senior would receive radically altering feedback.

It is the hope of Media Arts to align the meeting times for all sophomore design classes campus-wide to facilitate even more medium experimentation. The potential gathering and sharing of ideas and techniques continues to provide a rich digestion of core design concepts and an amazing foundation for undiscovered art.

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Genetic Literacy and Problem-Based Learning

Rick Voithofer

Introduction

The decoding and mass storage of the genetic codes of plants and animals (including humans) along with the capacity to manipulate and track those codes has brought about a number of social and cultural shifts, the implications of which are just beginning to be understood. The application of this growing ability to decode, manipulate, and store genetic information has increased the need for all individuals to have some degree of genetic literacy to understand the implications of genetics in their lives. Yet, the public's understanding of genetics is lacking (Haga, 2006). Lanie et al. (2004) found that only 34% of the adults that they surveyed across the USA alluded to the knowledge that genes are located in every cell, 24% incorrectly stated that the brain was the main location of human genes, and a mere 14% mentioned genes in association with DNA or chromosomes. Without a basic knowledge of genetic mechanisms, it is difficult to comprehend more complex applications of genetic concepts including genetic testing, genetic manipulation in plants, animals, and humans, and gene therapy.

This chapter describes a project that uses a critical approach to the intersection of genetics and culture to teach middle school students genetic literacy. Specifically, it outlines the underlying theories and research behind the design of a computer simulation used to build middle school students' genetic literacy across multiple subject areas including science, math, and social studies. It begins by describing the growing need to make connections between the science of genetics and the cultural

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construction of genetics. In the following section, a working definition of genetic literacy is provided, followed by a review of the ways that genetics has been traditionally taught. The second half of the chapter offers a description of the design goals of the project, in relation to the schools that are partnering on the project. This description includes a summary of the concepts in each of the content areas that the project is targeting and concludes with an example of a problem-based lesson that integrates the simulation.

The project is grounded in the following assumptions:

1. Many individuals across the social spectrum have insufficient basic genetic understanding to make informed choices about personal, social, and environmental issues related to genetics (Haga, 2006; Lanie, 2004)
2. Students learn best when instruction and content is relevant to their life experiences and cultural backgrounds (Ladson-Billings, 1994, 1995; Rivet & Krajcik, 2008)
3. Middle school is a crucial time when many underrepresented students (i.e., based on SES, gender, race, and ethnicity) turn away, are turned away, or are turned off from STEM subjects (Brickhouse, Lowery, & Schultz, 2000; Parsons, 2008)
4. Middle school students are most academically successful when their teachers work together to coordinate instruction (Wallace, 2007)
5. Problem-based learning (PBL) offers the opportunity for students to learn concepts and solve problems with long term retention (Hiebert et al., 1996)
6. The use of simulation tools helps students understand abstract concepts and think through multidimensional questions (Jong & Joolingen, 1998)
7. Genetic knowledge has evolved beyond its current coverage in the school curriculum and proficiency tests. Standards and curricula must be updated to accommodate current understandings of genetic mechanisms and possibilities (Dougherty, 2009)
8. Genetic and cellular activities are difficult to comprehend because genetic mechanisms cannot be seen directly (Marbach-Ad & Stavy, 2000)

With these assumptions, this project anticipates some of the provocative and compelling issues that many individuals will confront in the coming decades as researchers continue to uncover the relationships between single genes and gene clusters and the characteristics of living organisms; the increasing capacity to manipulate those characteristics; and the practice of storing genetic information in massive privately and publically controlled databases (Collins & McKusick, 2001; Kolsto, 2001). Because of these rapid technical innovations and growing applications individuals will have to make informed decisions on a variety of existing issues related to healthcare, food production, and emerging issues related to how genetic information will be utilized to identify and track citizens (Terry & Davidson, 2000). For example, while the Genetic Information Nondiscrimination Act (GINA) of 2008 was passed by the United States Congress preventing certain types of employment discrimination based on genetic information, there are still a number of ways that individuals can be discriminated against based on their genetic information. For example, despite this legislation, employers can still legally access and assess employee genetic markers in several ways (Wasick, 2009).

The Inter-relationships Between Genetics and Culture

The application of genetic knowledge is increasingly impacting the lives of individuals in many unexpected ways. For example, for about $300 there are companies (e.g., http://africanancestry.com/, http://dna.ancestry.com/) that offer African Americans a genetic test that provides them with a map of their heritage in Africa. As a diasporic group, African Americans who descended from slaves typically cannot reconstruct their ancestral history beyond the past five or six generations because there are often no public records beyond those kept by slave owners. The technology of genetics offers a way to create a history that would not otherwise be possible to construct. Yet the complexities of heredity, migration, and the relative early development of this technology complicate the desire of many African Americans to trace their history (Dula, Royal, & Secundy, 2003; Rotimi, 2003). For example, three different companies can provide one individual with three different results (Stahl, 2007). The technologies of genetics are raising numerous questions in addition to those around racial identity including those related to healthcare about what the underlying code reveals. The interplay between scientific knowledge and cultural factors creates a complex matrix of variables that individuals must weigh and unpack when processing the various sources of genetic information that they may encounter and perhaps pursue in their life. In what follows, I make a case for a broad approach to genetics literacy that takes into consideration this complex matrix.

In the twenty-first century, an increasing number of children will be born with their parents knowing their physical, intellectual, and emotional tendencies based on some interpretation of their genetic makeup. For example, a New York Times article reported on a genetic test that claims to identify an individual's athletic potential (Macur, 2008). The article mentioned Atlas Sports Genetics (http://www.atlasgene.com/), a company that sells a $149 test that promises a profile of someone's athletic capacity. The test detects one gene ACTN3 that has been linked to different kinds of athletic abilities. While the connections between the gene and athletic ability are contested, parents are using this test to forecast if their child has the potential to be a professional athlete or earn an athletic scholarship to college. This test is just one of a growing number of tests that are and will be offered to identify cognitive, emotional, and physical profiles of children. The genetic knowledge that parents bring to this information will have implications for what they do with this information. More specifically, parents' and educators' interpretations of this information will have a large impact on the expectations that they bring to educational institutions and individual students and groups. Tremendous problems arise when these expectations are grounded in the widespread misunderstandings of genetics that permeate society (Molster, Charles, Samanek, & O'Leary, 2009).

For example, immigration officials in the UK are using genetic testing on African asylum seekers in an effort to catch those who are lying about their nationality. A number of scientists in the UK have criticized the program because it is based on poor science (Travis, 2009). In another instance, multiple states including Texas, Michigan, and Minnesota are storing genetic information from newborn children, often without parental consent, that can be linked back to individuals (Stein, 2009). Understanding these practices and responding to them as informed citizens in democratic societies will require new types of literacy.

The psychologist, Steven Pinker (2009) observed that humans are prone to essentialize genetic information which gives them a reason to justify certain tendencies in their personalities. He argued that genes cannot directly impact behavior, but they create the wiring and operations of the mind that impact our curiosities, securities, aptitudes, empathies, and ambitions. Pinker noted that the behavioral geneticist Eric Turkheimer found that all human variation can be attributed to genes but that culture does play a role in how things turn out (Turkheimer, 2000). Judith Rich Harris asserted that the environment gives us the options to which our genes respond (Harris, 2006). Pinker concluded that genes will never offer a direct map of temperament and personality because of the influence of environmental factors on genetic characteristics.

The emerging field of epigenetics studies how environmental factors contribute to the expression of genes. Epigeneticists have found non-DNA inheritance between organisms and cells. Genes can be turned off and on as a result of environmental factors. This has altered or amended the theory of evolution. For example, it lays credence to the work of Jean-Baptiste Lamarck whose published research on evolution predated Darwin's research and argued that evolution is influenced in part by inherited traits. His classic example is his hypothesis that giraffes developed longer necks by stretching to reach higher trees and then passing along the stretched neck to subsequent generations, each generation passing along a slightly elongated neck (Lamarck, 1963).

As these different scientific findings and examples begin to reveal, the interplay between scientific knowledge, the perceived certainty around scientific knowledge, and cultural factors create a complex matrix of variables that individuals must weigh and unpack when processing the various sources of genetic information that they may encounter and perhaps pursue in their life. In the following section, I make a case for a broad approach to genetics in the curriculum that takes into consideration this complex matrix.

Genetic Literacy

Definitions of literacy have focused on both educational (e.g., reading and writing) and sociological/economic (e.g., being able to function in society) perspectives. A definition that combines both perspectives was suggested by Hillerich who said that: "Literacy is that demonstrated competence in communication skills which enables the individual to function, appropriate to his [or her] age, independently in his [or her] society and with a potential for movement in that society" (Hillerich, 1976, p. 53). This project takes this dualistic approach to literacy. Therefore, if literacy is defined as both the ability to understand one's needs and interests and the power to act, to protect, and to promote those needs and interests then it makes sense to treat genetics as a unique area of literacy within the growing proliferation of literacy categories (e.g., read/write literacy and emotional literacy).

There have been few attempts to address genetic literacy from a larger social and cultural context. Jennings (2004), however, has developed one model of genetic literacy that tries to take into account the potential for genetics to bring on new forms of discrimination. He noted that "genetic literacy may require, as its complement and supplement, some new forms of genetic citizenship (p. 39)." Jennings first identified what had been the predominant approach to genetic literacy: the public health model in which prudent consumers of genetic services are able to make informed choices in response to genetic information that is provided to them by a healthcare professional. He proceeded to define a broader notion of genetic literacy through a democratic model that considers two forms of citizenship that genetic literacy will enable: deliberative citizenship and informed consumerism. The democratic model of genetic literacy that he proposed will help to answer the following questions: (1) what are the nature and effects of genetic knowledge? (2) What constitutes legitimate social control of genetic knowledge in a democracy? And (3) what are the prerequisites for, and conditions of, social and moral learning about genetics in a diverse, pluralistic society?

Guided by Jennings' model, this project draws upon existing research about genetic knowledge and underrepresented groups to offer an approach to genetic literacy that takes into consideration the diverse needs and perspectives of groups who are often left out of technical discourses. For example, Lewis (2004) concluded that it is important to consider students' everyday views to help address the misconceptions that students have about the expression of genes. Venville, Gribble, and Donovan (2005) found that 9–15-year old students' (mis)perceptions about genetics are strongly based on their cultural origins.

For this project, genetic literacy was defined as *the capacity to apply relevant STEM knowledge to make well-reasoned and scientifically grounded decisions about personal and social problems that genetics can address and create*. The specific competencies associated with genetic literacy include:

- A basic understanding of genetic mechanisms in plants, animals, and humans.
- The capacity to think through the environmental, physical, social, and cultural impacts of genetic understanding and manipulation on individuals, the environment and social groups based on ethnicity, SES, race, and gender.
- The ability to act on the assessment of theses impacts based on principles that take into consideration personal, social, and environmental well being.

Methods of Genetic Instruction

Traditionally, genetics is taught based on the classical or transmission model that describes the patterns of inheritance observed when organisms reproduce and the probabilities with which different combinations of genes are likely to occur.

Table 1 Sample Punnett Square

	A	a
A	AA	Aa
a	aA	aa

This model is typically taught using a Punnett Square that allows someone to calculate the probability of a particular offspring's genotypes, given the parent's genotypes. Table 1 is an example of a recessive gene for a disorder (a), where (A) is the healthy dominant gene. If both parents are carriers of the recessive gene for this disorder, their offspring will have all a 25% chance of having the recessive disorder (aa), a 50% chance of being a healthy carrier (Aa and aA), and a 25% chance of being healthy and not inheriting the recessive allele at all (AA).

Punnett Squares are useful to understand the probability of inheriting phenotypes that are determined by a single gene. Many phenotypes have a more complex genetic basis. For example, they can be polygenetic—controlled by more than one gene. Or a phenotype can have incomplete dominance in which there are intermediate expressions of a gene. In another instance they can exhibit codominance, where two alleles can be dominant, or are multi-allele, where there can be three or more possible alleles for a gene (e.g., blood type A, B, and O). Punnett squares are less helpful in understanding these other genetic mechanisms.

Traditional methods of teaching genetics rarely provide students with tools to think more broadly about the big ideas of genetics. For example, analysis of high school biology textbooks revealed that while they did address some of the recent developments in genetics, such as the central dogma of molecular biology (Crick, 1970), they tended to focus on unnecessary details to the detriment of the development of a holistic view of genetics (American Association for the Advancement of Science (AAAS), 2006). In addition, other textbook analyses have shown that there has been an increase in pictures to increase student familiarity, at the expense of schematic and explanatory images (Lee, 2010).

Middle School and Genetics Instruction

Middle school was selected for this project for a number of reasons. There is a lack of learning environments and empirical research in genetics education at the middle school level (Duncan, Rogat, & Yarden, 2009). Little genetics instruction happens at the middle school level and, in turn, many high school students have misconceptions about genetics including problems making the conceptual jump from genes as coding for specific broad traits (e.g., eye color) to genes coding for particular proteins that build cells and tissue. Developing a progression of genetics instruction from grades 5–10, Duncan et al. suggested a curriculum that focuses on big ideas that lead to genetics literacy. "In a simple sense, genetics literacy involves being able to comprehend, use, or respond to information about genetic phenomena and technologies that an individual may encounter in everyday life situations" (Duncan et al., 2009, p. 657). Stewart, Cartier, and Passmore (2005) argued that knowledge of three integrated conceptual models is necessary to truly understand genetic phenomena. The first model is the genetic model (aka transmission model) in which students learn about the patterns and probabilities of inheritance when organisms reproduce. Learning about the second model, the meiotic model, students develop an understating of the cellular processes guided by gene recombination. In the third model, the molecular model, students begin to study the mechanisms that link genes to their biological outcomes. In this project, we addressed the first model while providing reasoning skills to move on to the other two models in later grades.

Project Description

According to Yoon (2008), "a growing body of research has advocated for educational experiences to simulate the discursive practices of scientists and the scientific community that are predicated on language, communication, and argumentation" (p. 901). To develop a learning tool to help to develop some of these discursive practices in middle school students who are being introduced to genetics a partnership was developed between the College of Education and Human Ecology (http://ehe.osu.edu/) and the Advanced Computing Center for the Arts and Design (ACCAD—http://accad.osu.edu/) at Ohio State University. This group partnered with five middle school teachers in one large and one small urban school district to create a genetic simulation and PBL teacher support materials. The program and corresponding materials are targeted for instruction in science, math, and social studies based on the assumptions that students need to develop knowledge from all three content areas in order develop genetic literacy.

The simulation is based on research within the field of interactive evolutionary design. In this field, researchers study problem domains in which a human evaluator must serve as the "fitness function" (i.e., choose which genes are passed to the next generation) using their knowledge and observations as the basis for genetic selection. In an interactive evolutionary design simulation, the user sees the results of parametric manipulation in real time. This innovation in genetic simulation is different from current models used in schools in which the user changes parameters and then the simulation calculates the results. In other words, interactive evolutionary design shows synchronous feedback, while traditional genetic simulations provide asynchronous results. The simulation is being developed using a Java-based environment called "Processing" (http://processing.org/).

Participating School Districts

This project focuses on middle school students because this is a period when many students from underrepresented groups turn away from, are turned away from, and are turned off from STEM subjects (Brickhouse et al., 2000; Parsons, 2008). In addition, middle school students have a sufficient sophistication in their grasp of mathematics, science, and social studies concepts to think through the complexity of the issues that are raised through the conception of genetic literacy that we are suggesting. There is a culture of team and coteaching in middle school that is central to the cross-curricular nature of this project (The National Middle School Association, 2009). Finally, it is important to note that genetics in the middle school curriculum has been underresearched. Most studies have focused on High School contexts, a period that may already be too late for many students to develop a solid foundation and interest in genetics (Duncan & Reiser, 2007).

For this project, we are collaborating with two middle schools: one in a large urban distract and another in a small urban school district.

Filmore City Schools

Filmore City Schools (FCS) (not the real name) is a district in a small urban community in Ohio with a low median household income ($34,791), where nearly 20% of the school age population lives under the poverty line. While the district has fewer available resources compared to more affluent districts, it nearly always meets or exceeds the state Achievement Test passing rate in mathematics in grades 4–8.

In FCS, we are working with a mathematics, social studies, and science teachers from Hood Middle School (HMS) who share some of the same 7th grade students across their classes. Hood has met expected growth in mathematics in all of grades 6, 7, and 8, is near but not at the state required proficiency level in mathematics; it is significantly lower than the required proficiency level in science and social studies at eighth grade, the only middle school grade where the testing is completed in those content areas.

Urban City Schools

Urban City School District (UCS) (not the real name) is an urban school district in Ohio serving over 64,000 students in prekindergarten through 12th grade. In 2008–2009 in grade 8, 36% of the students scored at or above basic proficiency in science, 42% in mathematics, and 21% in social studies. In UCS, we are working with two teachers from Oak Middle School (OMS). OMS is structured into Houses and the two participating teachers cover all the subjects for a House of 40 students in 8th grade. They are a "Project Lead the Way" (PLTW) school (http://www.pltw.org/) that offers Gateway to Technology (STEM) instruction to their students. PLTW is a STEM curriculum that focuses on the critical thinking and problem-solving skills taught in traditional career and technical education (CTE) curricula that also integrates national academic standards.

Cross-Curricular Concepts

This project is being designed to use genetic literacy to help teach middle school mathematics, science, and social studies. To identify the main concepts in each subject area, we referenced the national content standards and consulted with the participating teachers to make certain these topics would be useful to them and their students. We also spoke with all teachers to learn how their students learned content. While textbooks still were the most commonly used methods to deliver information, besides direct instruction, we discovered that teachers also utilize various other forms of representation including videos and web sites.

The following three subsections summarize the main concepts from each of the three subject areas that the production teams is referencing while developing the simulation and the accompanying support materials.

Main Genetics Concepts

1. Inheritance: the process by which genetically linked traits are passed from one generation to the next
2. Parent: the source of an organism's genes
3. Offspring: the product of reproduction, a new organism produced by one or more parents
4. Phenotype: observable physical or behavioral traits of an organism, largely determined by the organism's genotype
5. Genotype: the collection of genes that make up an individual organism
6. Gene: a section or segment of the DNA that controls a trait, the unit of heredity in living organisms
7. Population: a set of organisms in which any two members can breed to produce offspring
8. Characteristic or trait: an observable feature of an organism created by the expression of one or more genes
9. Reproduce: biological process by which new offspring individual organisms are produced from their parents
10. Generation: a group of offspring who share a common ancestry
11. Fitness: the degree to which an organism's traits yield survival and reproductive success
12. Gene pool: the collection of all the genes shared by members of a single population
13. Evolution: adaptive change over time in one or more inherited traits found in populations of organisms

Main Math Concepts

1. Randomness
2. Experimental vs. theoretical probability
3. Multiple visual representations of mathematics knowledge
4. Basic arithmetic skills
5. Proportions
6. Numerical concepts

Social Science Concepts

1. History: Interpret relationships over time and use of time lines.
2. People in society: Compare cultural practices, products, and perspectives of past civilizations to understand commonality and diversity of cultures. Explain how contact between different cultures impacts the diffusion of belief systems, art, science, technology, language, and forms of government.
3. Citizen's rights and responsibilities: Show the relationship between civic participation and attainment of civic and public goals; Identify historical origins that influenced the rights US citizens have today.
4. Government: Explain why people institute governments, how they influence governments, and how governments interact with each other.
5. Social studies skills and methods: Analyze different perspectives on a topic obtained from a variety of sources; Organize historical information in text or graphic format and analyze the information to draw conclusions; Present a position and support it with evidence and citation of sources; and Work effectively in a group.

Description of Simulation

To teach the concepts previously mentioned, the project team developed a web based-simulation based on an interactive evolutionary design model (see http://accad.osu.edu/readingthecode/). One of our primary design goals for this project was to create a tool in which students can explore a variety of topics in science, mathematics, and social studies using genetics as the context. The interface will present different types of visual and numerical data depending on the nature of the problem that we are presenting to students.

The main interface for the simulation is shown at the beginning of this section in Fig. 1. In the simulation, students are initially presented with a grid of randomly generated faces. Each face is composed of about 50 "genes" that determine physical characteristics, (e.g., eye, nose, mouth, and head size and shape), in addition to particular mannerisms (e.g., facial tics, blinking rate, etc.). The faces are designed

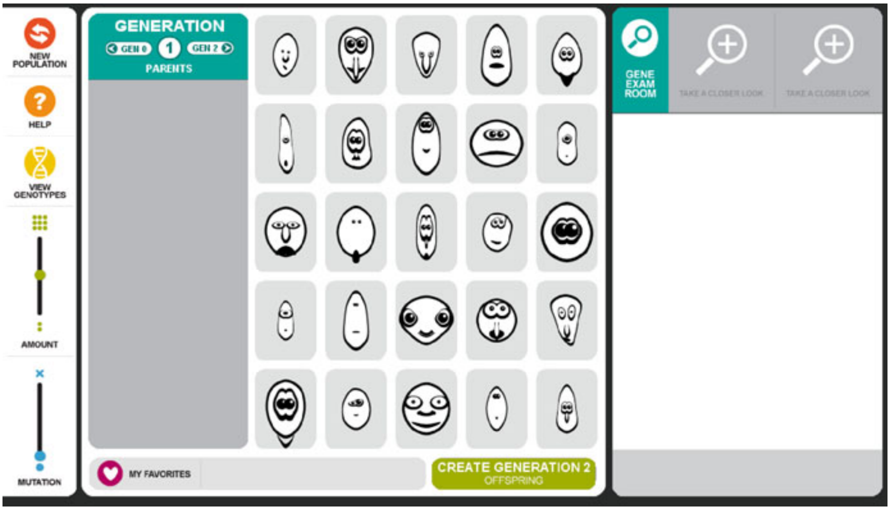

Fig. 1 Opening screen of interface

to be as ambiguous as possible around stereotypical representations of race, ethnicity, and gender thereby allowing students a subjective space to explore their own conceptions of the appearance of particular social categories.

Students choose a starting population of between 2 and 64 faces. From this initial population, students can select a group of faces that become the "parents" for the next generation. No matter how many parent faces are selected to reproduce the next generation, each face in the next generation will only have the genes from two parent faces. Figure 2 shows a screen shot with a histogram visible in which students can see the two parents of each offspring. Students can select a mutation level ranging from 0.0 in which the next generation will only have facial characteristics from their parents to 1.0 in which there is a high degree of mutation with little resemblance to the parents. Once students select a subgroup of parent faces, adjust the parameters, and click on "Reproduce" they are presented with the next generation of faces that are based on the genes from the previous generation selected.

The simulation possesses a favorites feature in which students can save particular face, and its genetic code, into the library. A face in the library can be inserted at any point into a particular generation, allowing students to experiment and try different, "what if" scenarios. By dragging a face into the "Gene Exam Room" area, students will be able to see different representations of the genes that make up an individual including the use of bar and pie charts, along with the ability to manipulate a face's genetic makeup. Because of the complexity of human genetics (humans have about 20,000–25,000 genes), the genetic model that we are presenting will focus more on students learning the genetic concepts that they can later apply to more complex models of genetic mechanisms. Based on our needs assessment with the participating teachers, students will have virtually no existing knowledge about genetic mechanisms when starting to use this learning tool.

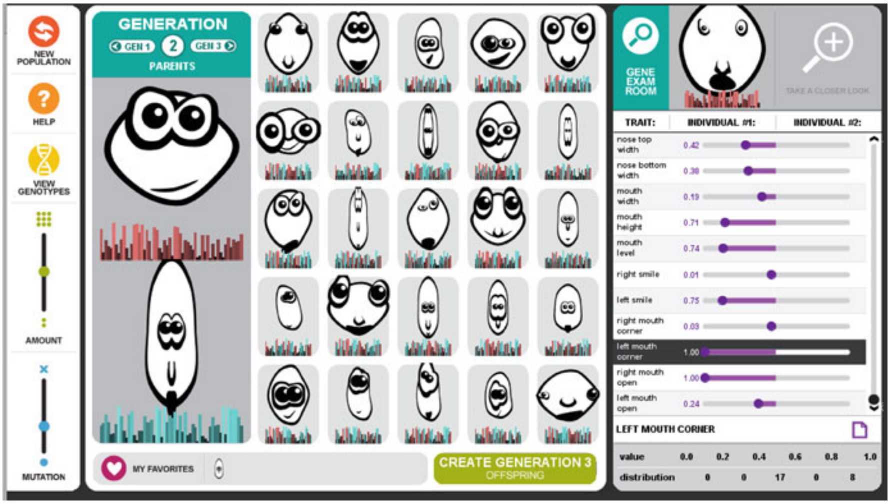

Fig. 2 Simulation in use

One of the early lessons the production team learned from testing with students is that the program is too complex for students to understand the basics of dominant and recessive genes. Most characteristics within the simulation are multi-gene or multi-allele, which are more advanced concepts for students to understand. To address this issue, we have developed a version of the program in which each characteristic has one of the two states (wide or narrow) as opposed to a continuous scale between 0 and 1. Each gene is then randomly designated as dominant or recessive and retains that state until the program is restarted. This random assignment to dominance provides an element of unpredictability that motivates students to return to the program. Through observations over multiple generations, students can then discover which genes are dominant and which are recessive based on their expression. The random assignment of dominance each time the program is run will require it be used in the context of a single class session. Given that this program is a scaffold to the full program, this should not be an issue; however, research will be conducted to evaluate this design decision.

Pedagogical Objectives and Sample Lesson

The program has been designed to encourage PBL. It is based on research supporting the claim that student motivation and learning are high when engaged in well-scaffolded problem-solving activities (i.e., PBL), across subject areas that are directly relevant to students' cultural understandings (Albanese & Mitchell, 1993). Scaffolding involves providing students with a series of increasingly complex problems to solve with a decreasing amount of pedagogical support. In other words, early problems are supported with various supports (e.g., handouts, mini-lessons, a problem-solving heuristic, solutions steps to similar problems), while later problems in a lesson are both more complex and have fewer pedagogical supports. PBL is typically organized with small groups of learners, accompanied by a teacher or facilitator. The process begins with a series of problems that are provided to learners along with guidance about how to solve these problems (i.e., worked examples). After students complete a series of worked examples and gain content and problem-solving expertise, guidance is slowly reduced (Sweller, 2006). As students become more familiar with the content and PBL process, they are given problems that are more complex and realistic. During PBL learners discuss problems, define what they know, generate hypotheses, derive learning goals, organize further work, and communicate results to larger group. The PBL cycle concludes with some form of reflection on the process. Problem-based approaches have been used with success across a variety of subjects including science (Markowitz, DuPré, Holt, Chen, & Wischnowski, 2008), mathematics (Hiebert et al., 1996), and social studies (Moye & Howard, 1998). The following section describes a sample problem scenario and lesson that has been developed for the tool.

Sample Lesson

This lesson assumes that students have successfully completed the simplified dominant/recessive version of the program using some worked examples and understand that genetics involves passing dominant and recessive genes from parents to offspring. The unit was guided by Jennings' three questions about genetic knowledge which ask about: (1) the nature and effects of genetic knowledge, (2) the control of genetic knowledge, and (3) the conditions of social and moral learning about genetics in a diverse society. It was inspired by the recent trend of software companies who attempt to patent broad software ideas by casting a wide net of lawsuits aimed to protect these patents. It is based on the assumption that within a short period of time, similar activities will be commonplace with genes being patented in plants and animals. In fact, this form of gene patenting is already taking place.

The lesson is an integrated unit between a middle school math, social studies, and science class. The overarching question that students will be posed in this lesson asks, "Who, if anyone, has the rights to develop, modify, and ultimately market the genetic information of an organism?" To answer this overarching question, they will seek answers to the following subquestions:

- What "rights", if any, does an organism possess in terms of its genetic information?
- What, if any, are human's moral and ethical responsibilities to the genetic information of an organism?
- Can humans own the genetic information of an organism? If, "yes" what does that ownership grant them? If "no", can anyone do anything that genetic information if they do not claim exclusive ownership?

- When and how, if at all, should legislators be involved in laws addressing the ownership of genetic information? What would be the consequences if genetic mapping, manipulation, and marketing went unregulated?

To answer this larger question, students will participate in a lesson in which they will be placed in one of four groups composed of about six students:

1. A group of genetic entrepreneurs: the entrepreneurs are trying to develop a creature based on a hybrid of genetic material from multiple animals that they have the exclusive rights (i.e., patent) to manipulate and market.
2. A group of biologists: The scientists work for the entrepreneurs and are tasked with developing an organism with specific characteristics.
3. An animal rights group: The animal rights group is lobbying legislators to pass legislation that would prevent the patenting of an entire organism, arguing that the genetic information that they are utilizing exists in nature and cannot be owned.
4. A group of legislators: The legislators are asked to develop legislation that would try to balance the rights of an organism with the investment of the entrepreneurs.

In the lesson, the entrepreneurs are interested in developing a creature in which they have total control over every aspect of its genotype and phenotype. One possible "application" of this creature is creating pets that are totally customizable in terms of their appearance. The scientists work for the entrepreneurs and they have developed the creature from a genetic database derived from multiple animals including primates, dogs, cats, birds, and reptiles. The animal rights group knows that the entrepreneurs will soon be going to market with their creature and are trying to prevent this from happening by lobbying the lawmakers to pass legislation to prevent the ownership of the genetic material of animals. The animal rights group is choosing legislation rather than legal action because there are no relevant laws at this point in time. The entrepreneurs are testifying before the legislators to argue against this type of legislation. They oppose the legislation arguing that the process that they use to develop the creature is no different from any other patents. The scientists would also testify to describe the processes that they use to develop the creature. The legislators would hear arguments for and against this legislation from the three other groups and be asked to formulate a law based on the stated problem and that takes into consideration all of the testimony.

Within this integrated lesson, students could only solve the defining lesson problems by completing specific lessons, activities, and projects in all three content areas. Students would do different activities in their math, science, and social studies classes that would all contribute content knowledge and problem-solving skills to argue for and against different positions related to the ownership of genetic information. The following sections describe how each of the four groups will engage with subject matter content in the three classes.

Mathematics: One of the main mathematics concepts that students are going to be working with using this tool is the representation of numerical information. The simulation interface provides a variety of opportunities for students to read different representations of the same numbers so that they can approach and solve problems from different perspectives, depending on the representation that makes the most sense to them. All four groups will engage in one or more of the following target concepts of the project including: randomness, multiple visual representations of mathematics knowledge, basic arithmetic skills, proportions, and numerical concepts. Our partnering teachers told us multiple times that students often struggle with both reading numbers and creating numerical representations of numbers. The scientists who are employed by the genetic entrepreneurs will develop some sample creatures whose features have specific proportions. They will show how they are able to reproduce certain appearances using the simulation and how they can reduce mutation to have predictable results. The genetic entrepreneurs will create a presentation for the legislator that shows the cost of the process that they use to create the creature and that shows how long it will take to recoup their investment. This group will present a handout of the costs that are associated with genetic development (e.g., equipment costs, lab costs, failure rate of experiments, time between experiments, etc.). The animal rights groups will respond to this aspect of the entrepreneur's testimony by disputing their calculations and potential profit and return rates. The legislators will interpret and make decisions based on the numerical information that are given to them by the scientists, animal rights groups, entrepreneurs. Another component of the mathematical aspect of the program will involve understanding microeconomics, a topic covered in the social studies curriculum.

Social Studies: Because the simulation allows for students to become genetic engineers and manipulate individual characteristics, students can be provided with opportunities to think about the larger issues of governance, rights, diversity, and ethics associated with animal (including human) and plant genetics. All groups will learn how the lawmaking process works and how lobbying influences legislators. The legislators will run the hearings at which the scientists, animal rights groups, and entrepreneurs will testify. All four groups will be provided with a lesson and handout about rights as well as one about ethics. Students will be asked to grapple with ideas about what rights animals and humans possess. In addition, they will learn about the basics of ethics including the process of defining morals and making moral decisions, in addition to balancing individual with group rights. As was previously mentioned the students would engage with content around microeconomics and macroeconomics. They will learn about basic microeconomic concepts including how to determine cost, prices, and profit. Looking at macroeconomics they will consider the dynamics of supply, demand, and monopolies.

Science: While the scientists will be directly involved with genetic mechanisms as they develop the creatures, the other three groups will also have to engage with scientific knowledge as they either make their case or make decisions based on testimony. An important issue that all groups must confront and the legislators must adjudicate is the question, "if one can manipulate a biological process, should one engage in this practice?" While the entrepreneurs and animal rights groups will have a more polarized perspective, the other two groups will need to engage in a more balanced approach based on their philosophical approaches to ethics and morals. The work in the science class will allow students in each group to better understand the processes that are at work in developing the creatures. It will show that science is not a nonneutral enterprise and that scientific knowledge can be contextualized within particular perspectives and take on new meanings.

How Will This Project Contribute to Genetic Literacy?

The definition of genetic literacy that guided this project includes the capacity to apply mathematics and science knowledge to form opinions about the implications of genetic knowledge and manipulation and take action based on those opinions. The assumption is that an individual will need knowledge in all three domains (math, science, and social studies) to be genetically literate. Because the literature review and needs assessment conducted for this project revealed that middle school students often have limited knowledge about basic genetic mechanisms, the project team prioritized the learning of basic genetic transmission mechanisms as a design parameter for the simulation. The integration of mathematical thinking and representation into the simulation will provide students with an opportunity to collect and communicate "facts and figures" to ground their opinions and actions. The social studies concepts in which they will engage will offer students "mechanisms for action" so that they can develop applications for their opinions within the contexts of real histories such as eugenics and real social mechanisms including governance (regulations, laws, constitutional protections etc.) and market dynamics.

Three primary goals will be pursued as the project moves forward. Now that the first version of the program is complete and publicly available (http:/accad.osu.edu/readingthecode/) we plan to work with our partnering teachers and with other interested educators to develop a set of lesson plans that are either integrated across the subject areas or are specific to a subject. The objective will be to make these lesson plans available on the website so that teachers can use them as a basis for their own lessons across a variety of learning contexts. Next we plan to conduct research to help determine the capacity of the program and accompanying lesson plans to help students to learn the target concepts for each of the subject areas, as well as, developing problem-solving skills to try to understand increasingly complex questions related to genetic literacy. This research will both guide future versions of the simulation and more importantly provide insights into how to teach genetic literacy to middle school students.

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Correlating Problems Throughout an Interdisciplinary Curriculum

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At Washington & Jefferson College, students can major in Information Technology Leadership (ITL) with a focus on Computer Science, New Media, or Data Discovery. The program integrates content found in traditional Information Technology and computer science curricula to form an interdisciplinary computing major that integrates strongly with the liberal arts tradition. As a result, the ITL program emphasizes not only the development of technical skills but also the deep understandings and critical thinking abilities that will make students future leaders in various technology fields. This chapter describes our experiences implementing problem-based learning (PBL) throughout the Information Technology curriculum at Washington & Jefferson College. We begin by quickly defining PBL, articulating some key definitions, and then illustrating some of the challenges that present themselves to students and faculty. We then continue by describing how PBL can be applied to computing education and give examples based on our own curricular development.

In all ITL courses, students learn about the historical and social contexts of technology, as well as leadership and ethical issues surrounding technology implementation. Additionally, all students study multiple methods of problem solving, and the interaction between technology and its users. Three important learning objectives underlie all of our courses. The first is that students graduate with a robust understanding of the interdisciplinary nature of computing—specifically that students understand how technological solutions can be applied to various fields of knowledge. The second is that students graduate with strong leadership skills, including an aptitude for effective technical communication, and strong project management abilities. The third is that students are able to develop flexible problem-solving skills using their technical expertise and effective communication and project management abilities.

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As we have developed this program, we have observed great success as we have deployed a PBL pedagogy—not only in individual courses but also throughout our entire departmental curriculum. By focusing primarily on problem-solving skills that are used across domains, we equip students for the diverse set of problems they will face upon graduation. This enables graduates to participate much more fully in the field than they would be able to if our focus were merely the development of technical skills. Graduates of our program have gone on to graduate studies in information security, IT management, web development, and entertainment technologies. Others have pursued traditional programming and system administration careers. Still others have pursued entrepreneurial ventures and branched out into human resources and technical writing.

Defining PBL

PBL appeals to educators that hold to a cognitive constructivist epistemology, suggesting that learners gain more through relating educational material to real-life experience, and that such experience informs their ability to conceptualize content (Duffy & Jonassen, 1992). Constructivism calls for learning opportunities that are experiential, active, collaborative, and that also develop problem-solving skills (Jonassen, 2000). Rather than passively absorb and relay information, learners need to actively engage with content, work through it with others, and effectively solve problems with the gained knowledge.

PBL requires and reinforces the role of students as self-directed learners. This underscores the importance of student motivation in achieving success with the process. When students have responsibility for the solution of the problem, learner motivation is increased (Savery & Duffy, 1995).

Problems need to be ill-structured so that students are free to pursue any direction of inquiry. This does not mean that there is no structure to the process as some might suggest (Kirschner, Sweller, & Clark, 2006). But rather, a looser structure governs learning and allows the student to maneuver in several different directions under the guidance of an engaged instructor. Moreover, the approach orients students toward making meaning from content rather than simply gathering information (Rhem, 1998).

PBL has seen its largest and earliest adoption in the medical education field (Boud & Feletti, 1997). However, much of the recent literature explores PBL outside of medical education. In this chapter, we explore the use of PBL in computing education. For an in-depth discussion of PBL, please see Savery (2006).

PBL vs. Project-Based Learning

One important element to recognize in regard to PBL is that it is not project-based learning. While it is true that the PBL often takes the form of projects, the activity of doing project work in and of itself does not constitute PBL. Rather, solving the defined problems based on the content knowledge that is generated by the project is the purview of PBL. Solving the problem is integral to the process, as students use the content provided along with their own experiences to construct knowledge relating to the problem at hand (Collins, Brown, & Holum, 1991). Thus, PBL and project-based learning are quite similar in that there is a shared goal of successfully completing an activity. However, they differ in that projects typically possess more structure to an explicit goal and also possess more direct guidance from the instructor. Problems, on the other hand, focus on the learner's role in identifying outcomes and parameters for success as well as attending to the educational task (Savery, 2006).

This is a particularly important point to emphasize as we describe the ITL curriculum at Washington and Jefferson College. Within this curriculum, we implement numerous projects while instituting an overall PBL approach. At the introductory levels, these projects are more defined and structured. In fact they could stand alone as clear implementations of project-based learning. However, these projects are simply elements of larger, overarching, course problems. The ITL curriculum employs more defined projects as a structure for piecing together content that students can then use to build their own answers for the problems presented throughout the course. As students advance through the curriculum, these projects become less defined, and the problems presented through the coursework become more ill-structured. So when thinking about PBL in relation to the curriculum for computing education at Washington & Jefferson College, it is important to remember the *problem* component, and not confuse it with the project. Throughout the remainder of this chapter, we draw upon this distinction fairly regularly.

Of course, other schools and programs have implemented PBL throughout their curricula. Certainly medical schools have been doing this for decades (Barrows, 1994). And, the University of Delaware has a broad-based program for implementing PBL throughout various disciplines (University of Delaware, 2011). They maintain a clearinghouse of information, syllabi, sample problems, and literature, as well as links to other institutions that are pursuing a PBL approach to undergraduate education. These resources address PBL in various curricular contexts, but our work here addressed PBL within the specific context of computing education.

Relating the PBL Approach to Traditional Computing Education

Several principles have emerged as driving forces toward our acceptance of PBL as the pedagogical approach for achieving our instructional goals in the ITL program. From a curricular standpoint, PBL specifically provides a unifying context for the content of our individual courses. Students must bring together many concepts from previous courses to solve the problems they encounter at each level of the curriculum. While PBL can be applied in any discipline, its appeal for computing education is evident since many courses (e.g., programming and visual communication) require the cultivation of problem-solving abilities in order to effectively address the theoretical knowledge covered within the course and not simply the acquisition of computing skills. Further, the rapid advances within our field make it particularly important that students understand how to be effective self-directed learners. Students are supported in self-directed learning when they are given opportunities to practice the necessary skills of managing their own learning, including time management, goal awareness, and appropriate use of peers and faculty in supporting their learning (Pintrich, 1995). We have found through our experiences and observations that PBL assists with the development of self-directed learning skills; and this impression is reinforced by findings from different fields including chemical engineering and medicine (Woods, 1996; Schmidt, Vermeulen, & van der Molen, 2006).

The PBL approach is not commonly found in computing education. Nonetheless, we think it holds great promise for helping computing education curricula reach the goals and standards set out by the Association for Computing Machinery (ACM). In the ACM's 2008 computer science curriculum interim revision, six ideal characteristics of computer science graduates were identified and described: a systems-level perspective, an appreciation of the interplay between theory and practice, a familiarity with common themes and principles, significant project experience, attention to rigorous thinking, and adaptability (ACM, 2008). From our experiences at Washington & Jefferson College, we believe that the PBL approach directly supports the last three characteristics and, with a careful selection of problems, can develop the first three characteristics as well. Our efforts within this chapter are to illustrate some of the challenges presented by developing a PBL curriculum, and to articulate the successes we have seen thus far.

Student Experiences and Instructor Challenges: By Course and by Curriculum

Leading students through the process of PBL is by no means easy. Developing good problems for students to solve is a challenging and critical step in providing effective instruction (Duch, Groh, & Allen, 2001). Fortunately, there are some good guidelines available for helping instructors develop successful problems (Hung, 2006). To be successful, these problems need to be reasonably understandable as students begin developing their problem-solving skills, but increasingly ill-structured as students progress throughout their coursework and classes (Savery, 2006). Quality problems must have solutions that are discoverable based on the knowledge students can be expected to possess and gain during the course. Further, good problems must also serve students working with different styles or at differing levels within a given class (Sockalingam & Schmidt, 2011). Considerable instructor time must be devoted to formulation of problems. Furthermore, PBL requires real investment in direct work with students, as the instructor must be available to mentor students in the problem-solving process as well as course content. Such mentoring diminishes as students become more capable of independent problem solving; but at the introductory level, this mentoring requires skilled guidance and focused attention on the part of the instructor to remain effective. At the advanced level of coursework, this mentoring can look much more like a faculty student research project (Pierrakos, Zilberberg, & Anderson, 2010).

The challenges of PBL present themselves for students as well. One of the frequent complaints that we hear from students is that they are being asked to do things they "have not been shown how to do." Invariably, this means that instructors have shown the students the pieces that are required to solve the problem, but have not shown them explicitly how these pieces fit together. From an instructor's perspective, this restraint in instruction is purposeful: the process the students need to follow has been illustrated and practiced, but the students are now expected to discover how this process applies in some new way. To the student, this experimentation may seem to "get in the way" of the immediacy of completing the observable task for a grade. However, without experiencing the process of experimentation with possible solutions and possible mistakes, students will not become self-sufficient problem solvers. This results in some noticeable discomfort on the part of some students. Savery (2006) wrote:

> The reality is that learners who are new to PBL require significant instructional scaffolding to support the development of problem-solving skills, self-directed learning skills, and teamwork/collaboration skills to a level of self-sufficiency where the scaffolds can be removed. (Savery, 2006, p. 16)

Inducing some discomfort while pushing instructional boundaries can be a good thing. Nonetheless, the focus on independent problem-solving and student-directed exploration encouraged in PBL can lead to situations where novice students feel overwhelmed by the degree of flexibility they have been permitted (Kay et al., 2000). This is an issue that all PBL instructors need to address. But at the same time, some students assume that they will simply be asked to complete highly structured problems that resemble the problems they have already been shown in class. These students assume that with a few adjustments, they can solve these types of highly structured problems by simply applying the same steps that they have already learned in the course. These students may not be familiar with the complex steps required to deconstruct a problem into its parts to search for a solution. It is important to understand this disconnect between students' and instructors' perceptions of what a problem is, because this disconnect can lead to misunderstandings between student and instructor that must be addressed (Ben-David Kolikant & Ben Ari, 2008). Recognizing this problem can enable the instructor to prepare for mentoring students through this process and helping them realize that this is a normal part of the problem-solving process.

But the challenges inherent in PBL as experienced within a single course are also present when considering the application of PBL approaches throughout an entire curriculum. This means that the challenges individual instructors face also present as issues for all faculty of the entire course of study. One area where this becomes particularly clear is with the occasional disassociation between students and faculty regarding the course objectives and the content they will be exploring. For instance, students often enter computing coursework at Washington & Jefferson College with an interest in the particular tools that they will be using, the software they want to learn, or a desire to construct the types of products they see other students generating in these courses. These goals are natural—and in fact provide good motivation to the students as they pursue difficult tasks—but few students enter our courses with a stated intention of becoming better problem solvers. Instead, they enter wishing to learn Java or Photoshop, build a video game, or perhaps create dynamic web sites. An appreciation for the general skill of problem solving comes only later in the curriculum, or more commonly, after graduation. Thus, we face a particular challenge when making this pedagogical approach central to our curriculum, since it sometimes generates student resistance.

Early iterations of PBL experiences in beginning courses can be designed to address this challenge. If instructors exhibit for students an alternate model for problem definition and solution, they can then introduce students to a cognitive approach that helps them develop their own problem-solving abilities. While it is appropriate to allow students a certain degree of mental discomfort and uncertainty, it is important that the creative leaps they are asked to make are within their grasp and that they can see a path to success with reasonable effort on their part. Our challenge, then, is to allow students to experience frustration without giving up. If the problem is too simple, students are likely to (a) study it only superficially and (b) exhibit poor motivation (Hung, 2006.) By applying a PBL approach across several courses within a curriculum, we can lead students effectively along this path of negotiating frustration and achieving success, with the end result of decreased student resistance and improved motivation.

PBL for a Computing Education Curriculum

With these challenges in mind, we developed our PBL approach to impact the entire curriculum of the ITL program at Washington & Jefferson College. Given the centrality of problem solving to the entire breadth of our computing curriculum, it seemed unrealistic to expect students to achieve a high level of proficiency during a single course. Rather, we viewed complex problem-solving skills as something to be developed over students' entire college careers. For novice problem solvers, simply learning that there may be more than one way to approach a problem—and that exploration is encouraged—may be a large enough step for one course. Certainly for some students, it seems to be a new idea. That realization in itself can set students up for greater success in later courses that presuppose an initial comfort with a PBL approach. It is for this reason that we use PBL as a framework for our entire curriculum as opposed to specific individual courses. The curricular approach provides an opportunity to address the significant criticisms related to PBL, specifically that students are unlikely to integrate the knowledge learned (Lieux, 2001). Approaching this at the curricular level provides opportunities in each course for integrating prior knowledge and reflecting upon the interrelations of that previously learned content.

The quick and easy answer is certainly the first that most students will reach for—and the one they desire most from their instructor! But the answer that results from working through a problem is the one that students tend to remember when reflecting on their work later. And when students are encouraged to develop their own problem definitions and solution strategies, faculty must plan on spending additional time to support these efforts—not only directing students toward additional content knowledge, but also by facilitating the problem-solving process. We have found that mentoring students through their individual struggles solving problems can be very time intensive. Therefore, if done well, PBL approaches can reflect an increase of workload as well as learning, and everyone needs to plan accordingly for that reality.

When applying PBL across a curriculum, we suggest a graduated approach for problem solving as well as content as students move from entry-level courses to more advanced material (Angeli, 2002). This means that instructors should plan on entry-level courses that introduce students to the process of problem solving throughout the course with a few projects or activities, and underscore the fact that students will be asked to approach course problems with a willingness to explore different solutions. Our department's experience has shown that in introductory courses, starting with minor projects works better than "throwing students into the deep end" with a large project that constitutes a significant portion of their grade. This approach also provides an opportunity for significant class time to be devoted to introductory content. And this introductory content is an important element for having the basic content knowledge necessary for more advanced problem solving that appears later in the curriculum. Instructors should expect to provide a fair degree of guidance at this introductory level regarding how particular problems might be defined, leaving students with modest gaps to fill in as they develop their own understandings of the problem.

As students progress through a program of study, they gradually take increased ownership of their learning and experience the pitfalls and dead ends that occur through a realistic problem-solving process. The scope of the problems they are expected to solve increases in complexity, and the degree of guidance they are given about how to solve the problem decreases. Problem-solving projects become a much larger portion of the students' grades for the term, and represent a greater amount of effort on their part. As students work through multiple courses, they must draw upon their earlier coursework to solve problems in later classes (depending upon course prerequisites). In fact, some higher-level content may only be accessible to students once they have solved problems indicating a thorough understanding of certain significant concepts covered earlier in the course—or in earlier courses. Eventually, students are typically able to effectively solve more complex problems; and by the time students are finishing the curriculum, we challenge them to tackle a significant real-world problem and produce results satisfying a real-world standard. This project work consumes the entire final term of the students' senior year, and requires them to address multiple problems relating to the planning as well as the implementation of their problem-solving techniques.

A Student Introduction to Problem Solving

Not all problem solving that we ask students to do takes place in a technical context. For example, all majors and minors in our program are required to take a 100-level course, IT & Society, which introduces students to the history of and social issues in computing. This is a reading- and writing-intensive course. While students usually enter this course having already completed an English composition class, we focus on the particular difficulties students have in reading technical content, judging the credibility of various sources, and formulating a cogent argument. Students learn how to write technical content that is accurate and appropriate for the intended audience. Our goal in this initial course is largely to make students aware of the complexities they will have to face when reading and writing about technology.

For example, students often enter the course poorly equipped to extract important details from technical writing that can be applied to a particular problem. They lack the ability needed in upper-level courses to read about a technique or algorithm and implement it in order to reach a higher-level goal. In order to guide students toward this necessary analytical skill, ITL 100 instructors explicitly model effective reading. Faculty also give samples of questions students should ask themselves, and require that students practice answering those questions. Instructors also read with students and discuss the focus of that reading. By explicitly modeling the analytical complexities of reading at the introductory level, faculty set the stage for students to practice this skill effectively and independently at the upper levels.

With 100-level courses required of all students, each student is guaranteed to get the same initial experience of solving a significant problem while being supported through detailed guidance. By the time students have reached the 400-level capstone course, they have also been exposed to numerous opportunities to deconstruct problems and build solutions. The capstone is also a shared experience that brings students from all three areas of study back together to work on broad real-world problems. Regardless of the subject matter specialization selected, students are expected to enter that course prepared for the independent, real-world problem solving required of them during the capstone experience.

Relationships Between Courses

To express how we implement PBL across the entire curriculum, Table 1 illustrates how select courses in New Media shepherd students through an intermediate offering toward high-level and more independent problem-solving tasks. These examples also show the increasingly ill-structured nature of the problems, as students acquire more of the responsibility for problem definition in the advanced course. This chart is not an exhaustive listing of every type of problem students would encounter, but it describes a major project for the two representative courses listed. Depending upon the content covered, other courses might build similarly but in different directions in response to the initial problem-solving abilities of the students.

Table 1 Relationships between New Media courses

Course: New Media (Content Level: Intermediate)***

Problem: Searching for a job upon graduation from College, you have been granted an interview by one of your top prospects. You have been asked by this potential employer to present a portfolio of work demonstrating your technical abilities, as well as your understandings of how viewers make meaning from imagery. The interviewer has suggested that you bring in a selection of 15–20 pieces of work that are representative of your experience with different types of visual content. They have also asked for a short written statement regarding your work.

You should consider the following questions as you plan your development work: How will you select these pieces? What type of work would be representative, yet complimentary? How will you write about this work, in a way that is meaningful to the reader?

Project: Develop a portfolio of digital imagery that illustrates the concepts of visual communication that have been covered in class. Carefully identify (through writing) methods for manipulating or reinforcing visual literacy. Develop technical skills in imagery production than enable the creation of meaningful content, and produce a 15 image portfolio with accompanying text descriptions. (4 weeks duration.)

Level of guidance:	Learning objectives/outcomes:
• Instructor models numerous examples and techniques for developing digital imagery. • Instructor lectures early in course provide basic understandings of visual communications theory. • Instructor provides indication of time needed for model tasks. • Students complete their imagery individually, but consult with peers in class and laboratory settings.	• Understand basic technical processes for creating digital imagery. • Develop a theoretical grounding for visual literacy and relate that to student development work. • Manage completion of project and subtasks on a schedule defined by the student. • Identify ways to collaborate with others, without necessarily producing specific results.

Course: Web Design & Development (Content Level: Advanced)

Problem: Your team has been retained by a local nonprofit organization to address their need for an updated web site. Their technical expertise is quite limited; however, they have collected the content they need for the new site (both text and imagery). Since you have the content, your focus will be on the design and development of the site. The client wants to know why their site is not more successful, and what they can expect as a final deliverable from a web site redesign. How will you critique the current site, and how will you justify this critique? Also, how will you show the client what they will be getting after your project work is complete?

Once you have answered these questions, discuss the project with your instructor and deliver the planning documentation also. Do this before proceeding to the development process of the project.

Develop a new web site for the client. Make sure that the new design operates correctly on all major platforms and browsers. Be sure to address the question of how mobile devices would interact with this content as well.

Project: Working collaboratively in groups, select a preexisting web site requiring a significant degree of redesign. Specify the problematic nature of the current design, and then develop planning documentation regarding the design to be implemented. Create the new site and code appropriately. (3 weeks duration.)

Level of guidance:	Learning objectives/outcomes:
• Instructor lectures early in course about basic coding syntax. • Example projects are provided, but students must select the site to be redesigned. • Students must identify design problems and develop a course of action for addressing them. • Instructor establishes deadlines, provides feedback, and approves redesign planning documents. • Class time is spent with groups discussing approaches and timelines among themselves.	• Recognize ancillary programming expertise that needs to be developed. • Identify project challenges and attentively select an appropriate site to recreate. • Propose a feasible task decomposition of a significant project. • Meet regular team obligations, with occasional instructor support. • Develop group problem-solving skills in a structured environment.

In the New Media course, many concepts are practiced through classroom exercises directly connected to the material, and then are used to complete the portfolio project. However, the student needs to determine how to tie these techniques together to create new work that is meaningful and capable of decoding by a wide audience. It is also the student's responsibility to determine which concepts are important and should be discussed through their writing. And this is where the problem is addressed—by figuring out what content is important and creating a series of arguments to support those decisions.

In the more advanced course, students are required to draw upon their knowledge of image production to help them in developing useful interfaces and relevant imagery to serve as a part of the overall communication from the web site designs they implement. Further, when students are asked in Web Design and Development to create a plan for solving their problem, they are required to think back to the basic design principles that they were taught in the New Media course, and to make sure their web site redesigns reflect those principles. This interrelation to earlier content is not specifically dictated by the projects used to examine the problem; however, as a part of group discussion and faculty mentorship, it is an element that is always covered.

But consider how a student might progress through an entire thread of the curriculum. Table 2 illustrates examples from another curricular focus within the ITL program: Computer Science. It lists examples from every level of the coursework in the curriculum. The descriptions demonstrate how the problems become increasingly ill-structured over time, and hands-on guidance by the instructor diminishes when students advance to higher levels of coursework. It further indicates the diversity of the reduction in direct guidance and the increase of student responsibilities as the coursework progresses through all the levels of instruction.

In the lower level courses, students do not always spend the entire course solving one overarching problem for that specific course. Instead, smaller problems are presented to students to work through as they discuss the projects they completed and the content knowledge they created. For example, in the programming course, each concept is practiced during class, and weekly homework assignments require students to combine a few of these concepts to solve a relatively small problem. As the course progresses, the in-class activities often take the form of giving students a broad problem to try to solve, sometimes in the context of pair programming activities. After the students have had time to think about the problems—having the instructor model their own problem-solving process at the front of the class—students begin writing code, and naturally face false starts and the expected creation of bugs that require fixing. All these classroom activities provide students with the necessary background to succeed with the larger problems presented at the end of the course. They also begin the process of developing the core content knowledge for addressing more complex problems in later courses.

So, the introductory course in this example provides basic content for building knowledge. But it also illustrates the way in which the curriculum increases student understandings through the sequence of courses. When students are asked in Data Structures (the intermediate level course) to create a plan for solving their problem, they are explicitly told to think back to the project specification they were given at the end of Introduction to Programming and to model their plan after that.

Thus, students not only have a model of what they should be doing, but also view the problem as a subset of components from their previous coursework. This also serves as an explicit attempt to encourage students to reflect upon the interrelatedness of the content they study (Hung, 2006).

This pattern continues when it comes to the interactions instructors have with student teams in intermediate versus advanced level courses. For the data structures project described in Table 2, the project focuses on storing and efficiently accessing the collected data. This project could have expanded to a point of intractability, given the knowledge of the students and the timeframe for the project, and a

Table 2 Relationships between computer science courses

Course: Introduction to Programming (Content Level: Introductory)

Problem: You are a recent hire at a company that produces remakes of classic computer games for their web site, and you have been assigned to produce their implementation of Missile Command. The project manager, designers, and marketers have already met to determine the look and functionality of the game, and the project manager has provided implementation guidelines to ensure that your code adheres to company standards. You have also been provided with some basic framework code that has been used in other games the company has produced. Within these guidelines, you need to produce a Java implementation that is correct with respect to the specification, has been thoroughly tested, is efficient, and has been well documented.

Project: Implement the *Missile Command* game using threads and arrays, and following the provided specification (2.5 weeks duration.)

Level of guidance:	Learning objectives/outcomes:
• Relevant sample code for given threads. • Specification to use arrays to store data about incoming missiles and active targets. • Provision of basic equations for distances between points, etc. • Instructions on testing for each subtask. • In-class exercises generating code directly related to the more complicated subtasks.	• Understand and add to provided code. • Create a longer implementation out of components the size of previously completed assignments. • Successfully work with a specified data structure across all components of a project. • Manage completion and testing of subtasks on a schedule.

Course: Data Structures (Content Level: Intermediate)

Problem: You are on a team tasked with the development of a large company or organization. Right now, the organization takes in a significant amount of data for bookkeeping purposes, but the question has been raised of whether this data could be put to better use.

You and your team will look at the data and propose a useful tool that can feasibly be constructed in the time allotted. Work closely with your instructor to resolve this into a clear problem statement as well as a timeline and work breakdown for the coming month.

Given your problem, your team should set as their first milestone to select the best data structure to support the entire breadth of operations desired on the data set. Prepare and have approved a justification of your data structure selection before proceeding. From there, follow your timeline to complete a full, efficient implementation of your tool. Your final tool should be accompanied by a report describing the tool's runtime behavior and why your implementation choices represent the best tradeoffs between run time and storage space for the overall set of all possible actions within the system.

Project: Identify a significant set of publicly available data, and propose an interesting implementation project using that data which requires significant data manipulation. Specify the complete set of operations to be done on the data, the data structure to be used (with justification of your choice), and a timeline for completing the project. Create the specified tool, ensuring that your code is correct and efficient, and prepare a report justifying your implementation choices. (6 weeks duration.)

(continued)

Table 2 (continued)

Level of guidance:	Learning objectives/outcomes:
• Sample projects suggested, but students must provide details and identify project. • Weekly graded deadlines set for project review and feedback by team members and instructor. • Explicit statement of task assignment to team members for each week required and approved. • Data structure choice and implementation strategy approved at first weekly deadline. • Class time spent meeting with groups, discussing approach and timeliness of progress.	• Propose a feasible task decomposition of a significant project. • Select and argue for the appropriate data structure and algorithms for the selected project. • Meet weekly team obligations, with occasional instructor support. • Implement and use studied data structures and algorithms following agreed upon interfaces. • Develop group problem-solving skills.

Course: Artificial Intelligence (Content Level: Advanced)

Problem: Your team has been hired as consultants for a local company to advise them on emerging technologies. Specifically, they know that artificial intelligence has been used effectively by their competitors and would like to know what the discipline might do for them as well. Your task is to present an overview of a relevant artificial intelligence technology or technique as well as a mock-up of how the technology could work for the client.

To start, you will select a specific problem that artificial intelligence has effectively been used to address, including citations for current work in the field that will inform your project. Discuss your selection with the instructor before proceeding.

From here, you and your team will prepare two artifacts. First, you must prepare a report summarizing the current state of the art for this technology. What problems can be solved, what are the current limitations, and how does the technology compare to non-AI approaches? This report must be written in language that is clear to a client with a moderate base technical background but no particular knowledge of artificial intelligence. Your goal is to tell them enough about the technology to enable them to decide if it is an area they should pursue further.

In parallel, you will supplement the report with a proof-of-concept implementation of the artificial intelligence technology you have selected. Propose (and have approved by your instructor) a restricted environment, relevant to the client, in which to illustrate the strengths and weaknesses of the technology. Create your implementation, and then prepare a demonstration that shows the range of behaviors of the system on different inputs. You should also collect any data necessary to contrast the abilities of the artificial intelligence technique relative to human abilities at the task.

Your final deliverable to the client will be a written report describing both of these pieces, as well as a demonstration (to be given in class) of your implementation.

Project: Select one of the artificial intelligence techniques that we have studied in class to research in more depth. Determine a problem or industry that could make particular use of the technique. From there, code a proof-of-concept implementation illustrating the use of the technique in that context. Finally, present the results of your research and implementation in a report that describes the current state of the art in the field and makes clear the strengths and weaknesses of the technique. (6 weeks duration.)

Level of guidance:	Learning objectives/outcomes:
• Initial project proposals are given feedback before final proposal is submitted. • Proposal for particular algorithm(s) to employ and reasons for rejecting competing alternatives submitted and approved prior to implementation of project development. • Instructor available for outside-of-class group meetings as initiated by teams.	• Set and manage own problem decomposition, with minimal guidance. • Select and justify choice of the most suitable algorithm out of competing approaches. • Definite standards of success for an open-ended AI problem. • Deliver an extensive implementation as part of a student-run team.

significant amount of instructor effort went into ensuring that the scope of the project was kept reasonable. It was not assumed that the students could yet anticipate what could or could not be accomplished during the time allotted and with the techniques they had learned. The instructor's role was to act as a reviewer on the regular progress reports and proposals for what to accomplish in the coming week. However, this same project could be used very suitably in our artificial intelligence course. In that setting, because of the topic and level of the course, it would be expected that students could determine for themselves what the appropriate scope for the project ought to be. While advice from the instructor would also be available, students would be expected to determine a reasonable set of features to include.

In this way, students become responsible not just for finding a solution, but also for defining the problem itself—an integral part of the problem-solving process that students sometimes fail to recognize (Sockalingam & Schmidt, 2011). By this point in the curriculum, students should realize that the problem-solving process involves important project-planning activities. Thus, they build content knowledge, problem-solving and organizational skills, and work habits as they move from one course to another. Some PBL practitioners have also expressed concern that when PBL is implemented in introductory courses but not followed at the higher levels, the positive retention effects seen early can be reversed as students are faced with a more conventional course formats (Kay et al., 2000). We are convinced by that argument, and it is one of the primary motivators behind our implementation of a PBL approach in advanced courses.

The Capstone Experience

In the capstone course, students partner with nonprofit agencies or organizations to provide IT services. This requires that students apply the real-world robust problem-solving skills they have learned. Rather than representing the end product of a single course, the students' projects are really the end product of an entire curriculum—again, not just the content of that curriculum, but also the independence and critical analysis skills that are intentionally developed through progressive courses. Table 3 lays out the learning objectives and instructor guidance provided throughout the capstone experience.

The emphasis on guidance during the capstone centers on helping students apply problem-solving skills in a real-world setting where money, organizational mission, and the needs and priorities of a client are as important as completion of the project itself. These constraints become an important part of the problem definition and the scope of the project—both of which are developed by the students in consultation with the clients. This is possible because of the shared preparation that all students taking part possess—regardless of the specific technical expertise they might possess. So, students with backgrounds in Computer Science, New Media, and Data Discovery all work together and combine their strengths while addressing their weaknesses through collaboration. They discuss these strengths and weaknesses as well as what they have learned through comprehensive weekly classroom discussions where each team updates the others on their work.

Table 3 The capstone experience

Course: Service Learning (Capstone course)

Problem: You have been retained by a nonprofit organization to assist them with their ongoing IT challenges. They have very limited staffing and similarly limited funding, and thus they have recurring technology problems and need additional help to address them.

You will need to collaborate with the nonprofit organization to identify their specific IT needs, define the problem(s) that your team will address, and then implement a complete solution. (Students define problem through a scope statement and also determine the criteria for success themselves.)

Project: Working in teams of 3–4, design and implement a solution to a current technology problem facing a local nonprofit organization. (Entire semester duration.)

Level of guidance:	Learning objectives/outcomes:
• Instructor introduces team members to organization liaison. • Deadlines given for initial project scope document and final deliverable. • Presentation of scope document to department faculty with feedback provided. • Instructor leads general course discussions related to readings on project management. • Departmental faculty available, at student initiation, for consultation on project issues.	• Student teams manage relationship with and needs assessment for organization. • Student teams internally manage establishing deadlines and task assignments. • Clear documentation of technological alternatives considered and justification of choices. • Appropriate training provided for organization. • Successful resolution of organization's problem, with specification of further steps needed as called for.

Closing Thoughts

While students may begin their work in ITL unaware that problem solving is a skill they must learn, by the time they graduate they are capable of explicitly discussing this issue and how they must adapt their problem-solving strategies to the requirements of their academic work. Our curricular model, with 100-level courses that instigate PBL approaches required of all students, ensures that every student gets access to the same initial experience of solving a problem while being supported through more detailed guidance. This preparation enables students to progress to advanced problem-solving activities in more advanced courses, culminating with our capstone course. This ensures that graduate will be capable not only of using their technical skills but also of solving authentic problems. We believe this is the culminating work of curriculum development as well as pedagogical approach.

PBL serves as a valid method of instruction for individual assignments and courses. Our purpose in this chapter has been to argue beyond those familiar parameters for how its potential can be leveraged for the delivery of an entire curriculum. This is not a new idea—it has been the basis of curricula in the medical field for decades (Barrows, 1994). But it is not an approach that has been widely discussed in computing education, and that is where the experiences from the development of the ITL curriculum at Washington & Jefferson College can be most useful. Based on our experience as faculty, we believe that PBL can be incorporated into multiple courses within computing education, so that those courses can build upon one another in method as well as content and learning objectives. As a method of instruction, we have found PBL to be quite effective. The approach has strengthened students' understanding of the content and enhanced their critical thinking skills. And in the end, it helps us provide a context for the content of these courses, resulting in graduates who can go on to solve technical problems on their own.

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Ethical Angles on Service Learning

Nick Eastmond and Jonathan M. Thomas

Service learning is defined in this chapter as educational experiences that provide a contribution beyond the confines of the classroom or university setting. Examples could be a student project completing a study for an outside agency or for an organization internal to the university, fundraising for a socially worthwhile end, or providing help to a community service effort. Service learning can sometimes be used to generate revenue, either for the students or for student causes like scholarships or funding internships. Furthermore, instructors who use a service learning pedagogy should ensure that genuine help is provided to the beneficiary. This chapter will discuss the use of service learning as a pedagogical method and the ethical implications associated with using service learning in authentic teaching situations.

Brief History of Service Learning

Even though its philosophical roots date as far back as the writings of Aristotle and Plato, service learning was not closely examined at the University level until the late 1980s. Hollander and Meerpol (2006) cited a backlash against the "me" generation of the 1980s as one reason behind the movement toward service learning by universities and community colleges. Indeed, the establishment of Campus Compact (a student service organization founded by University Presidents from Brown, Georgetown, and Stanford) was motivated by concerns about negative media stereotypes which portrayed students as solely concerned with profit motives or their own self-interests (Pomeroy & Bellner, 2005).

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As interest in service learning grew, so did governmental support for these efforts. In the USA, the National Community Service Act of 1990 established a commission charged with supporting the service learning projects in higher education. These efforts were further supported by the Community Service Trust Act of 1993 that established the Corporation for National and Community Service. Even more recently—in 2009—Senator Edward M. Kennedy helped pass the Serve America Act, which provided additional funds to service efforts implemented in the Community Service Acts of 1990 and 1993 (Frumkin & Jastrzab, 2010).

And there is some evidence that these efforts are paying off. According to a recent report by Campus Compact, during the 2009–2010 academic year member schools reported that 35% of the students who enrolled at the schools participated in service, service learning, or civic engagement activities (Campus Compact, 2011). The number of colleges offering service learning opportunities is also increasing. A 2003 survey conducted by the American Association of Community Colleges (AACC) indicated that 71% of all community colleges offered service learning opportunities (Prentice, Robinson, & McPhee, 2003). Beyond that, another 19% expressed interest in participating.

Service Learning Definition

Many definitions have been given for service learning. An initial effort to formally define service learning came about during the Wingspread Conference of 1989, where researchers Honnet and Poulsen (1989) brought together some of the leading researchers in the field to discuss best practices for implementing service learning projects. The document they developed outlined 10 attributes of effective service learning initiatives:

1. Engages people in responsible and challenging actions for the common good.
2. Provides structured opportunities for people to reflect critically on their service experience.
3. Articulates clear service and learning goals for everyone involved.
4. Allows for those with needs to define those needs.
5. Clarifies the responsibilities of each person and organization involved.
6. Matches service providers and service needs through a process that recognizes changing circumstances.
7. Expects genuine, active, and sustained organizational commitment.
8. Includes training, supervision, monitoring, support, recognition, and evaluation to meet service and learning goals.
9. Ensures that the time commitment for service and learning is flexible, appropriate, and in the best interests of all involved.
10. Is committed to program participation by and with diverse populations.

The guidelines provided by Honnet and Poulsen (1989) were an important first step in defining service learning; however, it can be difficult to implement the

Wingspread Conference attributes of effective service learning programs, particularly for teachers who simply want to use service learning as a pedagogical method in their classes without involving larger organizational structures. The definition given by the National and Community Service Act of 1990 is simpler and attempts to define the essential elements of service learning.

The act defined service learning as a pedagogical method that includes the following four components (Markus, Howard, & King, 1993):

1. The opportunity for students to learn and develop through active participation in thoughtfully organized service experiences that meet actual community needs.
2. Structured time for students to think, talk, or write about what they did and saw during an actual service activity.
3. Opportunities for students to use newly acquired skills and knowledge in real-life situations in their own communities.
4. Program features fostering development of the students' sense of caring for others, good citizenship, and civic responsibility.

The essential elements listed here are useful guidelines for identifying what service learning provides to students; however, questions still remain. What defines a "thoughtfully organized service experience" and what is meant by the phrase "community needs?" Could an internship count as service learning using this definition? Could students be paid for service learning efforts? Would having students simply engage in community service ever count as service learning? We believe the answer to all of these questions is a resounding "yes."

While a variety of definitions exist, the basic kernel of the movement for us has always been about students providing a contribution beyond the confines of the classroom or university setting. We realize that this definition includes a variety of options for the teacher and experiences for the students. Other researchers have addressed the wide variety of experiences that might be identified as service learning (Furco, 1996; Sigmon, 1997). Our own experience in implementing service learning projects has led us to believe that service learning principles can be used in a variety of situations. We believe that harnessing student energies to solve real world problems and to deal with the existing political and social settings, if implemented skillfully, provides major potential benefits to the students.

Recent work on our campus has examined the extent of involvement of faculty, students, and community agency people in service learning on a local level. Some examples of service learning with which one or both of the present authors has been involved includes:

- An evaluation project for a rural school district where the benefits and problems of Block Scheduling were examined in detail.
- A fund-raising effort conducted by three classes in an Honors Program that led to the building of a four-classroom school in the Republic of South Africa.
- A needs assessment study completed by two graduate level classes that became the basis for departmental accreditation preparation.
- Students creating online educational materials based on the content learned within an introductory technology course.

- A pre-assessment trip and resulting study became the basis for 5-year project involvement of USU's Engineers Without Borders (EWB) with a village in Central Mexico.
- An online class assignment of 6 h of volunteer work accomplished the transcription of video presentations used in the class allowed access to the course videos to students with hearing impairment (Eastmond & Legler, 2010).

The six examples cited above had significant impact on people and institutions beyond the classroom walls. The significant contribution represented by these efforts is a strong reason for engaging in service learning, but it is certainly not the only reason. We believe that service learning is problem-based learning (PBL) at its best and that some of the best reasons for engaging in it is the strength of the resulting learning.

However, in addition to the promise, there are potential ethical pitfalls with which to be reckoned. The intent of the remainder of this chapter is to explore those pitfalls and how they can be avoided or transformed into positive features for those engaging in service learning.

Assumptions

The chapter does not assume that the reader has had prior exposure to service learning, but it does assume that the person has the intention to teach better and to provide more options for students. The basis for the article is a belief shared with American educator John Dewey that the best education approximates the demands of real life, and the more that a student can be drawn into the full range of setting up and carrying out a project, the better the result will be, providing that there is time spent reflecting on the experience (Giles, 1994; Hatcher & Bringle, 1997).

The chapter further assumes that a variety of ethical codes exist in various professional organizations and that the reader can find one or more of these to which to subscribe. Although the purpose of this chapter is not to review these ethical codes, the reader is encouraged to review the work of Chapdelaine, Ruiz, Warchal, and Wells (2005), who proposed a professional code of ethics for the field of service learning. More recently these researchers have applied these ethical principles to international service learning research efforts and articulated the ethical difficulties inherent in research in differing cultures (Wells, Warchal, Ruiz, & Chapdelaine, 2011). Scenarios in which research is being conducted with groups of other cultures require that researchers understand and take into account the contexts under which service learning and research activities are carried out.

The assumption about universities, typical of our own institution, is that the service component of service learning is a "nice-to-have component" of the tenure and promotion reward system, but that service alone, without high marks for performance in research and teaching, will not be sufficient grounds for advancement or retention by the institution. In other words, the university reward system both subtly and overtly discourages extensive service as part of a university career, particularly at the assistant professor level (Macfarlane, 2007).

Overview of Ethical Dilemmas

Some potential ethical dilemmas include:

1. Employing untrained personnel to do professional work is unethical.
2. Paying students for work done for class can involve them in conflicting role demands. Similarly, faculty members may be involved in situations that represent a conflict of interest.
3. If the project involves human subjects, approval from the institutional review board (IRB) is required.
4. Completing the work required within the constraints of a semester can be difficult. Incomplete work is harmful to reputations and unethical.
5. Competing with outside enterprises is not what the university is set up to do and invites complaints from local business.

For each potential dilemma listed above, this chapter provides one or more teaching situations and then draws upon three sources of ethical statements that an evaluator working in Instructional Technology would likely draw upon, namely: The AECT Code of Professional Ethics (AECT, 2007); American Evaluation Association (AEA) Guiding Principles for Evaluators (2004); and the Joint Committee Standards for Educational Evaluation (2nd Edition).

Ethical Challenge 1: Employing Untrained Personnel to Do Professional Work Is Unethical

Consider a graduate level class that works under contract to complete an evaluation study for the State Library Commission. Students are expected to develop the instruments and carry out data collection to survey opinions of library personnel in local libraries of four types: public libraries, school libraries, academic libraries (usually connected with a university), and special purpose libraries (as libraries for the deaf or for a specific academic area, like a medical library). Students are paid for their work.

In order to do the work correctly (and ethically), students are required to learn about libraries in general and the problems they face in the twenty-first century. They must also learn how to sample opinion, including how to draw samples, develop survey questionnaires, and demonstrate the necessary skills to carry out focus group interviews with librarians and patrons. While the students are not yet professionals, it is expected that they will demonstrate professional demeanor and competence in dealing with clients.

Potential Solutions

The challenge for a teacher in situations like these is to ensure that students are not asked to do tasks for which they lack training. For example, before conducting focus groups, students should be thoroughly grounded in the procedures for conducting focus groups in an acceptable manner. This requires watching students conduct a simulated focus group and then coaching them to an acceptable level of performance. If a task must be completed that the class members cannot learn, then the faculty member must step in and complete the task in a professionally acceptable way.

Remaining Conundrums

Agreement exists in the evaluation community that "cultural competence" is both desirable and necessary for competent work (Samuels & Ryan, 2011). According to the AEA (2004) Guiding Principles document, evaluators are expected to "understand, respect, and take into account differences among stakeholders, such as culture, religion, gender, disability, age, sexual orientation, and ethnicity." While it may be possible to coach students directly on some of these dimensions, the amount of change in attitude that can be expected to occur in a single exposure to evaluation work is not huge. In the example given above, coming to be "culturally competent" in the "library culture," took several forms. Each member of the class was required to read and write a paper about a book about twenty-first century librarianship, in this case Marilyn Johnson's (2010) book entitled *This book is overdue: how librarians and cybrarians can save us all*. Each person was expected to attend and participate in the orientation session with the client; a 2-h panel discussion with four members of the State Library Division. And yet, did this level of involvement with the librarian community constitute a level of cultural competence that was ethically defensible? We would argue that yes, it was, recognizing that we could go only so far in orienting and helping mold the attitudes of these workers who would now be expected to function within the cultural parameters of the librarians of our state. In another such project, dealing with training given for reading instructors teaching Navajo youth, it seemed that becoming culturally competent to work in university settings near the reservation would pose a more formidable task. Again, students were required to read and discuss a book related to Native American ways. Whether members of the class reached the required level was (and always is) a matter of judgment.

Ethical Challenge 2: Paying Students for Work Done for Class can Involve Them in Conflicting Role Demands

Similarly, faculty members working in this kind of setting may encounter conflict of interest situations.

In the example of the library study given above, students were paid for their work, with funding from a federal grant provided as a subcontract with the

University. Sometimes, the demarcation between work done for the class and work for the client was difficult to make.

Potential Solutions

While there are certainly concerns with compensating those involved in service learning projects, paying students for work done in completing a project helps students and faculty in several ways: (1) students see that the project is a real one, demanding their best efforts; (2) it trains them to deal with financial matters, concerns that are frequently omitted from normal student problem solving; (3) it helps them learn to set and maintain a project budget; and (4) it rewards them for the extra work that is frequently required to successfully complete a service learning contract. Where such financial arrangements are not possible, completely voluntary effort is also an acceptable mode of working.

The idea of paying students for service learning work begs the question of why a client would choose to pay for services when they might be expected to obtain similar services for free under other circumstances? First, there is the question of whether such funding is even a possibility. If it is, then paying students can have some of the advantages listed above. For another, if the client recognizes that paid contracts receive priority treatment over unpaid ones, it may be worth considering paying for services, thus allowing their project to go to "to the front of the line."

Typically, the rate of payment is not a source of conflict. Receiving payment from an unexpected source, i.e., being paid for work performed in completing a university class, is generally welcomed by students. In the case of the project investigating the practices of teaching reading at higher education institutions located near the Navajo reservation, the amount of funding for each student was much lower than would generally have been paid for professional work. [This project took up the students' week of spring break and paid each person $300, as well as their travel and per diem expenses, but the effort also resulted in a $1,700 contribution to a student internship fund for overseas work for other students in the future. So the payment was really not proportional to the work, at least by most standards of payment, but no one objected, since travel costs, including food and lodging expenses were paid for with the contract, and payment for university experiences is so unusual]. Similarly, the final decision in the library example was that the students were compensated for their work done away from campus, but then expected to volunteer for work done on campus, assuming that such work would have been part of the course without the service learning component in place.

Remaining Conundrums

It is possible to have a situation where a faculty member might be drawing extra contractual pay but not funding any student pay. This situation was the subject of some lengthy faculty discussion at our institution many years back, and the outcome was memorable: faculty involved with evaluation made the decision that faculty may not receive payment for a contract involving students unless students are paid also. That unwritten agreement among faculty has guided behavior for nearly three decades. Will it continue when the people who made the agreement have all retired or moved on? At this point, there is some question that payment for student work or even taking on student contractual work will continue in future years.

Ethical Challenge 3: If the Project Involves Human Subjects, Approval from the Institutional Review Board (IRB) Will Likely be Required

If adherence to IRB procedures has become routine at an institution, why would this situation pose problems for service learning projects? It would be one thing if the approval for such projects could be obtained in a short period of time, say 2–3 weeks maximum, but in our experience the approval process has required far longer than that, even to the point of jeopardizing the success of the project. Sometimes potential delays can be foreseen and worked around, possibly by submitting the IRB application prior to the start of the semester of the course. But setting up and submitting the project application before the term has begun will require that the instructor do all the set up thinking and deciding prior to the class even wrestling with the problems, somehow defeating the purposes of authentic problem solving. So the dilemma becomes: do students receive the authentic experience of defining the problem, working with the client to do so, or do these decisions get made before students even see the problem, just so that the IRB requirements can safely be negotiated in the time provided in the semester? Stated another way, is it ethical for students to work at ways to circumvent the bureaucracy designed to ensure ethical research practice?

Potential Solutions

Sometimes the necessity of working with an IRB can be avoided. For example, if the project involves polling workers of a company, where a nondisclosure agreement would preclude any sort of publication of findings, sometimes IRB administrators are willing to leave the decision to the instructor and the private company, thus avoiding a lengthy approval process. Sometimes, as described above, with enough advance planning, the process can be begun and completed in a timely fashion, so that the service learning project is not delayed (e.g., the approval comes through while class members are receiving initial required training). Occasionally, there are overlapping spheres of influence for IRBs for separate institutions, and dealing with one but not another can save time and effort. For example, the IRB for the Navajo Nation is notorious for making access difficult for nonnative researchers. By confining our study to universities outside the reservation, and dealing only with our own institutions' IRB, the potentially long and involved process of working with the Navajo IRB was avoided.

Remaining Conundrums

As teachers we have to be careful about how we represent our encounters with the IRB. We have to ask ourselves if students come away from their individual training (required, 4 h of online orientation and quizzing) and application for approval for projects with the belief that these agencies are designed to safeguard research procedures or believing that this is bureaucracy, pure and simple, and best avoided. It is hard to forget the candid assessment of a French intern, who, after hearing IRB concerns discussed for more than 2 h, offered her own assessment: "This is a total waste of time!" The temptation for the service learning instructor in situations similar to this one is to design the research so that it will easily pass IRB scrutiny. A better approach, and one that we advocate in this chapter, is to design the research to answer the research questions adequately and then to work with IRB employees to discover ethical procedures for handling these questions.

Ethical Challenge 4: Completing the Work Required for a Service Learning Project Within the Constraints of a Semester can be Difficult. Incomplete Work Is Harmful to Reputations and Is Itself Unethical

The semester limitation imposed by courses has come to be more onerous as years have gone by. At our university, working on a 10-week quarter system prior to 1998 meant that completing a service learning project was barely possible. Then in 1998, every public institution in the entire state was required to move to the semester system. At first it seemed like a dream come true: there was ample time to do all that was required and then some. But, true to the Law proposed by Parkinson (1957): "Work expands to fill the time allotted." The expansion of IRB requirements and course content expectations, made completing a service learning project nearly impossible, even with 16-week semesters.

Potential Solutions

The most common way that the semester deadlines are met is by "turning on the heat" and getting deadlines met. Often students will set other classes' projects aside to concentrate on the service learning's demands on their team's efforts, thinking that once these demands are past, they will be able to regain their balance by handling the projects that had been set aside. Unfortunately, the level of quality required by working with an outside client often demands that teams respond to multiple drafts and keep the effort moving, even when it is most uncomfortable because of the demands of other classes, family expectations, or "the regular job" that is paying their bills. From personal experience with students it is much easier to have "buy in" to the idea of serving outside clients at the beginning of the project, before the pressure of completing the project builds up.

If students are committed to completing a project, they will often devise ways to overcome the semester limitations. For example, an Honors class that took on a fundraising project to build the school in Africa was willing to conduct their Walk-a-Thon fundraiser in the spring semester, when the weather was more conducive to being outdoors, rather than in the fall term when they had the course. This group raised over $4,000 and was ultimately successful in having the school built in former Transkei area of the Republic of South Africa (Eastmond, 2002).

Remaining Conundrums

A criticism sometimes applied to service learning is that the projects primarily serve the needs of faculty and students, and to a lesser extent the recipient organization. That objection seems to loom larger with this semester requirement than with any other arrangements. After all, the client is not restricted by those semester limitations and can hardly be expected to worry as much as faculty at the prospect of having an incomplete project, being left "holding the bag," while students pursue their own postsemester agendas.

One way universities work around the semester constraints is by hiring graduate research assistants to work on projects that know no semester-imposed boundaries. Some of our clients have opted for this type of involvement, rather than engage with classes with set beginning and ending dates separated by a mere 16 weeks.

Ethical Challenge 5: Competing with Outside Enterprises Is not What the University Is Set Up to Do and Invites Complaints from Local Business

Questions from local businesses about competing practices are common in our community, from the University Inn on campus being accused of undercutting the business of local hotels and bed-and-breakfasts to campus-based engineering projects seen as competing with local engineering firms. The concern seems to grow mainly from private enterprises perceiving that they are competing with enterprises supported with tax dollars, and that in large measure the competition is unfair.

Proposed Solutions

When outsiders contract with a university to have a job done by students in training, they realize that they are working under different conditions than if they were bidding for a consultant or a regular business enterprise. The markets are really quite different and are seldom in direct competition. In the experience of the present authors, complaints about competition with local businesses are virtually nonexistent. The smart competitor sees where his or her business' strengths lie and may even work to obtain benefit from student help to do a better job. Our classes frequently do work for local consulting groups, sometimes for pay and sometimes on a volunteer basis. The skillful entrepreneurs in these companies seem to be able to see ways to keep their niche competitive.

Remaining Conundrums

Sometimes the long-term consequences of working with student projects may undercut professionals' competitiveness as a consultant, simply because the services are priced in a lower range that would have been the case as a freelance consultant. There may be value in maintaining some professional distance from the work of students learning on the job, just to maintain an image of high professional standards. In other words, to stay in the highest paid consultant position, it is likely that university professors do better in separating their personal consulting from that involving service learning. Probably physicians can face similar problems when offering volunteer services at free community clinics, simply because the potential clients looks at the other setting, where the work is performed voluntarily, and reason "why should I be paying top dollar when some other community members get the help they need for free?" Possibly the best route is to maintain separate market niches and to expect that potential clients will see that both are necessary, as the one (highly paid) essentially subsidizes the other (the volunteer work).

Conclusion

There is no substitute for learning before the pitfalls described above are encountered. "Forewarned is forearmed." However, every project develops its own wrinkles and sometimes raises ethical dilemmas unforeseen at the beginning. It can be argued that encountering and resolving these ethical conflicts makes for the best student learning. As has been evident from the beginning of this chapter, we argue that the benefits of working on authentic tasks and using student energies in socially beneficial ways far outweigh the taking of the slight risks involved in facing the ethical challenges involved in service learning. The enhanced student learning (and frequently the stronger course ratings) underline the value of these guided "encounters with reality" engineered by the faculty member.

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Conclusion: Building on the Strengths of Interdisciplinarity

Brian R. Belland and Samuel B. Fee

In the spirit of the book series of which this book is a part—*Explorations in the Learning Sciences, Instructional Systems and Performance Technologies*, it is important to take a look back at what can be learned about how dialogue can be promoted between research communities. Unfortunately, it is all too common for educational researchers to constrain their research to specialized academic silos (Bullough, 2006). Many have called for interdisciplinarity in educational research (e.g., Bullough, 2006; Eisenhart & DeHaan, 2005). But it is crucial that interdisciplinarity not be pursued simply for interdisciplinarity's sake, but rather to help educational researchers accomplish tangible goals (Bullough, 2006). One such tangible goal is to apply various theoretical perspectives from diverse disciplines to shed new light on the research and practice of educational technology. By offering multidisciplinary perspectives through which educational research can be interpreted, this book is meant to steer educational technology researchers towards that goal.

Authors in this volume used or described unique disciplinary perspectives to be used as critical lenses to examine educational research and practice. These perspectives include, but are not limited to, those from philosophy, art, sociology, and archaeology. For example, philosophical perspectives on logic and epistemology are represented in J. Michael Spector and S. Won Park's chapter (Chapter "Argumentation, Critical Reasoning and Problem Solving"), which offered a fresh take on argumentation and problem solving. One may imagine that this is influenced by Dr. Spector's background in the field of philosophy. Charlotte Belland (Chapter "Design for Media (D4M): Nurturing the Transition of Media Arts Students from Consumers to Producers through Deliberate Practice") considered her background

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and expertise as an accomplished artist to critically evaluate what the Columbus College of Art and Design's sophomores needed to develop their own personal expression, rather than just learn isolated techniques. One of the present authors (Brian) has a Master's degree in French. During his Master's degree program, he took a class on the sociological writings of Pierre Bourdieu (1977, 1979, 2004), which figure prominently in his chapter (Chapter "Habitus, Scaffolding, and Problem-based Learning: Why Teachers Experiences as Students Matter"). In addition to his advanced degrees in educational technology, the other present author (Sam) holds a Master's degree in classical archaeology. This interdisciplinary background has informed all of his instructional design work, giving him advanced knowledge of a specialized content area to focus upon. But in the 1990s, that field was also exploring the ideas of postmodernism and the social construction of knowledge at the same time the field of education was looking toward developing constructivist pedagogies. As such, his background in both fields impacts his understandings of how knowledge is constructed, and this broad view is illustrated in the curriculum he helped design at Washington & Jefferson College (Chapter "Correlating Problems throughout an Interdisciplinary Curriculum").

So from whence do these multidisciplinary perspectives come? One of the most satisfying aspects of our positions as faculty members in educational technology is meeting the new students who arrive each fall and learning about their diverse backgrounds. One of us (Brian) teaches in a department that offers two different master's degree programs (one of which has online education and face-to-face delivery options) and a PhD program that attract four different populations of students. And within each program, there are students who come to the field from many different disciplinary backgrounds and work experiences, including English Education, Physics, Business, Technical Writing, and Law. This is by no means problematic; rather, it is a great strength of the educational technology field. Students' backgrounds in these diverse fields can provide a very important set of theoretical perspectives that can be used to critically evaluate educational technology literature. The other (Sam) teaches at a small liberal arts college in an interdisciplinary technology program. The main focus of this program is to teach students to solve computing problems contextualized from various content fields. The students in this program come from every conceivable field in the arts, humanities, and social and physical sciences and are looking for ways to tie technology into their content studies. This is a very exciting approach as it creates opportunities for collaboration between students and faculty from diverse fields. It also underscores the important differences of looking at problems from multiple perspectives and various fields of inquiry.

Unfortunately, the application of critical frameworks from study and work in other disciplines does not come naturally to most. Many do not naturally see how ways of *thinking about problems* in a different discipline can be applied to educational technology. Rather, they may think of ways to apply educational technology to *the content* of a different discipline. For example, former English teachers may think that since their background is in English Education, they need to study how to develop educational technology interventions to teach English. Indeed, one of the present authors (Brian) had difficulty realizing how to apply his background in

French and French Education to his newfound research interest in Science Education, which emerged while working as a graduate research assistant. But a vision of how to apply critical frameworks from his background in French emerged as he read the literature on technology integration and teacher behavior. Technology integration and teacher behavior is, of course, central to the study of educational technology interventions in K-12 schools. As he read the literature, he began to think critically about the underlying assumptions of that literature. And as he thought about the assumptions, he remembered Bourdieu's (1977, 1979, 2004) sociological research on why people do what they do. Then he began to think about how to apply that framework to the literature on technology integration. Similarly, the ways that literary critics think about texts may be used to examine educational texts and media.

So what is the way forward? First, it is very important that educational technology scholars and practitioners remember to read the literature with a critical eye. But of course reading the literature with a critical eye does not mean discounting or disparaging other's work. Rather it means being mindful of (a) different ways research results can be interpreted, (b) the perspectives from which original researchers operated, and (c) how research results can be applied to educational practice. Educational technology scholars should also remember that applying critical frameworks and theories from a variety of sources can help enable the type of critical reading and interpretation of the literature that will allow for new insights into the process of education. As noted by Glass (1976), accumulating dozens of studies on a topic without synthesizing what was learned runs the risk of educational researchers "knowing less than we have proven" (Glass, 1976, p. 8). Of course, empirical research is and will always be central to educational research. Without testing educational theories and interventions with real people, there is no way to know if they really work. But it is crucial to synthesize lessons learned as well.

Second, educational technology scholars should not constrain their research to silos. Rather, they should actively seek collaboration with others who come from different perspectives. By working from different perspectives, scholars may be able to more thoroughly understand a research problem. For example, educational technology scholars who are studying technology integration may find that a sociologist at their university is also studying technology integration. It would make a lot of sense in that case to walk across campus to discuss shared research interests and the different research/theoretical approaches used to pursue those research interests. The benefits would extend to both sides. Examining problems from different perspectives can generate interesting and original research questions and correspondingly interesting and original research. Universities have a vested interest in promoting these types of collaborations, because such collaborations can lead to highly original and publishable research. Furthermore, many granting agencies are pushing for interdisciplinary project teams.

In short, space for the third paradigm—the critical paradigm—should be created in educational technology research. The use of critical frameworks in the interpretation of the literature can allow for innovative synthesis of the literature. This in turn can help prevent the proverbial spinning of the wheels that happens too often in educational research.

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