Lecture Notes in Educational Technology

Begoña Gros
Kinshuk
Marcelo Maina *Editors*

The Future of Ubiquitous Learning

Learning Designs for Emerging Pedagogies

Springer

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Begoña Gros · Kinshuk · Marcelo Maina
Editors

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Editors
Begoña Gros
Facultat de Pedagogia
University of Barcelona
Barcelona
Spain

Marcelo Maina
Department of Psychology and Education
Universitat Oberta de Catalunya
Barcelona
Spain

Kinshuk
Athabasca University
Edmonton, AB
Canada

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Preface

The Context

It is evident that we are living through an important and rapid transformation of society that is changing the way we learn and the places where learning occurs. There is need for a fundamental change in the way in which we design and support learning. A number of changes are evident. First, the complexity of modern society requires specific types of competences to interact within this context, such as higher-order thinking skills, problem solving, systems thinking and the ability to communicate, collaborate and interact effectively with others (Rychen 2003).

Second, the connectivity in today's society has not only altered the production of knowledge but also the spaces and times where learning takes place. Sharples et al. (2012, p. 24) used the concept of seamless learning to describe when a person experiences a continuity of learning across a combination of locations, times, technologies and social settings. "Such learning may be intentional, such as when a learning activity starts in a classroom then continues through an informal discussion with colleagues, or online at home. It can also be accidental, for example when an interesting piece of information from a newspaper or television programme sparks a conversation with friends. Seamless learning can be a collective or an individual process. It can extend across time and locations, offer ubiquitous access to learning resources, encompass physical and digital worlds, engage multiple types of device, and integrate different approaches to teaching and learning".

Third, technologies have an increasing impact on how learning is designed and supported. These changes are directly promoted by the use of emergent technologies. Digital technologies enable students of all ages to operate across different contexts.

Fourth, in terms of approaches to learning, there has been a general change from instructional approaches to those that are more authentic, contextual and social in nature, as these are perceived as more appropriate for equipping learners with the skills they will need to participate in a constantly changing broadly societal context (Conole 2014).

To sum up, because the context of current education is rapidly changing, traditional approaches to the design and delivery of learning interventions are being challenged and may no longer be appropriate to meet the needs and expectations of today's learners. Everybody is aware of this situation, but the challenge is to develop new pedagogies and innovative uses of technologies to fulfil the real needs and expectations of learners.

This book aims to contribute by providing new pedagogical perspectives based on the design of new learning spaces supported by digital technologies. Four important concepts present in the different contributions should be emphasised: ubiquity, emergent pedagogies, learning designs and personalisation.

Ubiquity

Learning becomes ubiquitous. This ubiquity implies a special capacity for flexibility and adaptation to different contexts. Whereas in a traditional classroom the teacher is the main source of information and students are required to stay in the same place and participate simultaneously in the same activity, in a situation of ubiquitous learning activities can be resolved in a different space and time for each student. In addition, teaching materials are available at all times and are accessible from any device. Burbules (2013) notes that for learning to be effectively "ubiquitous" requires a more distributed experience in time and space. It is well understood that a ubiquitous learning environment is a situation in which even the student may be learning without being fully aware of the fact.

The use of mobile technology means that we are "always on", we are headed towards a time when being constantly "connected" is a way of life, and this fact has important implications. The limits between "work/play, learning/entertainment, accessing/creating information, public/private, formal/informal are distinctions that have conceptually been clear but currently are becoming unclear" (Burbules 2013, p. 2).

Besides space changes, temporal changes are also important. Burbules (2013) notes that instead of one's schedule being created around opportunities to learn, there has been a shift, and with mobile and ubiquitous computing learning can be scheduled around one's habits and preferences. Personalisation is, therefore, very important.

There is also a shift in the perception of and interaction with time. Rather than "lifelong learning" being something that adults do after traditional school is over, lifelong learning becomes continual learning. Technology has promoted this situation, and, at the same time, we need new technology to support the differences among learners as not everybody has the same approach to learning and therefore personalisation is required.

Emergent Pedagogies

Digital technologies can widen access to information, open up new ways of learning and provide opportunities for communication, collaboration, participation and the acquisition of skills. However, it is necessary to rethink the methods, content and structure of the educational process.

Emergent technologies and emergent pedagogies are interdependent. According to Veletsianos (2010, p. 33) emergent technologies are "tools, concepts, innovations, and advancements utilized in diverse educational settings to serve varied education-related purposes". Employing emerging technologies to further educational goals may necessitate the development of different theories, pedagogies and approaches to teaching, learning, assessment and organisation. If we employ emerging technologies in education, we should also be prepared to experiment with different lenses through which to view the world and with different ways to explore such ideas and practices as knowledge, scholarship and collaboration. The implications of emergent pedagogy for emerging technologies in education are twofold: on the one hand, technologies developed for purposes other than education find their way into educational institutions and processes, while on the other, once technologies are integrated into educational practice, they both evolve through practices.

An emerging pedagogy needs to rethink and explore new meanings of the existing/traditional pedagogies within the currently evolving contexts of a networked knowledge society.

Learning Design and Personalisation

Learning design has developed as a means of helping educational professionals to make informed choices in terms of creating pedagogically successful learning interventions that make effective use of technologies. Goodyear and Yang (2008, p. 167) use the related term educational design, which they define as "the set of practices involved in constructing representations of how to support learning in particular cases or the set of practices involved in constructing representations of how people should be helped to learn in specific circumstances".

Design is a conscious and planned process of generating new ideas and taking decisions in order to create something different. Designs for emerging pedagogies provide specific information and research for acquiring the requisite skills to both design and support learning opportunities that harness the potential of available technologies.

To sum up, the aim of the book is to explore emerging pedagogical perspectives based on the design of new learning spaces supported by digital technologies. *The Future of Ubiquitous Learning: Designs for Emerging Pedagogies* provides specific information and research for acquiring the requisite skills to both design and support learning opportunities that harness the potential of available technologies.

Key organising questions addressed by the authors include:

- What pedagogical perspectives might provide new understanding of the assumptions underlying education needs?
- How can learning be designed following these new pedagogical perspectives?
- What are the issues that are relevant for ensuring effectiveness of adaptive and personalized learning?

Structure of the Book

The book is divided into three parts: Foundations of Emerging Pedagogies, Learning Designs for Emerging Pedagogies and, Adaptive and Personalized Learning.

The first part—Foundations of Emerging Pedagogies—has five chapters which set out the theoretical background for the book.

The book begins with an introductory chapter that provides an overview of the context of current education, the relationship between emergent technologies and emergent pedagogies, and a description of the main characteristics of emergent pedagogies.

Chapter 2 discusses guidelines for networked learning. First, several definitions are analysed and it is concluded that networks are essentially different to communities, although the former will contain the latter. After analysing pertinent metaphors of learning, epistemic design turns out to be subject to the maxim that learning networks cannot be designed, only designed *for*. With this as a limiting perspective, guidelines for the social design of learning networks are derived, in which the notion of ad hoc transient communities plays a key role. In the context of the set design, examples of tools for supporting social interaction, navigation and (formative) assessment are inventoried. Together, the results of the analysis of epistemic design, the guidelines for social design and the inventory of tools for set design provide a valuable, albeit still growing, toolkit for the designer of learning networks.

Chapter 3 discusses the principles, processes and design of heutagogic learning environments with specific emphasis on digital technologies Heutagogy is form of self-determined learning, it is a holistic, learner-centred approach to learning and teaching in formal and informal situations. The theory is grounded in humanistic and constructivist principles and brings together numerous threads of early learning theories into a composite picture of learning that is suitable for and much needed in today's educational systems.

Chapter 4 aims to provide a theoretical and analytical understanding of the approach and its implications for teaching and learning using Learning Analytics (LA). The authors analyse the implications based on McLuhan's semiotic analysis of media (1988). The chapter outline which practices of teaching and learning may become more likely to become common when the LA tools are taken more widely in use, as well as which other will be relegated.

Chapter 5 proposes the metaphor of learning ecologies to provide a framework to analyse interactions between individuals and their environment, and the way their experiences across different contexts throughout life promote and shape learning processes. Learning ecologies allow exploring frontier pedagogies connecting formal, non-formal and informal educational contexts, acting as personal strategies that may orchestrate life-long, life-wide and life-deep learning.

Chapters 6–10 centres on Learning Designs for Emerging Pedagogies.

The second part of this book—Learning Designs for Emerging Pedagogies—is a theoretical and practical exploration of current trends in designs for learning in the digital era. It is composed of five chapters, ranging from Chaps. 5 to 9. Theoretical approaches to learning design, detailed processes of the design activity, and illustrative examples of leaning with technologies make up this part aiming at providing a substantive framework to meaningfully merge emerging pedagogies and technologies into the learning experience.

Chapter 6 explores the relationships between teaching and learning in light of technological and social shifts: from standardized and stable education to dynamic, flexible, distributed and open learning. The author develops the notion of multimodal and distributed designs for learning anchored in rich media, communication and expanded networks.

Chapter 6 highly concentrates in the affordances of open spaces and availability of resources on the Web as enablers of pedagogies that provide experienced and self-regulated learners a multitude of learning opportunities. The author presents the challenges facing teachers in providing creative ways that encourage learning personalization and learners' agency.

Chapter 7 synthesizes years of experience in designing for learning from a robust design-based research approach. It presents a set of design phases that comprehensively relate the analytical and creative perspectives of design. Tools and specific examples of the design exploration and design construction of solutions phases are added.

Chapter 8 provides a state of the art of the design activity, this time on the basis of a community platform that enables teachers to share and reuse learning design solutions. A specific design environment, the Integrated Learning Design Environment (ILDE) supporting collaborative and visual design is presented and accompanied with cases of use.

Chapter 9 introduces the reader to a whole set of learning design representations that support design thinking, design communication and design implementation. An effort in the description of these design languages is put forward. The same learning activity is illustrated according to the various types of representations documented in the text.

Chapters 11–13 centre on Adaptive and Personalized Learning. A wide range of issues related to adaptive and personalizations are the focus of these chapters, illustrating the wider benefits such approaches can potentially provide to improve the learning process.

One of the crucial aspects of Adaptive and Personalized Learning is the continuous changes in the way a course is presented to the individual learners, to suit learner's current situation. At the same time, continuous monitoring also provides opportunities for improvement in the course as and when weaknesses are detected. Chapter 11 deals with this issue by looking at measuring the quality of a course continually, formatively and summatively, through factors such as the quality of resources used, learner motivation, learner capacity, learner competency growth and instructor competence. A system, called MI-IDEM, is developed using Bayesian Belief Network, which receives streams of data corresponding to these factors and estimates of quality of the course offering based on individual factors as well as an overall quality of the offering. Through two case studies, the approach is demonstrated for a course offering in a blended online learning environment and a training course offering in an industry environment.

Chapter 12 looks at using games for adaptive and personalized learning, and the causes of their limited adoption in practice. A major issue identified is the implementation difficulties, as it usually requires a host of techniques and skills from several areas such as pedagogy, game design, adaptive instructional systems and artificial intelligence. As a solution, a conceptual model of adaptive educational games is presented in the chapter that supports educational process of reflection and analysis required at the game design stage. The model not only supports flexible game design but also enables an abstraction layer over the technical details, which allows non-technical persons, such as educators, to design educational games with ease.

Chapter 13 takes a critical look at personalizing learning in developing countries. It starts from the observation that majority of personalization efforts have concentrated on developed world context. The chapter provides an expanded definition of personalized learning that encompasses developing countries. A number of approaches are then suggested that take into consideration the capital and human resource constraints, and information and communication technology affordances, and various types of personalization opportunities in school systems of the developing world.

The last chapter in this part looks at the role of cognitive abilities of the learners in adaptive and personalized learning. While there have been significant advances in recent years towards understanding the importance of differences in cognitive characteristics of learners and associated effects on learning, there is still not much clarity regarding how these cognitive characteristics are determined and what impact various media and design choices bring on different personal characteristics changes. Chapter 1 looks at various neuropsychological tests for determining cognitive profiles, and then discusses the differences in learners' interactions with the content due to the differences in individual cognitive characteristics.

Audience

The book should be of interest to researchers and practitioners in a number of fields, including: educational technology, learning technology, learning design and education. The primary audience is researchers in the field of pedagogy and technology-enhanced learning. This includes those with a broad interest in researching the use of technology in learning and teaching, as well as individuals with more specialist interests; in particular the research areas of networked learning, learning design, pedagogical theories and personalisation. More broadly, the book will appeal to researchers in a number of related fields such as computer science, education, information sciences and psychology. It should also be of interest to researchers undertaking Master's and Ph.D. programmes in the field.

Begoña Gros
Kinshuk
Marcelo Maina

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Contents

Part I
Foundations of Emerging Pedagogies

Chapter 1
The Dialogue Between Emerging Pedagogies and Emerging Technologies

Begoña Gros

Abstract This chapter discusses the mutual influence of emerging technologies and emergent pedagogies. The potential of one specific technology or application has to be analysed in a particular scenario. We maintain that the dialogue between technology and pedagogy is absolutely necessary because there is a constant influence between them. The difference is that as technology becomes more invisible, pedagogy needs to make its practices visible offering practices that take into account the fundamental needs of modern society. This chapter is divided into three sections. Firstly, we will describe the main educational challenges of the networked knowledge society. Secondly, we will centre on the main directions and theories that support emergent pedagogies. Finally, we will conclude this chapter with an analysis of the implications and relationship between emerging pedagogies and emergent technologies.

Keywords Emerging pedagogies · Emergent technologies · Learning design · Network learning theories

1.1 Introduction

It is a fact that ICT is affecting what, how, where and when people learn. The ubiquity of technology provides new opportunities to fulfil individual learning needs. The standardization of traditional teaching and learning systems does not respond to the demands of the globalized world. Formal education should provide

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B. Gros (✉)
Universidad de Barcelona, Passeig Vall d'Hebron, 171, 08035 Barcelona, Spain
e-mail: bgros@ub.edu
URL: https://www.researchgate.net/profile/Begona_Gros

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more flexible learning systems to accommodate the different needs and demands of students. A holistic change is urgently required to implement a fundamental shift in the learning paradigm for the twenty-first century. The potential of ICT for promoting learning opportunities depends on the skills used to design learning activities that align pedagogy and technology for the benefit of learners.

In 1980, Robert Taylor, an early pioneer in the field of educational technology, considered that there were three different ways to use computers in schools (Taylor 1980): (1) as a tutor in which the computer presents some subject material, the student responds and the computer evaluates the response; (2) as a tool in which the computer provides some functionality that facilitates the task for the students, for instance, the use of a word-processor; and (3) as a tutee in which the computer is "taught" something by being programmed by the learner. These types of uses have remained unchanged over the past decades in most pedagogical proposals. However, in all of them, technology is something external, an instrument to support different activities. Technology is either a replacement or a substitute for an already existing function. As a consequence, technology can be introduced using the same teaching methods. Moreover, there is an empirical determinism in how to evaluate the role of new technologies in education. This determinism is a result of simplistic notions of technology as a vehicle for efficiency. Much of the research on the use of ICT in education takes a rather naïve view based on the idea that technology transforms educational practice. What is clear is that no technology has an impact on learning in its own right; rather, its impact depends upon the way in which it is used.

In this chapter, we will sustain that emergent technologies and emergent pedagogies are interdependent. Technology is not something external; it is the context in which learning takes place. The Internet and digital media are the main infrastructures of the knowledge society. Learning is located in the connections and interactions between learners, teachers and resources. Consequently, technology does not determine the nature of its implementation, but rather evolves in accordance with evolving practice. The potential of one specific technology or application has to be analysed in a particular scenario. Therefore, we hold that the dialogue between technology and pedagogy is absolutely necessary because there is a constant influence between them. The difference is that as technology becomes more invisible, pedagogy needs to make its practices visible and to design practices that take into account that a fundamental shift is needed towards a "more personalized, social, open, dynamic, emergent and knowledge-pull model for learning, as opposed to the one-size-fits-all, centralized, static, top-down, and knowledge-push models of traditional learning solutions" (Chatti et al. 2010a: 67).

This chapter is divided into three sections. Firstly, we will describe the main educational challenges of the networked knowledge society. Secondly, we will centre on the main directions and theories that support emergent pedagogies. Finally, we will conclude this chapter with an analysis of the implications and relationship between emerging pedagogies and emergent technologies.

1.2 The Future of Learning

An important number of prospective studies have been published in recent years on future educational trends, taking into account technological issues as well as educational changes (Facer and Sandford 2010; Facer 2011; Fullan and Langworthy 2014; Mayes et al. 2009; Redecker et al. 2011; Sharples et al. 2012, 2013; Sinay and Yashkina 2012; Stoyanov et al. 2010). The main goal of these reports is to provide input for educators and to support new policies in education. It is important to stress that many of these studies coincide in pointing out similar directions, trends and challenges.

In 2002, The New Media Consortium (NMC) launched its Horizon Project, which is designed to help educators and leaders by providing them with expert research and analysis on emerging technologies for teaching, learning, research and information management.[1] All the reports have a similar structure; there is a description of six emerging technologies distributed over three periods of time: one year or less, two to three years, and four to five years. These reports have continued to be published annually and have diversified geographically, gaining extensive dissemination.

Analysing the evolution of the estimated impact of emerging technologies in the last five years (2010–2014), we have observed some patterns among the technologies present during this period which we have grouped in five trends (Table 1.1):

1. Mobile technologies. In 2010, mobile referred mainly to the portability of the device, but the concept evolved to include other importance aspects such as a permanent connection, and the availability of multiple applications designed to support learning.
2. Learning analytics. Within this trend, there are various tools and techniques for collecting, analysing and displaying data related to participation, performance and student progress.
3. Games and Gamification. Game-based learning appears in all the latest reports and in 2014 gamification appears, that is, the use of game mechanics in non-game contexts in order to engage students.
4. Hybridization is composed of several technologies that have the interconnection and integration of the physical and digital worlds in common: augmented reality (2010, 2011), the Internet of things (2012), *wearable-technology* devices (2013), and the *quantified self* (2014).
5. Natural interaction with devices. Systems to interact with devices through facial expressions, gestures or voice recognition.

Ng'ambi (2013) points out that although these reports are useful, they do not provide an answer to questions of whether the predicted adoption over time will be different for educators and students, or what institutional conditions and pedagogical needs will accelerate the adoption of the technologies, nor do they provide a

[1]The first NMC Horizon Report was published in 2004.

Table 1.1 Trends in the implementation of emerging technologies in relation to their impact on higher education between 2010 and 2014

Emergent Technologies					
	2010	***2011***	***2012***	***2013***	***2014***
Short tem	Mobile computing	Mobile devices	Mobile Applications	MOOCs	Flipped Classroom
	Open content	e-books	Tablets	Tablets	*Learning analytics*
Medium term	e-books	*Game based learning*	*Game based learning*	Gamification	Gamification
	Augmented reality	Augmented reality	*Learning analytics*	*Learning analytics*	3D-Printing
Long term	Visual data analysis	*Learning analytics*	Internet of things	Wearable technology	Quantified self
	Gesture-based computing	Gesture-based computing	Gesture-based computing	3D-Printing	Virtual assistants

Source Mas (2014)

model of use to transform practice. In similar direction, Veletsianos (2010) considers that emergent technologies are context-specific, what is emerging in one context or geographical location may not be emerging in another. “Employing emerging technologies to further educational goals may necessitate the development of different theories, pedagogies, and approaches to teaching, learning, assessment, and organization. If we employ emerging technologies in our work, we should also be prepared to experiment with different lenses through which to view the world and with different ways to explore such ideas and practices as knowledge, scholarship, collaboration, and even education” (Veletsianos 2010: 18).

Besides the analysis of emergent technologies, most of the reports analyse the evolution of society and the main educational trends. In the research entitled *The Future of Learning: New Ways to Learn New Skills for Future Jobs*, which has been published in different reports (Ala-Mutka et al. 2010; Stoyanov et al. 2010; Redecker et al. 2011), participants from the main stakeholders (policy makers, scientists, educators and learners) were asked to generate ideas about the future of education by reacting to the trigger statement: “One specific change in Education in 20 years will be that…” The resulting ideas were then sorted into groups according to similarity in meaning and rated on two scales: importance and feasibility. Multidimensional scaling and hierarchical cluster analysis were applied to depict

Table 1.2 Description of the clusters (Stoyanov et al. 2010)

Technology applied to education	Integration of various technologies (mobile devices, augmented reality, wearable technology, etc.). Or technology in general, educational activity
Tools and services to enhance learning	The role of technological tools (tools, resources, services, etc.) as facilitators of learning, includes social media and learning in online communities
Education and open educational resources	Open and universal access to education and knowledge as OER (Open Educational Resources), digital content for everyone (digital library services, universal access to the Internet, etc.). New forms of accessing training and educational content (recordings of lectures, online courses, e-portfolios, social networking, social bookmarking, etc.)
Education focused on driving individual and professional needs	Self-directed learning, personalization, adaptation and development of curricular itineraries according to individual needs and professional and employment needs, etc.
Teacher's role	Evolution of the role of the teacher to become the guide, facilitator and mediator of learning; the teacher as a learner
Learning throughout life	Access to training and learning through various deals and arrangements and in various contexts, including the concept of learning throughout life (integration of learning into everyday life, instead of work and through communities)
Moving towards the formal and informal	Increasing the role of informal learning in the training of individuals, emergence of new contexts and situations beyond classroom training and the limits of the traditional training scheme and interdisciplinary learning
Individual and social nature of learning	Caring for cognitive and social learning refers to flexibility in the application of different learning styles, empowerment strategies and skills related to learning capacity, and active learning based on the practice and forms of social and collaborative learning
Ontological and epistemological foundations of teaching methods	Theoretical foundations of learning methodologies, including, among others, gamification, the application of constructivist principles, and curricular design and interdisciplinary crossover, empirical and theoretical foundations of emerging pedagogies

emerging structure in the data. The result is a set of 12 thematic clusters, which summarize what experts consider, will be the main changes to education and training over the next 10–20 years (Table 1.2).

One of the most important findings is the central role of the lifelong learning cluster, indicating its vital role for the future of learning. This cluster is a nexus for all the others, suggesting that many of the envisaged changes to learning strategies and pathways are related to the fact that skills and competences will be acquired in a lifelong learning process.

Statements were also rated by importance and feasibility, revealing some of the expected changes as being of particular importance. These include as follows:

- The nature of learning will become more learner-centred, individual and social;
- Personalized and tailor-made learning opportunities will address individual and professional training needs;
- Innovative pedagogical concepts will be developed and implemented in order to address, for example, experiential and immersive learning and social and cognitive processes;
- Formal education institutions will need to flexibly and dynamically react to changes and offer learning opportunities that are integrated into daily life; and
- Education and training must be made available and accessible for all citizens.

When comparing the cluster ratings on importance and feasibility, it becomes clear that while the experts are optimistic about the development of technology-enhanced learning opportunities, they are sceptical about the feasibility of implementing learner-centred approaches in formal education and, in general, the ability of formal education systems and institutions to keep pace with change and become more flexible and dynamic.

In a similar direction, Sinay and Yashkina (2012) released a new framework to enhance the development of twenty-first-century competencies. The framework underpins the holistic education notion that schools must better prepare students to thrive in a fast-changing and highly connected world. It is based on the premise that the use of technology to enhance learning provides a constructivist perspective through social interaction based on experiences, active participation and the use of complex environments. Four basic elements focus the training strategies: personalization, active learning, collaborative learning and self-directed learning.

The overall vision is that personalization, collaboration and informal learning will be at the core of learning. The central learning paradigm is thus characterized by lifelong and life-wide learning and shaped by the ubiquity of technology. With the emergence of lifelong and life-wide learning as the central learning paradigm for the future, learning strategies and pedagogical approaches will undergo drastic changes. With the evolution of ICT, personalized learning and individual mentoring will become a reality and teachers/trainers will need to be trained to exploit the available resources and tools to support tailor-made learning pathways and experiences which are motivating and engaging, but also efficient, relevant and challenging. Along with changing pedagogies, assessment strategies and curricula will also need to change (Fullan and Langworthy 2013).

As we have mentioned, there are many coincidences in the descriptions of future changes in education. Chatti et al. (2010a: 66–67) summarized very well when they said that the consequences of improving the use of technology include a new vision for learning. “Learning is fundamentally personal, social, distributed, ubiquitous, flexible, dynamic and complex in nature. Thus, a fundamental shift is needed toward a more personalized, social, open, dynamic, emergent and knowledge-pull model for learning, as opposed to the one-size-fits-all, centralized, static, top-down, and knowledge-push models of traditional learning solution." While these are desirable educational outcomes, the realization requires new learning designs based on the new pedagogical approaches, which is not an easy task. In fact, important investments have been made based on the assumption that technology-mediated learning environments provide better opportunities for students to achieve competencies that are relevant in society. However, the history of the use of technology in education suggests that integration is hampered by many different problems. Educational practices reveal organizational difficulties in incorporating digital technologies, but above all, there is an incorporation of digital technologies from a traditional perspective, technologies are used as vehicle and not as a medium for transforming educational practices. The integration of technologies is based on the low-level use, mainly for drilling and practice and looking up information.

1.3 Theoretical Foundations of Emerging Pedagogies

We use the term pedagogy, although its meaning is not unique and depends on the academic traditions developed in different countries. The European view of pedagogy brings together within one concept the act of teaching and the body of knowledge. In typical pedagogical studies, pedagogy encompasses a general vision of culture and society together with elements relating to children and their learning—psychology, child development and, as a third group of knowledge, what Alexander (2004: 10) describes as "aspects relating to the subjects to be taught" regarding content knowledge such as mathematics and languages. In Asia, pedagogy is also a general term for educational studies, including fields such as history of education, philosophy of education, school education, adult education, etc. According to Abiko (2011: 358), "if we need to discuss 'pedagogy' in Japan, we do this as problems or issues of curriculum and instruction, didactics or teaching methods, school or classroom management and assessment." In the English-speaking world, pedagogy and education refer to the whole context of instruction and the actual operations involved therein. In summary, the word pedagogy expresses the relationship between teaching and learning and does not treat teaching as something that can be considered separately from an understanding of how learners learn.

Professional competencies encompass multiple pedagogical components including content knowledge, pedagogical knowledge, and more recently, technological knowledge and the knowledge generated within the intersections of these components (Mishra and Koehler 2006; Shulman 1987). All these approaches are equivalent to what Shulman (1987) calls "pedagogical content," which in many countries is called didactics. In English, didactics suggest traditional direct instruction. For this reason, in Britain and the USA the term curriculum is more fully developed, partly because both of these countries inherited traditions of curriculum decentralization. In contrast, in many European countries the scope and balance of the school curriculum has long been centrally determined.

We are using the term pedagogy in a similar way to Alexander (2004) who defines pedagogy as the activity of education together with its attendant discourse. It is what one needs to know and the skills one needs to command in order to make and justify the many different kinds of decisions in which education is constituted.

Pedagogy is not only multidimensional, but also a complex evolving phenomenon based on the changing contexts of society. It has to provide a foundation for educators to develop transformative practices and to understand more about the evolving pedagogical contexts, exploring new meaning within the contexts. Currently, evolving pedagogical contexts include the networked knowledge society, the knowledge economy, diversity-oriented democracy and digital literacies. These contexts are generated within the interplay of pedagogical components (e.g. technology, pedagogy and content) and the contexts (e.g. network society), especially with the greater influence of the networked knowledge society and its constitutive elements. According to Gurung (2013, p. 10), "pedagogies become non-static practices requiring new reflections on them on a regular basis. This is why the notion of pedagogies should be framed as 'emerging pedagogies' that involve rethinking, transformative practices, and 'routine' new reflections entailing conceptual and practical shifts in the existing pedagogy."

Thus, emergent pedagogy becomes a dynamic phenomenon that provides new scenarios for learning. Much of our understanding of how and why learning happens and the best ways to design effective learning activities are based on the theories about learning. There have been different approaches to explain the learning process (behavioural, cognitivist, sociocultural, sociomaterial, neuroscience, etc.). Each one has allowed new aspects and nuances to be introduced. The problem as Goodyear and Carvalho (2014: 13) point out is that "the new paradigm displaces rather than builds on the old. This has knock-on effects for pedagogy and educational practice." Anderson (2010a) claims that some theories of learning continue to be useful because emerging technologies are often applied to the same challenges and problems that inspired educators and researchers. However, he establishes an important distinction between pre-net theories and Net-aware theories.

According to Anderson (2010b), pre-net theories were developed in a world in which communication was expensive, geographically restricted and the information and content scarce. In contrast to this situation, Net-aware theories try to understand learning in a connected society with abundant access to information and enormous communications capacity that have created many forms of interaction and collaboration. Some pre-net theories, such as constructivist or sociocultural theories, continue to be useful because emerging technologies are often applied to the same challenges and problems that originally inspired educators and researchers. In addition, some of these theories have evolved by incorporating elements of the Net.

Following Anderson's (2010a) distinction, we will focus on the analysis of network-centric learning theories that can support emergent pedagogies. We have established a distinction among the theories that try to explain the network as a whole by analysing the interrelation among the different nodes and connections; the theories that are more focused on the social–personal interaction; and the theories focused on the design of the network (Fig. 1.1).

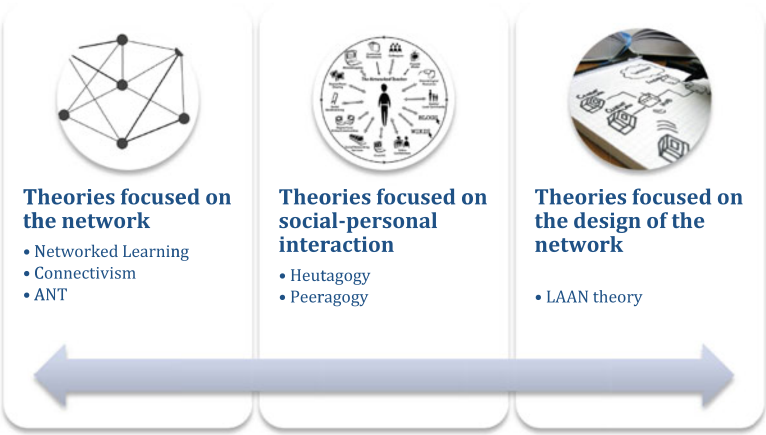

Fig. 1.1 The network learning theories

1.4 Theories Focused on Network Connections

According to Goodyear et al. (2004: 2), "networked learning is learning in which information and communications technology (ICT) is used to promote connections: between one learner and other learners; between learners and tutors; between a learning community and its learning resources." This definition has had considerable influence, especially in European research where it has been developed in a number of publications and has been associated with the Networked Learning Conference[2] series since 1998.

The definition of networked learning goes beyond merely denoting "online learning" or "e-learning," as it encompasses theoretical assumptions about learning and how to design for learning. Although there are particular values and ideals associated with networked learning, as expressed in the networked learning manifesto (Beaty et al. 2010), it does not privilege a particular pedagogical model. However, learning and knowledge construction is located in the connections and interactions between learners, teachers and resources, and seen as emerging from critical dialogue and enquiry. As such, networked learning theory seems to encompass an understanding of learning as a social, relational phenomenon, and a view of knowledge and identity as constructed through interaction and dialogue.

In many ways, connectivism (Siemens 2005, 2006) aligns well with networked learning theory. The concept of network is also prominent; it characterizes knowledge as a flow through a network of humans and non-humans (artefacts). A network comprises connections between entities (nodes), where the nodes can be individuals, groups, systems, fields, ideas, resources or communities. However, the

[2] http://www.networkedlearningconference.org.uk/.

difference is that the starting point of connectivism is the individual. "Personal knowledge is comprised of a network, which feeds into organizations and institutions, which in turn feed back into the network, and then continue to provide learning to individuals. This cycle of knowledge development (personal to network to organization) allows learners to remain current in their field through the connections they have formed." (Siemens 2005). Along the same lines, Downes (2006) considers that knowledge is not only in the mind of an individual but is also distributed across an information network or multiple individuals.

According to Siemens (2005), knowledge and learning are today defined by connections; "know where" and "know who" are more important today than "know what" and "know how." Learning resides outside the individual learner and is focused on connecting specialized information sets and the connections that enable us to learn more than our current state of knowing. As Siemens (2006: 29) points out "learning networks can be perceived as structures that we create in order to stay current and continually acquire experience, create, and connect new knowledge (external). And learning networks can be perceived as structures that exist within our minds (internal) in connecting and creating patterns of understanding."

In summary, the individual's capacity to filter, find and utilize various networks to retrieve resources and ideas is very important. In this approach, it is not clear what role dialogues, collaboration, social practice or mutual construction of knowledge play or how well connectivism can account for such patterns of learning.

Actor-network theory (ANT) (Latour 1997, 2005) proposes a sociotechnical account that makes no distinction in approach between the social, the natural and the technological. ANT explores the ways that heterogeneous networks of both human and non-human actors are constructed and maintained and focuses on tracing the transformation of these heterogeneous networks. ANT is based on the principle of generalized symmetry, employing a single conceptual framework when interpreting actors, both human and non-human. Latour (1997) writes "an 'actor' in ANT is a semiotic definition –an actant–, that is, something that acts or to which activity is granted by others. It implies no special motivation of human individual actors or of humans in general. An actant can literally be anything provided it is granted to be the source of an action." An actor is also a simplified network. The central concept is the notion of an evolving, dynamic actor-network. It assumes that nothing lies outside the network of relations, and as noted above, suggests that there is no difference in the ability of technology, humans, animals or other non-humans to act.

Latour (2005: 16) claims "it is possible to render social connections traceable" (and that the role of ANT is to trace actor-networks). In complex knowledge systems, however, there is no chance to trace social connections, nor is it possible to follow the actors or their actions. Latour himself acknowledges that following the actors themselves is not an easy task since, as he writes, "the actors to be followed swarm in all directions like a bee's nest disturbed by a wayward child" (Latour 2005: 121). Thus, there is no means to trace actors' actions and connections because their actions are uncertain, unexpected and often hidden; their connections are varied, ubiquitous and open. The main problem of this approach is that it reduces all actors into black boxes and thus ignores internal actions such as reflecting, self-criticizing and detecting/correcting errors.

1.5 Theories Focused on Social–Personal Interaction

The relationship between online and offline social networks and moving from physical communities to virtual networks is complex. Some authors refer to networked individualism. Bennett and Maton (2010) suggest that networked individualism places the focus on the individual who navigates through their own personal networks. In a society in which lifelong learning is basic, self-determined learning is crucial.

Self-determined learning (SDL) is an approach in which learners take control of their own learning processes and experiences. Tan et al. (2011) describe the processes of SDL based on a series of requisites or qualities: (a) ownership of learning; (b) self-management and self-monitoring; and (c) extension of own learning. The authors argue that providing opportunities to establish and control one's own learning objectives, as well as to direct and monitor the associated educational tasks, helps increase the subject's motivation and commitment to learning. Furthermore, they also insist on interaction between the different components.

A form of SDL with practices and principles rooted in andragogy has recently resurfaced as a learning approach after a decade of limited attention. In a heutagogical approach to teaching and learning, learners are highly autonomous and self-determined and emphasis is placed on the development of learner capacity and capability with the goal of producing learners who are well prepared for the complexities of today's workplace.

Hase and Kenyon (2000) define heutagogy as the study of self-determined learning. Heutagogy applies a holistic approach to developing learner capabilities, with learning as an active and proactive process, and learners serving as "the major agent in their own learning, which occurs as a result of personal experiences" (Hase and Kenyon 2007a, b: 112). As in an andragogical approach, in heutagogy the instructor also facilitates the learning process by providing guidance and resources, but fully relinquishes ownership of the learning path and process to the learner, who negotiates learning and determines what will be learned and how it will be learned.

A key concept in heutagogy is that of double-loop learning and self-reflexion. In double-loop learning, learners consider the problem and the resulting action and outcomes in addition to reflecting upon the problem-solving process and how it influences the learner's own beliefs and actions.

The heutagogical approach can be viewed as a progression from pedagogy to andragogy to heutagogy, with learners likewise progressing in maturity and autonomy (Canning 2010). More mature learners require less instructor control and course structure and can be more self-directed in their learning, while less mature learners require more instructor guidance and course scaffolding (Canning and Callan 2010).

Web 2.0 and social media have played an important role in generating new discussions about heutagogy within higher education. Web 2.0 design supports a heutagogical approach by allowing learners to direct and determine their learning path and by enabling them to take an active rather than passive role in their individual learning experiences.

1.6 Theories Focused on the Affordances/Design of the Network

The Learning as a Network (LaaN) theory represents a theoretical framework for PLE-based learning models. The PLE (Personal Learning Environment) is not an application, but rather an emerging concept and a new vision of learning. It represents a significant shift in pedagogic approaches towards constructivist and connectivist learning that puts the learner at the centre and provides more autonomy and control over the learning experience. A PLE is a more natural and learner-centric approach to learning that takes a small piece, loosely joined approach, characterized by the freeform use of a set of learner-controlled tools and the bottom-up creation of knowledge ecologies (Chatti et al. 2007).

LaaN builds upon connectivism, complexity theory and double-loop learning. It views knowledge as a personal network and represents a knowledge ecological approach to learning. LaaN has a number of points in common with other learning and social theories, mainly that knowledge and learning are inherently social. However, its focus on the learner and their personal knowledge network (PKN) is quite different. It implies that a learner needs to be a good knowledge networker as well as a good double-loop learner.

A good knowledge networker is one who can create and maintain an external network to embrace new knowledge nodes, identify connections between different knowledge nodes and locate the knowledge node that can help to achieve better results, in a specific learning context. Furthermore, a good double-loop learner is one who has the ability to detect and correct errors and eventually change his or her theories-in-use according to the new setting.

This approach implies new roles for the learning institution and the teacher. In LaaN, the learning institution needs to act as a hub connecting third parties providing personalized learning experiences for the learners. And, teachers need to step back from their traditional role of instructors and experts. The new role of the teachers is to act as co-learners and facilitators of the learning experience. Their major task is to help learners build their personal knowledge network in an effective and efficient way. According to Chatti (2013), the way to achieve this goal is to provide a freeform and emergent environment conducive to networking, inquiry and trial-and-error; it should be an open environment in which learners can make connections, see patterns, reflect, (self)-criticize, detect and correct errors, inquire, test, challenge and eventually change their theories-in-use.

In summary, the pedagogies underlying twenty-first-century learning need to meet the requirements of contemporary learners. Network-based pedagogies place the emphasis on the design of learning in the offline, online and networked world, which offers greater autonomy and flexibility for learners. In the next section, we will discuss the characteristics of emergent pedagogies.

1.7 Characteristics of Emerging Pedagogies

Veletsianos defines emergent technologies as "tools, concepts, innovations, and advancements utilized in diverse educational settings to serve varied education-related purposes" (2010: 33). This definition supports the mutual relationship between emergent technologies and emergent pedagogies. Employing emerging technologies to further educational goals may necessitate the development of different theories, pedagogies and approaches to teaching, learning, assessment and organization. If we employ emerging technologies in education, we should also be prepared to experiment with different lenses through which to view the world and with different ways to explore such ideas and practices as knowledge, scholarship and collaboration. The implications of emergent pedagogy for emerging technologies in education are twofold: on the one hand, technologies developed for purposes other than education find their way into educational institutions and processes, while on the other, once technologies are integrated into educational practice, they both evolve by practices.

Emerging pedagogies arise within the contexts of the networked knowledge society. They are based on the integrating digital technologies, exploring and modifying existing pedagogies and developing new theoretical and practical proposals. The theoretical foundations described previously support the main principals and approaches of emerging pedagogies. However, it is necessary to integrate pedagogical principles that provide better adjustment to the current needs of learners into educational systems and to evaluate their effectiveness. As all the components of emerging pedagogies including technology, pedagogy, content and society are evolving, educators need to develop adaptive expertise to understand how these components interplay with and influence their own practices. In this regard, the Teaching and Learning Research Programme (TLRP)[3] has made a highly relevant contribution by developing an analysis of the evidence-informed principles for pedagogies.

TLRP uses the term *effectiveness* based on the idea that the results of pedagogical practices need to be evaluated by referencing the goals and values of society. According to James and Pollard (2011: 276), "within contemporary

[3]http://www.tlrp.org/.

Western democracies, three major strands of philosophical and political thinking on educational purposes are well established. The first concerns teaching and learning linked to economic productivity –and has taken various forms historically as labour market needs have evolved. The second concerns social cohesion and the inclusion of different groups within society –this remains important within our unequal and diverse communities today. The third concerns personal development, fulfilment and expression –with a contemporary manifestation perhaps in the term 'wellbeing'. The three are, of course, deeply interconnected. Indeed, the view taken here conceptualizes 'effectiveness' as a mutually beneficial synergy among the three." Along these lines, developing effective pedagogy means establishing the general principles of teaching and, in the light of these, determining what modifications of practice are necessary to meet specific individual needs.

In TLRP, the principles are conceptualized in a way that makes them applicable to all sectors. James and Pollard (2011) consider that it is not justifiable to make unequivocal claims about findings in terms of categorical knowledge or cause–effect relationships. However, it is possible to offer "evidence-informed principles," which could engage with diverse forms of evidence while calling for the necessary application of contextualized judgement by teachers, practitioners and/or policy makers. Such principles could enable the accumulation and organization of knowledge in realistic and useful practical ways.

Along these lines, we propose ten characteristics to identify emergent pedagogies that we have grouped together based on the four main clusters used by James and Pollard (2008): educational values and purposes; curriculum, pedagogy and assessment; personal and social processes and relationships; and educators, policies and research[4] (Table 1.3).

1.7.1 Emerging Pedagogies Support Lifelong Learning

Most educational systems are based on the stratified and segmented organization in which there is little connection between sectors, which might be regarded as contributing to the concept of lifelong learning. Emerging pedagogies provide practices to support lifelong learning. Dispositions and capabilities developed during the years of compulsory schooling can be enhanced or undermined by the opportunities and constraints experienced in later life. The curriculum must enable individuals to learn to work effectively within social networks for educational, social and civic purposes, and to develop strategies to establish social networks for their own purposes. According to Facer (2011), such a curriculum might comprise, for example, opportunities for learners to learn and work within meaningful socio-technical networks and not wholly within single educational institutions; to develop

[4]In the last case, the original is 'teachers and policies'. We have extended the cluster to educators and researchers.

Table 1.3 Principals of effective pedagogy and emerging pedagogies

Clusters	Principals of effective pedagogy	Emerging pedagogies
Educational values	1. Effective pedagogy equips learners for life in its broadest sense	1. Emerging pedagogies support lifelong learning
Curriculum, pedagogy, assessment	2. Effective pedagogy engages with valued forms of knowledge	2. Emerging pedagogies support ecologies of learning
	3. Effective pedagogy recognizes the importance of prior experience and learning	3. Emerging pedagogies use different forms of knowledge
	4. Effective pedagogy requires learning to be scaffolded	4. Emerging pedagogies integrate the use of technology as mindtools
	5. Effective pedagogy needs assessment to be congruent with learning	5. Emerging pedagogies change the traditional role of teachers and learners
Personal and social process	6. Effective pedagogy promotes the active engagement of the learner	6. Emerging pedagogies integrate self-regulation, co-regulation and social share regulation
	7. Effective pedagogy fosters both individual and social processes and outcomes	7. Emerging pedagogies promote deep learning tasks
	8. Effective pedagogy recognizes the significance of informal learning	8. Emerging pedagogies are transparent
Educators, policies frameworks and research	9. Effective pedagogy depends on the learning of all those who support the learning of others	9. Emerging pedagogies are based on socioconstructivist pedagogies
	10. Effective pedagogy demands consistent policy frameworks with support for learning as their primary focus	10. Emerging pedagogies demands new forms of assessment

capacities to manage information and intellectual property, build reputation and trust, develop experience of working remotely; and, to explore the human–machine relationships involved in sociotechnical networks.

1.7.2 Emerging Pedagogies Support Ecologies of Learning

The new ecology of learning makes the assumption that learning is multidirectional and multimodal and learning is understood as part of living in different sociocultural contexts, not as something that takes place exclusively within the confines of formal education. Pedagogy should take account of what learners already know in order for them, and those who support their learning, to plan their next steps. This includes building on prior learning but also taking account of the personal and cultural experiences of different groups of learners.

It is important to work towards the creation of open, flexible and networked relationships across diverse educational institutions, both formal and informal. Such working arrangements would attempt to reduce the barriers to participation across institutions, increase the chances of learners enjoying high-quality educational experiences based on the shared understanding of learners' histories and prior understanding and ensure that education in workplaces and other settings is valued.

1.7.3 Emerging Pedagogies Use Different Forms of Knowledge

Emerging pedagogies are based on the knowledge creation metaphor of learning that highlights competencies in producing knowledge. Emerging pedagogies are "knowledge pull." "The knowledge-pull approach to learning is based on providing learners with access to a plethora of tacit/explicit knowledge nodes and handing over control to them to select and aggregate the nodes in the way they deem fit, to enrich their personal knowledge networks" (Chatti et al. 2010b: 82). These skills are increasingly related to the use of digital technology which provides a flexible way to support modelling, sketching, testing and social interactions.

1.7.4 Emerging Pedagogies Integrate the Use of Technology as Mindtools

The ubiquity of technology calls for a shift away from "low-level" use of technology such as drilling and practice and looking up information. Rather, emergent pedagogies encourage the "high-level" use of technology, utilizing it as a "mind-tool" or "intellectual partner" for creativity, collaboration and multimedia productivity. Technology must enable and accelerate learning relationships between teachers and students and between students and other "learning partners" such as peers, mentors and others with similar learning interests.

1.7.5 Emerging Pedagogies Change the Traditional Role of Teachers and Learners

In the old pedagogies, a teacher's quality was assessed primarily in terms of their ability to deliver content in their area of specialization. Pedagogical capacity was of secondary importance. In contrast, emergent pedagogies are based on the foundation of teachers' pedagogical capacity—their repertoire of teaching strategies and their ability to form partnerships with students in mastering the process of learning.

Technology in the new model is pervasive, and it is used to discover and master content knowledge and to enable the deep learning goals of creating and using new knowledge in the world. It is necessary to choreograph the elements of the wider educational ecosystem into coherent educational experiences for learners. It requires expert mentors, able to work with students and families to think carefully about possible futures, and to build programmes of education around them.

1.7.6 Emerging Pedagogies Integrate Self-regulation, Co-regulation and Social Share Regulation

The metaphor of the personal learning environment (PLE) is useful for characterizing the need to integrate three types of processes: self-regulation, co-regulation and social share regulation. A PLE is conceptualized using Web 2.0 tools and networked technologies and refers to an individual's own knowledge management tools, services, resources and connections which shape their educational platform to direct learning. Such learning ecologies tend to be more open, personalized and networked. A PLE is, in fact, an approach to learning based on Web 2.0 applications and emerging technologies which has been discussed and studied by many researchers to emphasize the potential of these participatory media and to put more value on learner-controlled learning tools in contrast to institutionalized learning management systems (e.g. Attwell 2007; Chatti et al. 2010b; Downes 2006, 2010).

1.7.7 Emerging Pedagogies Promote Deep Learning Tasks

Deep learning tasks restructure learning activities from a singular focus on content mastery to the explicit development of students' capacities to learn, creates and proactively implement their learning. In their most effective instances, deep learning tasks are guided by clear and appropriately challenging learning goals, which ideally incorporate both curricular content and students' interests or aspirations; include specific and precise success criteria that help both teacher and student know how well the goals are being achieved; and incorporate feedback and formative evaluation cycles into the learning and doing processes, building students' self-confidence and "proactive dispositions."

1.7.8 Emerging Pedagogies Are Transparent

Pedagogy requires making practices visible. Pedagogical reasoning must be as transparent as possible and shared between students, teachers and others involved in students' learning.

Teaching is a design science and the full pedagogic description of an intervention must include the design criteria, the properties of the teaching–learning activities, and the capabilities of the conventional and digital tools and technology being used.

1.7.9 Emerging Pedagogies Are Based on Socioconstructivist Pedagogies

Most instructional elements of new pedagogies are not "new" teaching strategies; although we would say that the active learning partnerships with students are new. Many of the teaching strategies that have been advocated for at least a century by the likes of Dewey, Piaget, Montessori and Vygotsky are beginning to emerge. Previously, the conditions for these ideas to take hold and flourish did not exist. Today, there are signs that this is changing. Crucially, the new ideas, compared to the past ones, potentially have greater precision, specificity, clarity and, above all, greater learning power. We are seeing a form of positive contagion as these powerful teaching strategies begin to take hold in regular schools. They are emerging almost as a natural consequence of student and teacher alienation, on the one hand, and growing digital access, on the other hand. These developments have profound implications for curriculum and learning design and assessment.

Emerging pedagogies are not necessarily new pedagogies. Emerging pedagogies need to explore and re-examine existing pedagogies by looking into their contribution in the contexts of the networked knowledge society.

1.7.10 Emerging Pedagogies Demands New Forms of Assessment

There is a need to move beyond traditional forms of assessment, using new methods to combine different levels. Data from tracking and management of learning activities can inform learning design by providing evidence to support the choice of media and sequence of activities. Such analytical feedback to students can continuous during a course enable learners to focus on areas of weakness.

Besides the use of technology, emergent pedagogies emphasize the active engagement of students in their own learning, learner responsibility, metacognitive skills and a dialogical, collaborative model of teaching and learning. For this reason, self-assessment and peer assessment are also very important. Andrade and Du (2007) provide a helpful definition of self-assessment that focuses on the formative learning that it can promote: "Self-assessment is a process of formative assessment during which students reflect on and evaluate the quality of their work and their learning, judge the degree to which they reflect explicitly stated goals or criteria, identify strengths and weaknesses in their work, and revise accordingly" (2007, p. 160).

Peer assessment involves students taking responsibility for assessing the work of their peers. They can therefore be engaged in providing feedback to their peers. It is a powerful way for students to gain an opportunity to better understand assessment criteria. It can also transfer some ownership of the assessment process to them, thereby potentially increasing their motivation and engagement

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Author Biography

Begoña Gros is full professor of education at the University of Barcelona. Her research is centre on the use of ICT to support learning, learning design, game-based learning as well as innovation. She co-authored more than 70 peer-reviewed publications in scholarly journals and conference proceedings and has co-authored or edited six books.

Chapter 2
Heutagogy: A Holistic Framework for Creating Twenty-First-Century Self-determined Learners

Lisa Marie Blaschke and Stewart Hase

Abstract Heutagogy, a form of self-determined learning, is a holistic, learner-centered approach to learning and teaching, in formal and informal situations. The theory is grounded in humanistic and constructivist principles and brings together numerous threads of early learning theories into a composite picture of learning that is suitable for and much needed in today's educational systems. With its learner-centered approach, heutagogy shifts the focus from the teacher back to the learner and learning. This chapter discusses the principles, processes, and design of heutagogic learning environments with a specific emphasis on digital technologies.

Keywords Heutagogy · Self-determined learning · Learner-centered teaching

2.1 The Challenges for Education

There is a revolution occurring in the way in which people learn (Blaschke and Hase 2014). This revolution is affecting our educational and training systems, teachers and trainers of that system, workplaces and other organizations, our social systems, and learners. What is odd about this revolution is that it has been so long in coming. It may well have had its origins with Socrates as he walked the gardens answering the anxious questions of his pupils. However, it was the constructivists and psychological humanists building on the shoulders of Vygotsky, and Maslow

L.M. Blaschke (✉)
Carl von Ossietzky Universität Oldenburg, C3L—Center für lebenslanges Lernen,
Ammerländer Heerstraße 136, 26111 Oldenburg, Germany
e-mail: lisa.blaschke@uni-oldenburg.de
URL: http://lisamarieblaschke.pbworks.com

S. Hase
Stewart Hase and Associates, 28 Conrad Close, Iluka, NSW 2466, Australia
e-mail: stewart.hase@gmail.com
URL: http://stewarthase.blogspot.com/

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and Rogers that identified the role of human agency in the learning process. Since then, and specifically relevant to this discussion, human agency has been connected to learning: Don Schön's notion of reflective practice (1983), Argyris and Schön's double-loop learning (1978), Bandura's self-efficacy theory (1977), Deci and Ryan's self-determination theory of learner motivation and autonomy (2002), learner-centered learning, Stephenson's ideas about capability (1992), action learning, and action research. At the same time, there has been a steady criticism of the structure of our educational systems (Doll 1989; Emery 1974; Kozol 1975; Doolittle 2000; Ackoff and Greenberg 2008; Sumara and Davis 1997) with Sir Ken Robinson (2010) providing the most contemporary call for a rethink of how we go about education. (For a summary of this argument, see Hase and Kenyon 2013b.)

The advent of heutagogy, a form of self-determined learning, in 2000 brought together these lines of evidence into a coherent framework for applying to education and training practice (e.g., Hase and Kenyon 2000, 2007, 2013b; Blaschke 2012). Like the theories that spawned it, heutagogy has gained some traction, particularly among practitioners and researchers in the e-learning world (Anderson 2010; Blaschke 2012, 2013; Cochrane et al. 2012; Gerstein 2013; Helmer 2014). It is contributing to the revolution, but the Bastille has yet to be breached. This despite some very successful experiments with learner-centered learning in the shape of Steiner and Montessori schools (Lillard 2005; Lillard and Else-Quest 2006; Woods and Woods 2005), which have been generally ignored by the establishment.

Where theory has failed, the interface between technology and social need may well succeed, driven by globalization and complexity. The revolution is occurring in the way in which individuals, teachers, and institutions obtain information and communicate or network to use today's parlance. It is occurring despite a reluctance of these three groups to fully understand the implications for formal education and training as a system. We are in the age of knowledge and skill emancipation. There are no barriers to knowing, and the skills required to be an effective learner in the twenty-first century have changed dramatically, as the learner evolves from passive recipient to analyst and synthesizer. On Bloom's taxonomy, these are levels that are rarely reached in formal education. Now, they are vital skills for survival in a complex environment where knowledge management, or what is now called curating, is more important than access. It is a revolution in which gurus can no longer lay claim to the stage as sole expert by virtue of access to information. The same power shift is occurring in the professions and bureaucracies of all sorts where, previously, people relied on "those who were in the know." Education is no exception.

The vision of lifelong learning, the education catch-cry of the 1990s, is now potentially achievable. Never before has the access to knowledge, skills, and competencies been easier. However, we are also in an age where competence is not enough, given the complex and rapidly changing world that we now inhabit. In addition to competency, people also need capability. When we talk to CEOs and talk to them about capability (Stephenson and Weil 1992; Stephenson 1996; Hase and Davis 1999; Davis and Hase 2001)—the capacity to use one's competence in novel as well as familiar circumstances—they reply positively and want capable people in their organizations. Capable people are simply more likely to function effectively in ambiguous, changing environments, or turbulence, as Emery and Trist (1965) described the environment we are in.

Our educational and training systems are based on a model that was developed to meet the needs of the industrial revolution. They prepare and maintain people to fit an economic model of society. To a large extent, this is still the prevailing political mental model that drives educational policy. However, this model is no longer enough given our twenty-first-century world and the challenges briefly touched upon above. Increasingly, we are seeing a system that emphasizes standardization and performance but not learning, creativity, or innovation. Instead, we need a system that creates and develops capable lifelong learners who have a rounded set of skills that prepare them for managing rapid change, with a concomitant desire to learn.

It is within this context that the following chapter examines heutagogy as a holistic model for advancing lifelong learning within multiple contexts, and a model further supported and propagated by technological developments such as Web 2.0 and the potential for Web 3.0.

2.2 Heutagogy Essentials

Heutagogy is defined as the study of self-determined learning (Hase and Kenyon 2000) and was developed as an extension to andragogy, or self-directed learning (Blaschke 2012). One of the differences between andragogy and heutagogy is that heutagogy further expands upon the role of human agency in the learning process. Thus, the learner is seen as, "the major agent in their own learning, which occurs as a result of personal experiences" (Hase and Kenyon 2007, p. 112). The learner and teacher, or *learning leader* (Hase 2014), work in partnership as the learner negotiates what it is she or he will learn and how she or he will learn it. The learner is at the center of the learning process rather than the teacher or the curriculum. In fact, both of these agents need to be flexible, able to shift as learning occurs, and the learner forges new paths, new questions, and new contexts. Other differences to andragogy (Blaschke 2012) include the emphasis on developing *capability*, *self-reflection*, *and metacognition* or an understanding of one's own learning process, *double-loop learning*, and *nonlinear learning and teaching processes.* Table 2.1 describes the basic principles that form heutagogic design.

As well as building on constructivist and humanistic visions of learning, heutagogy also draws on the more recent advances in neuroscience that have shed considerable light on how it is people learn at a cellular level. A summary of this research and its relation to heutagogy can be found in Hase and Kenyon (2013a) and Blaschke and Hase (2014). What this research does is to support learner-centered approaches to education and casts doubt on much of the current orthodoxy surrounding teaching methods. In addition, these advances in understanding how the brain functions seem to have a strong association with the ways in which people learn naturally at work and play, and even in educational settings. It is no wonder that the Internet and all that it offers have been greedily embraced by humans eager to learn and to associate.

Table 2.1 The principles of heutagogy

Principles	Description	References
Learner-centered and learner-determined	The role of human agency in learning is a fundamental principle. The learner is at the center of all heutagogic practice. The learner is self-motivated and autonomous and is primarily responsible for deciding what will be learned and how it will be learned and assessed	Hase and Kenyon (2000, 2007, 2013b), Hase (2009), Deci and Flaste (1995), Deci and Ryan (2002), Long (1990), Pink (2009)
Capability	Capability is characterized by the following: being able to use one's competencies in unfamiliar as well as familiar circumstances, learner self-efficacy, communication, creativity, collaboration (teamwork), and positive values	Cairns (1996, 2000), Stephenson and Weil (1992), Gardner et al. (2008), Hase and Kenyon (2000, 2003, 2007)
Self-reflection and metacognition	Within heutagogy, it is essential that reflection occurs in a holistic way. This translates to the learner reflecting not only what she or he has learned, but also the way in which it has been learned—and understanding how it is learned (metacognition)	Schön (1983, 1987), Mezirow and Associates (1990), Blaschke and Brindley (2011)
Double-loop learning	Double-loop learning requires that learners are both psychologically and behaviorally engaged. They reflect on not only what they have learned, but also the way in which this new knowledge and the path to learning have influenced their values and belief system	Argyris and Schön (1978), Eberle and Childress (2009), Eberle (2013)
Nonlinear learning and teaching	As learning is self-determined, the path to learning is defined by the learner and is not established by the teacher. As a result of learners choosing their own path, learning happens in a nonlinear format	Peters (2002)

2.3 Developing Self-determined Learners

Heutagogy offers a variety of benefits to today's learners, in particular the way in which the approach gives them a learner-centered environment that supports them in defining an own learning path. From the learner's perspective, Brandt (2013) describes heutagogy as empowering education as, "The students' self-determined studies lead to transformational experiences; this benefits individual learners and ultimately society" (p. 111). Heutagogy can also equip learners with the skills and capability that will help them better transition to the workforce. Our learners are faced with an environment that is vastly different from that experienced by previous generations. The pace of change is alarmingly rapid, particularly within the workforce. Employers want and need employees who are innovators, complex problem-solvers, and good communicators, and who are able to apply what they learn to real-life scenarios (Hart Research Associates 2013). Graduates need to be productive at the start of employment with little or no ramp-up time, *and* they must adapt quickly to new and disruptive innovations, continuously acquiring new skills:*…the complexities of the workforce in the 21st century require that employees have a wide range of cognitive and meta-cognitive skills, such as creativity, self-directedness, innovativeness, and knowledge of how they learn* (Blaschke 2014, p. 1).

In addition to these skills, other twenty-first-century workforce skills include communication, collaboration, digital literacy, and curation (Prensky 2010; Partnership for 21st Century Skills (P21), no date; Thomas and Brown 2011; Trilling and Fadel 2009). Learners also need to be able to work independently, as well as on teams. Chattopadhyay (2014) has elegantly linked the Cynefin model (Snowden 2000) to learning needs. Cynefin distinguishes between four work environments: simple, which requires best practice; complicated, which needs good practice; complex, which requires emergent practice; and chaotic, which demands novel practice. In the twenty-first century, we are mostly faced with complex and chaotic environments in which events are rapidly changing and where the relationship between cause and effect is difficult to establish. This means that normal planning and problem-solving are inadequate. We often have to act long before we have been able to fully understand what is happening. Complex and chaotic environments require a different style of learning, which is informal, driven by the experience of work, involves double-loop learning, is collaborative, and is cooperative. People in these environments need to know how to learn, and the organization needs to be adept at harnessing knowledge as it emerges. There is no time for formal training programs. Learning is "just-in-time" and emergent.

Education, however, has been slow to respond to the needs of learners in preparing them for the workforce. Arum and Roksa (2011) found that students are not learning skills that are needed for the workplace, such as critical thinking and creativity. According to research by Bentley's PreparedU (2014), "thirty-seven percent of recent college graduates give themselves a grade of 'C' or lower on their individual level of preparedness" for the workforce, with 4 out of 10 blaming the institution issuing the degree (p. 9).

A heutagogic approach to teaching and learning provides a holistic framework for developing self-determined learners: the type of learners in demand by today's employers. Heutagogic learning can help prepare learners for employment, as many of the skills they need align well with and are nurtured and developed through heutagogic learning. This type of learning is further supported by the advent of numerous new technologies and Web developments such as Web 2.0 and Web 3.0, which support learner-centered design and activities, as well as learner exploration, creativity, reflection, collaboration, and networking (Gerstein 2013; Sharpe et al. 2010; Conole 2012; McLoughlin and Lee 2007). A heutagogic design has the potential to turn that around and help students become more prepared for and productive in their roles in tomorrow's workplace.

2.4 The Heutagogic Design Process

Where to begin in realizing a heutagogic design in your classroom/training environment? A first step is to understand the process of designing for heutagogy (Fig. 2.1). Next, it is important to understand how to develop heutagogic learning environments (Fig. 2.2).

The first part of the heutagogic design process is *defining the learning contract*. During this phase, the learner and teacher work together to identify learning needs and outcomes. What does the learner want to learn/achieve? What should be the result of the learning experience (learning outcome)? In addition, specific course or program learning outcomes that may be required by the institutional environment should be taken into consideration. Next, the learner and teacher negotiate the assessment process. How will learning be assessed and who will assess it? In other words, how do we know that learning has been achieved? The curriculum should

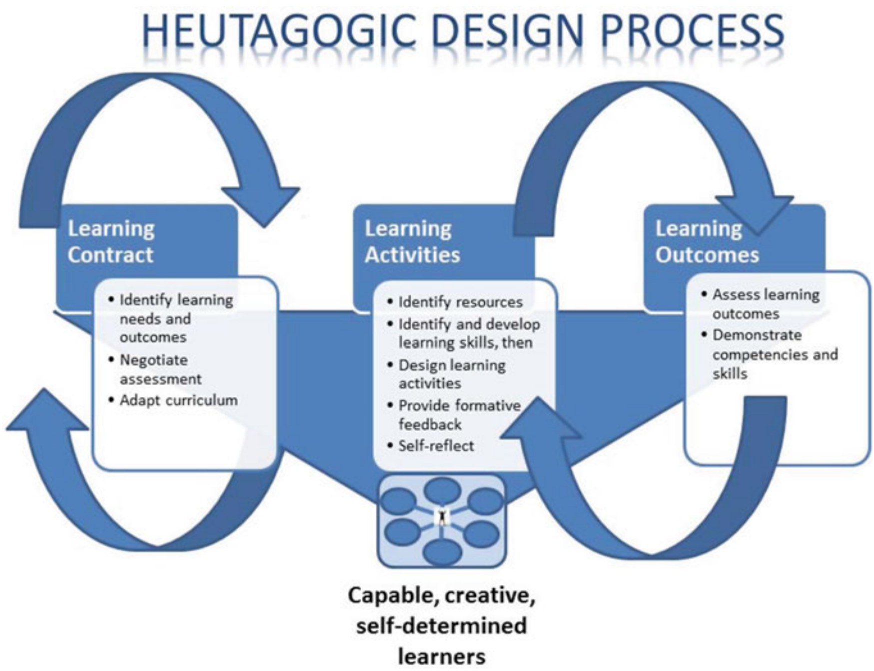

Fig. 2.1 The heutagogic design process

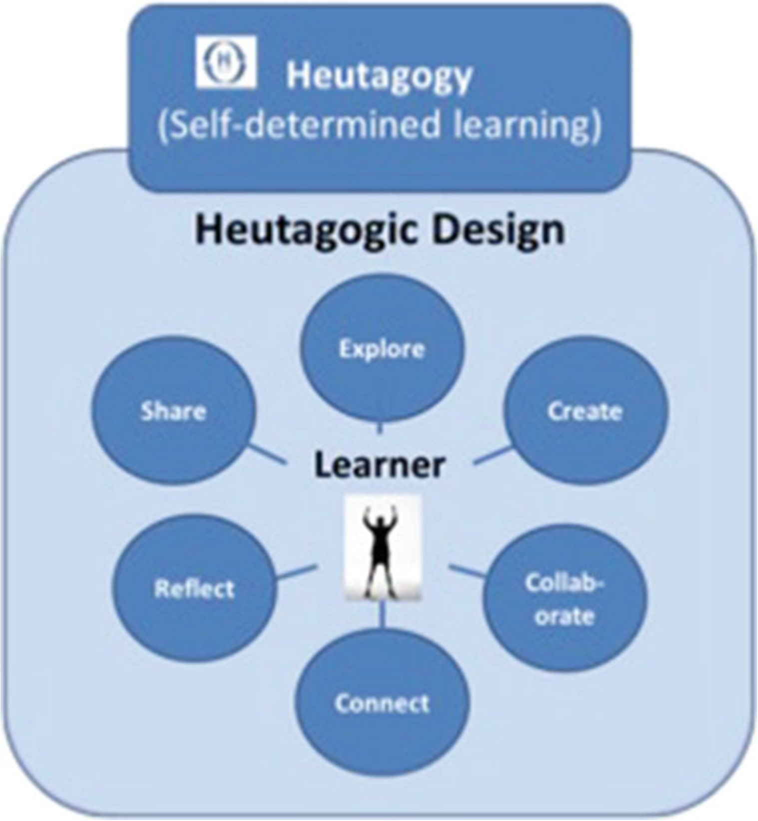

Fig. 2.2 Heutagogic design elements

then be adapted to the learning outcomes, as well as throughout the learning process. At the end of this part of the process, a learner contract is created and agreed upon.

The next part of the process is *development of the learning activity*. Dick (2013) identifies three universal aspects in this activity: challenge, autonomy, and support. To be successful in this design process, teachers need to create “a challenging, achievable and worthwhile task, providing participants with as much autonomy as possible, and engendering support based on strong and collaborative relationships” (Dick 2013, p. 52). Once the learner and teacher have reached agreement on the design for the learning, the learner and/or teacher can then choose any media, application, or tool to support their learning activities. It is essential that learners and teachers select those that support the learning activity and the desired learning goal. During this phase of the process, teachers should support learners in defining activities for learning, providing ongoing, constructive feedback, and provide opportunities for learners to self-reflect on new knowledge gained and on the learning process. In the next section, you will find more details about the elements of designing and developing learning activities for heutagogy. Examples of heutagogic learning activities can be found in Dick (2013).

In the last part of a heutagogic design process, *learning is assessed* in order to determine whether the agreed-upon outcomes have been achieved. How learning is assessed is based on the learner contract defined at the start of the process. Learning outcomes are reviewed and assessed, and specific competencies and skills acquired are identified. As heutagogy is learner-centered, the learner is the primary assessor of his or her learning.

In thinking about designing for heutagogy, a number of design principles for learning can be applied, no matter what the context is (Hase and Kenyon 2013a, b; Kenyon and Hase 2013). These can be summarized as follows:

- Learners need to be involved in negotiating what and how they learn (Kenyon and Hase 2013; Hase 2013)—throughout the design and learning process.
- Curricula should be flexible and take into account learners' questions and motivations and how thinking shifts as a result of things they have learned.
- The learner and teacher need to work together to negotiate how learning outcomes will be assessed. Evaluation could also include forms of participative (self- and peer) evaluation, allowing learners to learn from each other and through self-reflection (Dick 2013).
- The role of the teacher is to guide the learner, providing formative feedback that is personalized according to the learner needs.
- The learning environment needs to incorporate opportunities for learners to explore and reflect on what they have learned and how.

As a cautionary note, teachers should be aware that learning in a heutagogic classroom often creates inner conflict for learners. Learners are not accustomed to taking responsibility for their learning and being placed in such a position that can be intimidating and uncomfortable. However, as Brandt (2013) relates in her writings on heutagogy from a learner perspective, once learners have a taste for self-determined learning, few want to return to the restrictions of a fully structured curriculum.

2.5 Heutagogic Design Elements

Based on the negotiated learner contract, the learning activities for the heutagogic learning environment can be designed and developed, as shown in Fig. 2.2.

In the following sections, we will describe each of these design elements and provide examples of how each can be supported using technology.

2.5.1 Explore

Fundamental to heutagogy is the element of exploration. Learners must be given the freedom and opportunity to explore a variety of paths and sources of knowledge on their journey. They need to be able to develop and test hypotheses, and ask and answer questions—all of which arise during the process of exploring. Structured curricula are out; learner-defined curricula are in. With its nonlinear structure, the Internet provides the ideal environment for self-determined exploration. Google (www.google.com) and Wikipedia (www.wikipedia.com) are primary examples of online sources that can be used as starting points for one's learning explorations. Another source of information are digital libraries and magazines. Applications such as Flipboard (www.flipboard.com) allow learners to organize their discoveries and information resources in one place, thus beginning to create their own personal learning environment. Social media provides the opportunities to access people with expert opinion or with ideas. Not all learners find it easy to be explorers and may need additional guidance initially, and the role of the teacher is to provide possible resources to help learners orient themselves and begin moving forward in the process. As learners learn to roam free, they become more self-directed in their learning and will begin to seek out new pathways and resources to further their learning.

2.5.2 Create

Another important design element of heutagogy is giving the learner the freedom to create. This can be achieved using a variety of learning approaches, e.g., writing, designing, and drawing. One useful learning approach is creating mind maps. Within the online environment, learners can use a variety of tools to create mind maps of their learning, such as Popplet (http://popplet.com/) and bubbl.us (https://bubbl.us/). Learners can also use online blogs, such as WordPress (www.wordpress.com), PBWorks (www.pbworks.com), and Weebly (www.weebly.com), for designing and writing activities. Creations do not have to be limited to individual blogs and Web sites, however. Learners can also create an online presence by collaborating with others.

2.5.3 Collaborate

Collaboration is another key element to heutagogy and aims to provide the kind of environment where learners can learn from each other. Working together toward a common goal, learners are able to solve problems and reinforce their knowledge by sharing information and experiences, continuously practicing, and experimenting by trial and error. They simply help each other along the way. The teacher serves as coach during the collaboration process, letting learners forge forward together and stepping in only when absolutely necessary. In applying heutagogic practice in teams, Dick (2013) recommends giving team members complete autonomy, allowing teams to manage learning activities and the learning process. For online and blended learning environments, numerous Web 2.0 tools are available for learners who want to bring their collaboration online. Using tools such as GoogleDocs and Wiggio, teams can work together in real time, share resources, *and* develop skills that are easily transferable into tomorrow's work environment.

2.5.4 Connect

Networks and connections are a critical aspect within heutagogy, as it is through these connections that new avenues of learning can be created. Making connections is easy with today's social media, which gives learners an opportunity to network with people across the world. As Brandt (2013) relates, "Virtual connections, made through the Internet, can provide opportunities for real-time input from experts in the field of study" (p. 110). Whenever possible, learners should be encouraged to connect with others within their discipline using the media available. Examples of social networking sites include Twitter (www.twitter.com), LinkedIn (www.linkedin.com), Academia.edu (www.academia.edu), Facebook (www.facebook.com), WhatsApp (www.whatsapp.com), and Google+ (https://plus.google.com).

2.5.5 Share

Once learners have started connecting, they can begin sharing. Numerous Web 2.0 tools are available for this purpose, such as SlideShare (www.slideshare.net), ResearchGate (www.researchgate.net), Twitter (www.twitter.com), and Facebook (www.facebook.com). By sharing information with each other, learners are able to learn from each other's discoveries and experience, as well as identify others with similar interests, which can lead to potential opportunities for future collaboration. Teachers can help learners identify and use information sharing tools and applications, as well as provide guidance for evaluating online information. Included as part of the sharing process is curation. To curate information online, learners browse for information, critically review the relevance and value of the work, publish the information (usually a link) to an online space, and then share the information with their followers/friends. ScoopIt! (http://www.scoop.it/) is one such online curation site that is currently popular. Using the tool, learners can create an online space around a specific topic and then publish their news scoops directly from the Web while saving the *scoops* to their individual news page. An example ScoopIt! site can be found here: http://www.scoop.it/t/future-of-learning-self-determined-supported-by-technology. Using tools like ScoopIt! to curate and publish information encourages exploration, development of digital literacy skills, and network and community building.

2.5.6 Reflect

Finally, within every heutagogic learning environment, learners need to have opportunities to reflect. This is where there is potential for new learning to occur and previous learning to be consolidated. Reflection provides an opportunity to ascend to higher levels of cognitive activity such as analysis and synthesis. Repetition helps information move from short- to long-term memory. This reflective activity should include reflecting on the new knowledge that the learner has gained, as well as how she or he has learned—and the ways in which this learning experience has influenced his or her value system and beliefs. One common method for reflection is the use of reflective learning journals, which can also be created and shared with others online (Blaschke and Brindley 2014). The teacher can support the learner throughout the reflective process by providing formative feedback and nurturing inquiry-based learning.

2.6 Skilling Learners and Learning Leaders

One of the challenges of any kind of change is to overcome cognitive schema or mental models. Education and training is no different. Politicians, policy makers, the recipients, and many practitioners have cognitive schemas about educational practice that are based on their previous experiences of education. This may explain why constructivist and humanistic models of learning have been slow to catch on, despite the evidence of their effectiveness.

An important shift of perspective needed in twenty-first-century learning is recognizing that the needs of the learner and the skills of the teacher, or *learning leader*, are different from those needed in a more structured environment. The idea of capability already mentioned in this chapter touches on the need for a changing skill set given the complexities of the world in which we live.

The learners of the twenty-first century, or *heutagogic learners*, primarily need to be highly skilled learners. They need to be able to respond to a knowledge or skill deficit by knowing where to go to fill the gap, whether this is by networking or searching the monstrous database that is the Internet or library. They need to be good researchers with the appropriate digital literacies. Given the vast amount of information now available on the net, learners more than ever need to be able to separate the wheat from the chaff by being able to check data with reputable sources, to analyze and synthesize information, to recognize a good argument, and to differentiate between correlational and causal relationships. According to Gerstein (2014), today's learners need to:

- be agile and adaptable,
- have good oral and written communication skills,
- be able to collaborate across networks, be curious, and be imaginative,
- be optimistic,

Table 2.2 Attributes and skills for learning leaders

The capacity to accept and manage ambiguity	The ability to foster engagement	The ability to learn	The ability to apply open systems thinking
Attributes			
Low need for control Openness to experience (one of the Big 5 personality traits) Moderate on perfectionism scale (Big 5) High stability (low anxiety) (Big 5) Capability	Empathy Optimism Flexibility to change approaches as circumstances change	Willingness to change own ideas or beliefs	Willingness to empower others
Skills			
Project management Ability to use social media	Interpersonal effectiveness Ability to self-regulate Understanding of how to motivate others Ability to foster a shared purpose and vision Maintaining direction Fostering the joy (and rewards) of learning	Ability to research and learn Being thoroughly on top of one's subject areas Having wide and accessible networks Ability to share openly with others Knowledge management skills The ability to foster collaborative learning Ability to apply learning Willingness to change own ideas and beliefs	The capacity to frequently scan the external environment Ability to foster participative democracy/collaboration decision-making and process Capacity to work in a team as leader and member Ongoing internal and external analysis of effectiveness (continuous improvement) The ability to filter information (research skills)

- have critical thinking and problem-solving skills,
- demonstrate initiative,
- be entrepreneurial,
- have vision,

- be resilient, and
- have empathy and a sense of global stewardship.

Learning leaders also need special abilities to cope with the turbulent environment they inhabit, as well as the challenges of twenty-first-century learning such as those espoused by heutagogy (Hase 2014). These attributes and skills are provided in Table 2.2.

You can see that these skills and attributes have more to do with leadership than they do with technique. They involve particular cognitive schema as an attribute and facilitation rather than direction as the core skill. The learning leader needs to be able to relinquish the need for control and to adapt to the changing needs of the learner. Command over process and resources is critical, as well as the ability to be a colearner together with the student.

2.7 Conclusion

Change is no longer an exception in the current world we inhabit. It is the normal state and is discontinuous. The ability to learn, for both individuals and institutions, is critical to survival. While it has always been so, adaptation in the past could comfortably take place over a long period of time. Now, that is no longer possible. And we have the tools to be able to learn quickly and effectively: whenever and wherever we are. What needs to happen now is a concomitant shift in our thinking about educational and training systems that keeps pace with both the need to learn effectively and the technology that enables it. This change in our cognitive schema about how we learn needs to become based on the readily available science that tells us clearly about how people learn best rather than outdated models that were built for the industrial revolution. Learners, learning practitioners, policy makers and politicians, and managers of organizations need to be prepared to use this science and to adjust their thinking about learning in the twenty-first century. Heutagogy, or self-determined learning, provides them with a framework to think about learning in a revolutionary way.

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Author Biographies

Lisa Marie Blaschke is program director of the Master of Distance Education and E-Learning (MDE) graduate program at Carl von Ossietzky Universität Oldenburg, Germany, as well as an associate professor (adjunct faculty) within the program. She is an executive committee member of the European Distance Education and E-Learning Network (EDEN) and an EDEN Fellow. Her research interests are in the areas of lifelong and self-determined learning (heutagogy) and the pedagogical application of Web 2.0 technologies. Before rejoining academia in 2006, Lisa worked for an international software company for nearly two decades, leading and implementing enterprise-wide knowledge management and training solutions.

Dr. Stewart Hase is a psychologist interested in human adaptation, change, and learning. He has been an academic, therapist, and organizational consultant. Currently, he is involved in assisting organizations with developing winning learning programs as well as developing effective leaders. Stewart along with Chris Kenyon was the founder of self-determined learning in 2000.

Chapter 3
Design for Networked Learning

Peter B. Sloep

Abstract This chapter discusses guidelines for networked learning. First, a few definitions are analyzed and it is concluded that networks are essentially different than communities, although the former will contain the latter. Then, the notion of learning design is examined, resulting in the conclusion that the distinction of Carvalho and Goodyear between epistemic, social, and set design should guide the design of networked learning. Each of these design aspects is then scrutinized. After analysis of pertinent metaphors of learning, epistemic design turns out to be subject to the maxim that learning networks cannot be designed, only designed *for*. With this as a limiting perspective, guidelines for the social design of learning networks are derived, in which the notion of an ad hoc transient communities plays a key role. In the context of the set design, examples of tools for social interaction support, navigation support, and (formative) assessment support are inventoried. Together, the results of the analysis of epistemic design, the guidelines for social design, and the inventory of tools for set design provide a valuable if still growing toolkit to the designer of learning networks.

Keywords Networked learning · Learning network · Learning design · Social design · Epistemic design · Set design · Ad hoc transient community · Design of · Design for

P.B. Sloep (✉)
Open University of the Netherlands, Valkenburgerweg, 177, 6419 AT Heerlen, Netherlands
e-mail: peter.sloep@ou.nl
URL: http://www.pbsloep.nl

P.B. Sloep
PO Box 2960, 6401 DL Heerlen, Netherlands

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3.1 Introduction

One of the earliest definitions of networked learning is by Linda Harasim and co-authors. In 1995, already they wrote that 'Learning networks use computer networks for educational activity (…). [These networks] depend on the hardware and software that form the communications network, but they consist of the communities of learners (…)' (Harasim et al. 1995, p. xi). Although Harasim et al. were the first to coin the term 'learning network,' to the modern reader who is aware of the existence of a social Web next to the information Web (Berners-Lee and Fischetti 1999), their definition seems odd. By focusing on communities only, it ignores the dimension of the larger (social) network. Rob Koper seems to share Harasim et al.'s penchant for putting communities center stage as he writes: A Learning Network (…) is defined as a *technology supported community of people* who are helping each other (emphasis added, Koper 2009, p. 6). In both definitions, the 'network' in learning network seems to refer to the technical infrastructure only. And indeed, Koper's book is primarily about Web-based services. But, clearly, it is the formation of online *social* networks that differentiates networked learning from other forms of social learning (situated learning, collaborative learning, problem-based learning, etc.).

The critique of uniquely basing networked learning in communities of learners is also leveled by Goodyear and Carvalho (2014) in the introductory chapter to their book *The Architecture of Productive Learning Networks*. Interestingly, though the above definitions ignore the social in favor of the technological, more generally speaking 'the nature of [technological] tools is still an under-theorized topic' (ibid., p. 14, who cite Oliver 2013 in approval). And the criticism of Goodyear and Carvalho of extant definitions ranges wider. From their survey of a variety of definitions, they therefore conclude that any satisfactory definition of networked learning should:

1. allow one to individuate a learning network, i.e., discern instances from each other;
2. avoid the use of language that is customary in formal education;
3. emphasize technology as well as people; and
4. mention the individual as well as the collective.

I will not attempt to come up with a stipulative definition that satisfies all these conditions. In my view, the process of concept formation in the field of networked learning has not matured sufficiently yet to do so. Instead, I will provide two more, contrasting definitions. I do so as they form a convenient starting point for the remainder of the discussion in this chapter while satisfying at least to a large extent of the above four criteria.

First, Jones and Steeples (2002, p. 2) and later on Goodyear (2005, p. 114) proposed that networked learning is 'learning in which information and communication technology (C&IT) is used to promote connections: between one learner and other learners, between learners and tutors, between a learning community and its learning resources.' This definition emphasizes a *mechanism* through which networked learning operates: through the online mediation that various kinds of connections provide. What it fails to do is underscore the element of design: as with all learning environments, learning networks are also the result of a deliberate design process. Although the three authors all subscribe to the view that learning networks need to be designed—it is the whole point of Carvalho and Goodyear's *Architectures* book (ibid)—this aspect is not part of their definition. In contrast, the definition given by Sloep and Sloep and Kester stresses precisely this aspect. They defined a learning network as 'a particular kind of online, social network that is designed to support informal learning in a particular domain' (Sloep 2009, p. 64; Sloep and Kester 2009). What is missing here is the 'mechanistic' aspect of how the network is formed. I surmise that, at least for now, both definitions may coexist as they are of a different nature: The first one lists *causal* mechanisms, and the second one focuses on the *functions* that those mechanisms are supposed to serve (cf. Robinson 1972 for a discussion of the alternative roles functional and causal definitions play). It is the functional, design stance that will guide the discussion in this chapter (Sect. 3.2), but the functional aspects will be fleshed out in a discussion of causal mechanisms (Sect. 3.3). This chapter concludes with a brief summary and discussion of a number of issues that were left out thus far but nevertheless may not be omitted in a discussion about the design of networked learning (Sect. 3.4).

3.2 Design for Networked Learning

Design is a key to teaching and learning, even though this is not always apparent, such as in school-based formal learning[1] or in formal corporate training. Who would see teaching in a classroom as the result of a conscious design decision? But according to Diana Laurillard 'Teaching is (…) a design science because it uses what is known about teaching to attain the goal of student learning, and uses the implementation of its designs to keep improving them.' (Laurillard 2012, p. 1). Some decades ago, the term 'instructional design' was popular, 'learning design' as a notion did not even exist. However, according to many, the two share the same aim: supporting learning. Michael Spector is of the opinion that it is unfortunate that 'instruction' as a term has fallen out of grace. He suggests that 'the wrong-headed assumption that instruction is a rigid process with fixed steps that do not take individual learners or new technologies into consideration' is to blame (Conole 2014, p. v). True or not, 'learning design' is the term that is *en vogue* nowadays and

[1]Since it is only tangential to the present discussion, I will not elaborate the distinction between formal and non-formal learning here. The interested readers may want to consult a blog post of mine on the topic. It locates the difference in the presence or absence of a social contract between al learner and a learning institution (Sloep, About Formal and informal (non-formal) learning. *Stories to TEL*, August 2012. http://pbsloep.blogspot.nl/2012/08/about-formal-and-informal-non-formal.html).

I will use it here. If a substantive distinction is to be made at all, it is that learning design seeks to put the learner at the focus of the attention while instructional design focuses more on the instructor role.

The first time the term 'learning design' caught wide attention was when in 2003 the *IMS Learning Design specification* (for short, IMS LD) was published (IMS Global Learning Consortium 2003). IMS LD is an attempt formally to specify 'under which conditions, what activities have to be performed by learners and teachers to enable learners to attain the desired learning objectives' (Koper and Olivier 2004, p. 98). Central to IMS LD are the notions of 'activity,' 'role,' and 'environment' (ibid, Fig. 1; Koper and Manderveld 2004, Fig. 1). According to Koper (2001) their centrality emerged from a substantive search through the then extant pedagogical and educational literature. In the context of networked learning, Goodyear and Carvalho distinguish three similar elements. They 'focus on understanding how structures affect and influence activities, acknowledging that human activity tends to be goal oriented (though not tightly goal-driven) and physically and socially situated' (Goodyear and Carvalho 2014, p. 59). They thus split the total design job in three parts. To the goal orientation and activities they refer as the *epistemic design*, to the design of the social environment as the *social design*, and to the design of the 'physical' as the *set design* (physical in scare quotes, as physical usually refers to the virtually physical). The term 'set' derives from the theatrical metaphor they use. Interestingly, the theater metaphor is also used in the context of IMS LD (Koper and Olivier 2004). Other authors, such as Conole (2014) and Laurillard (2012), adopt slightly different terminological conventions in arguing their commitment to learning design. Here, I will use the design terminology of Goodyear and Carvalho as a guiding principle. I do so as theirs, unlike the terminology by the other authors, is specifically geared toward the topic of this chapter: the design of networked learning. However, I will formalize it somewhat more than Goodyear and Carvalho did.

Figure 3.1 uses UML conceptual modeling conventions more formally to draw the distinctions that Carvalho and Goodyear (2014) made in their Fig. 3.1 (ibid p. 59). For those who are unfamiliar with UML (conceptual) domain modeling conventions, boxes are concepts, and the lines connecting them denote associations; associations with arrows denote a 'is a kind of' association, those with diamonds a 'is a part of' association. A dotted line indicates attributes that are specific to a particular association (for more details on the notation see for example Fowler 2000).

The middle (white) part of Fig. 3.1 depicts the *epistemic* design. It shows how learners perform learning activities with the aim of achieving particular learning goals, which have been translated in tasks. Section 3.3.1 goes more deeply into the epistemic design. The dark-shaded upper part of Fig. 3.1 covers the *social design*. Learning activities are carried out by a learner in a social environment, which may take the form of a team (dyad or larger), community or entire network, depending on the task at hand and its translation in a concrete activity. Perhaps the three types of social environment indicated will not exhaust all that is possible, but they suffice to suggest what is to be understood by the social environment. Section 3.3.2 discusses the dynamics of the social environment in networked learning. The *set design*, finally, is covered by the light-shaded lower part of Fig. 3.1. The set consists of two kinds of

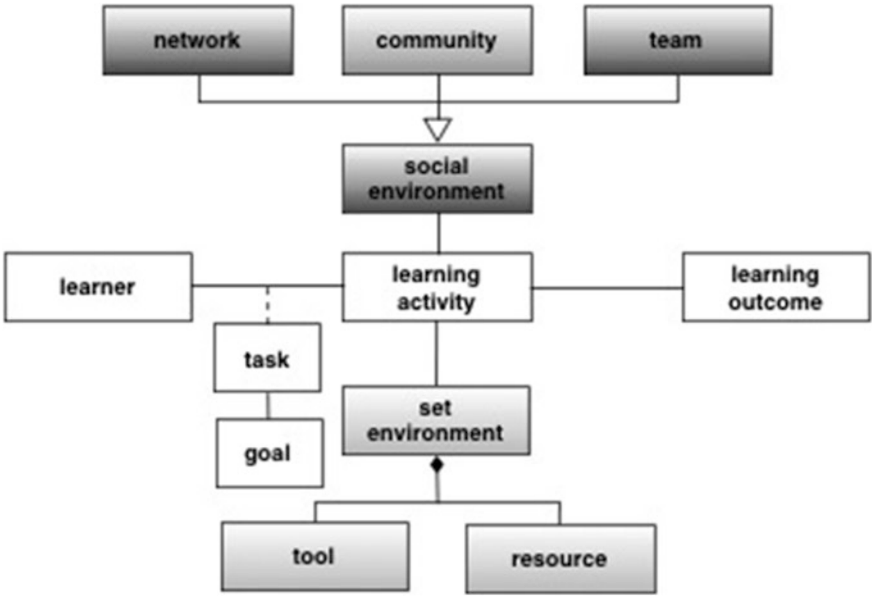

Fig. 3.1 A UML conceptual domain model of the epistemic (*white boxes*), social (*dark boxes*), and set (*light boxes*) design. Expanded from Goodyear and Carvalho (2014, Fig. 3.1)

parts, which conveniently may be labeled tools that the learner may deploy and resources that the learner may access in the course of carrying out his or her learning activities. Resources differ from tools in that the latter are of an interactive kind, whereas resources aren't. So, a typical tool would be a question answering service (say a search engine such as Google or DuckDuckGo) and a typical resource would provide background materials (say a library, Wikipedia, or YouTube). Section 3.3.3 will discuss a number of tools that suit networked learning designs particularly well.

Those who are familiar with the IMS LD UML conceptual modeling diagrams will notice the structural similarity that Fig. 3.1 bears with those, for example, with Fig. 3.1 in Koper and Olivier (2004). Although terminology may differ (the set is called the environment), and theirs is a much more detailed model with many additional concepts, the structure of the associations is similar. There is one major exception to this. In IMS LD, the learner is a special kind of *role* and the other actors (peers, teachers, and tutors) are other specialisations of the role element. Indeed, peers are not even mentioned explicitly and they are just other learners. In the present account, the roles of peers (and other actors) are dealt with in the social design. The social environment is thus on a par with the set environment. This puts emphasis on the social aspect of learning, which of course should be a key to any design account of networked learning. Indeed, IMS LD has been critiqued for the lack of explicit attention to these social aspects (cf. Laurillard and McAndrew 2003).

3.3 Designing for Networked Learning

In this section, the three aspects of designing for networked learning—epistemic design, social design, and set design—will be discussed in turn.

3.3.1 Epistemic Design

As Fig. 3.1 shows, the *epistemic design* concerns activities that learners perform toward the achievement of particular outcomes. The design aspect becomes apparent when a teacher (tutor, instructor, etc.) designs goal-related tasks. Diana Laurillard describes five design patterns for learning. They range from learning through acquisition via learning through inquiry, discussion, or practice to learning through collaboration (Laurillard 2012). These patterns certainly fit the context of networked learning, although some better than others. The learning-through-discussion and learning-through-collaboration patterns would seem obvious candidates, after all they demand social interaction, which is a prerequisite for networked learning. The patterns, as do all learning design approaches, connect goals with outcomes. The intention is that the goal behavior as envisaged by the designer closely resembles the outcome behavior as exhibited by the learner. However, in actual fact, they will almost invariably be different. This difference between intended and actual outcome arises for at least two reasons. The one is related to very general characteristics of design activities, and the other has a deeper, pedagogical background. Since they impact any epistemic design effort, I will discuss them in turn.

Although it may demand a stretch of the imagination, learning designs are *artifacts*. Perhaps they are not singular technical systems themselves, such as a car, computer, or a mobile phone, but since all learning designs will at least *contain* artifacts (even a blackboard is an artifact) they are for sure sociotechnical ensembles. This distinction derives from the sociologist of technology Bijker (1999, 2010). His main thesis is that ‘technology does not have its own intrinsic logic but is socially shaped’ (Bijker 2010, p. 66). This socio-constructivist stance sharply contrasts with the received instrumentalist view—intuitively held by many—that technical tools all have intended specific functions and only those functions (Creanor and Walker 2010). The instrumentalist view also gives rise to the mistaken idea that one may use a technical tool or not at one’s liking. In actual fact, because such tools are socially shaped and part of sociotechnical system, their use becomes at some point unavoidable. However, as Bijker’s analysis shows, ‘the description of an artefact through the eyes of different relevant social groups produces different descriptions—and thus different artefacts. (…). There is not one artefact, but many.’ (Bijker 2010, p. 68). Thus, one may use technical artifacts as one sees fit, irrespective of its intended usage. Bijker refers to this as the artifact’s *interpretative flexibility*. Jon Dron and Terry Anderson put it this way: ‘Much modern social software is an example of (…) a *deferred system*: one whose form only emerges after it is designed, through the actions of its users' (emphasis added, Dron and Anderson 2009, p. 3). The implication for the epistemic design of learning networks is that whatever the designer's intentions, learners pick up (of fail to pick up) what in relation to their purposes suits them best. This sets natural limits to the expectations one may have of designs, i.e., any design including learning designs. To teachers, who make every effort to educate their pupils and students on the intricacies of, say, Mendelian genetics or the Spanish *pretérito indefinido*, this will of course not come as a surprise.

There is a second reason the relation between goals and outcomes is a rather loose one. It relates specifically to the nature of networked learning. Goodyear and Carvalho argue that 'networked learning cannot be designed—it can only be designed *for*' (emphasis in original, Goodyear and Carvalho 2014, p. 11). Their seemingly innocuous remark has far reaching consequences, which are deeply rooted in the pedagogical aspects of networked learning. In a seminal paper, Anna Sfard distinguished two metaphors of learning, the acquisition and participation metaphor (Sfard 1998). I cannot delineate their difference any better than Betty Collis and Jef Moonen did: 'Key aspects of an acquisition approach to learning include knowledge, fact, concept, and attainment, the *having* of knowledge. (…) The participation metaphor (…) places the nature of learning in belonging, participating, communicating, becoming a member of a community (…) in *doing*' (emphases in original, Collis and Moonen 2008, p. 97). To simplify somewhat, learning through transmission of knowledge as practiced in many classrooms and lecture halls is contrasted with learning through co-constructing knowledge. Eight years after Sfard published her paper, a third metaphor was added into the mix. To learning through knowledge acquisition and participation, Sami Paavola, Lasse Lipponen, and Kai Hakkarainen added the idea of learning through knowledge creation (Paavola et al. 2004). I surmise that this kind of learning best fits networked learning.

The learning situations the third metaphor characterizes are those of professionals collaborating on solving ill-structured (Simon 1969) 'wicked problems' (Stahl 2006) that demand creativity and thinking 'out of the box.' The professionals learn, certainly have the intention to learn, but the situations in which they learn do not allow teachers simply to developed tasks from goals (Boud and Hagar 2012; Sloep et al. 2014). Indeed, the defining characteristic of wicked problems is that they cannot be described with any precision nor can their solution space. The learning goals that the epistemic design wants therefore can only be described in the vaguest of terms and so can the tasks. Forms of scaffolding are the best one can strive for (Ge and Land 2004), for example through the design of an environment ('enabling space') that enables learning through knowledge co-construction without trying to 'manage' it (Peschl and Fundneider 2014). It is this enabling-instead-of-directing character of networked learning that prompted Goodyear and Carvalho to claim that one cannot design networked learning, only design *for* it. This maxim encapsulates quite succinctly the essence of epistemic design.

Before continuing, I should stipulate that in networked learning situations there may well be room for learning through acquisition, for instance the just-in-time acquisition of items of explicit, codified knowledge (Sloep 2013). And since much innovation demands multidisciplinary teams, who need to invest in common grounding, there will also be ample room for learning through participation (Sloep et al. 2014). However, in the next two sections, I will ignore acquisition learning and focus on participative and in particular creative learning. I do so because much is already known about acquisition learning, through research carried out in schools. We know much less about learning through participation or learning through knowledge creation. But more importantly in my conviction, networked learning only shows its true strength in connection with participation and in particular knowledge creation.

3.3.2 Social Design

I began this story by analyzing a few definitions of networked learning and pointing out how two of them in my opinion failed since they ignored the network and restricted networked learning to communities only. For sure, communities matter much in networked learning, but one should not take them for granted but instead look at their dynamics to understand how they matter. Before continuing, I should point out that for the sake of the present argument a community is thought to consists of people with a joint goal, in contrast to networks that consist of people with merely a shared interest. Other distinctions may be made, such as that generally speaking communities count fewer people than networks and the social fabric of a community is usually more developed than that of a network—but I will avoid going into those issues here (but see Dron and Anderson 2009, 2014).[2]

The most influential work on social learning was carried out by such people as Bandura (1977) and, later on, Lave and Wenger (1991). Was Bandura interested in all kinds of learning, primarily formal, school-based learning, Lave and Wenger focus on the informal learning of professionals in so-called communities of practice. The participants of such communities learn by *peripheral participation*, that is, through their presence in the many professional discussions that take place in the context of the community. Lave and Wenger's case studies are about people who see each other frequently in the course of their jobs or occupations and exchange 'war' stories. They discuss the problems and challenges they have to face, the solutions they come up with. These stories become part of the group lore and are exchanged at team meetings but more often during coffee breaks (Wenger et al. 2011). John Seely Brown and Paul Duguid in their book *The Social Life of Information* tell an illustrative tale about people who repair Xerox machines (Brown and Duguid 2000, pp. 99–109). It illustrates how detrimental it is to the quality of these technical representatives' work if, in an effort to increase efficiency, the company's management ignored the social learning dimension and forbade

[2] I elaborated on the distinction in a blog post of mine, from which also parts of the text presented in this subsection were derived (Sloep 2013, Learning in networks and in communities of practice. *Stories to TEL*, September 2013. http://pbsloep.blogspot.nl/2013/09/learning-in-networks-and-in-communities.html).

them to meet informally. So, in communities of practice, people learn in virtue of the tight social group that the community forms, with (almost) everybody strongly linked to everybody else through regular and topic-bound interactions. Note that in communities of practice, learning is social, as with Bandura, but also largely accidental: This is where the coffee breaks come in. This accidental character nicely fits in with the participation and knowledge creation metaphors of learning introduced in the above.

Learning in networks does not only focus on the strong, community-bound links as in the above example, but particularly emphasizes the importance of weak and latent links (i.e., indirect links that run via network members). Chris Jones and colleagues were among the first to note this, although Caroline Haythornthwaite already discussed the principles in the context of distance learning several years earlier (Jones et al. 2008; Haythornthwaite 2002). Of course, weakly let alone only indirectly linked people do not learn from each other, precisely for want of the direct social interactions that social learning requires. However, the importance of weak and latent links for networked learning is their potential to develop into the kinds of strong links that sustain communities. So a learning network is thought to consist of people who are connected to each other through strong as well as weak and latent links. Strongly linked individuals learn from each other, and weakly or latently linked individuals learn from each other once they get connected more firmly. This requires (i) that the not-so-strongly-linked learners somehow get more strongly connected, and (ii) that there is a motivating need for them to learn from each other. I will discuss these two points now in turn.

It is a fact of common experience that our mental ability to maintain strong relationships is limited, often indeed to our own embarrassment. There is also scientific evidence for why this is so: our limited brain capacity. Roger Dunbar argues that the upper limit to the number of people with whom we can maintain strong relationships is in the order of 150 people only (Dunbar 1993). Social networks, in particular online networks, can of course be much larger. For whatever the numbers are worth, Google searches for ‘active users of [fill in some online social network]’ reveal that at the time of writing Facebook had over a billion active users, LinkedIn over 300 million and niche research networks such as Mendeley and ResearchGate still 2.5 and 1.5 million, respectively. Clearly, from the vantage point of the individual learner, these are overwhelming numbers. So, to explore the weak and latent links in such networks and to ensure that one connects with the right people, people with whom one can learn better, technological aids are needed that suggest limited numbers of potentially highly interesting people. Section 3.3.3 will explore some of these technologies.

However, merely suggesting people is not enough, and there is a need for a kind of mediating device, an intervening community that allows a learner to explore someone’s suitability as a future peer or collaborator. I have introduced the term *ad hoc transient community* to denote small groups of such suggested peers (Kester and Sloep 2009; Sloep 2009). Others have made similar suggestions and also called attention to the role of technology. In his discussion of open source communities, Steven Weber writes: ‘Internet technologies radically undermine organizational structures because they reduce the cost of communications and transactions toward an asymptote of zero. This is supposed to enable the formation of *episodic communities on demand*, so-called virtual organizations that come together frictionlessly for a particular task and then redistribute to the next task just as smoothly' (emphasis added, Weber 2004, p. 171). Whatever their name, the important point to note is that such temporary groupings allow one to 'get a feel for' one's peers. As a result of that, the temporary grouping may disappear once the problem is solved or the individual participants may maintain the connections, even to the extent that the entire ad hoc community turns into or becomes integrated in a full-fledged community of practice. Through this device of ad hoc transient communities, our picture of networked learning achieves a dynamic. A learning network will usually consist of many communities that wax and wane or even emerge and disappear as a consequence of the actions of the networked individuals (Sutcliffe et al. 2012). Ad hoc transient communities provide the mechanism for the dynamics of forging new links, our limited brain capacity the mechanism for the breaking or weakening of existing links.

The dynamic described here presupposes that network participants are at all interested in forging new, strong links. Much may be said about this, particularly from an explanatory point of view, but I will restrict myself here to a number of remarks that are relevant to the present design context in particular. Assuming in the first instance that the network is largely self-organizing and no facilitators are present, Liesbeth Kester and I myself gleaned some advice from the literature on how to increase the success of ad hoc transient communities as mediating devices (Kester and Sloep 2009). Building on the assumed goal-directed nature of ad hoc transient communities, we arrived at three principles for their composition. First, they should have a heterogeneous composition in terms of participants, for example with veterans as well as newbies, lurkers as well as posters, and domain novices as well as domain experts. Second, the participants should have recognizable roles, for example the role of expert or facilitator. And third, participants should be accountable for their actions, so they should have a persistent identity and their actions should be entered into record that is accessible to all members.

These guidelines also apply when the network is somehow managed and facilitators (tutors, teachers, moderators) are available. However, then the facilitators should abide by a few guidelines. Although focused on formal learning at a distance, Gilly Salmon's five-step model for e-moderating may still serve as convenient starting point (Salmon 2000). Translated into network learning lingo, a facilitator (moderator) should first make sure the participants have access (URL, username if applicable) to the network and get to know each other; then the facilitator should ensure the participants exchange information and indeed learn with and from each other; and finally, a facilitator should help the participants to widen their perspective toward the network as a whole. That said, any facilitator should also keep in mind that (i) each learning network is unique, depending on the type of learning that takes place (formal, informal), the pedagogy used, the domain of interest, the available online tools, etc.; it therefore demands *adapted* moderation, (ii) each learning network should be weaned off facilitator support as much and as quickly as possible in order to activate the participants and not the facilitators; it thus demands and *adaptive* facilitating response (Bitter-Rijpkema et al. 2014).

The implementation of many of these guidelines relies on technologies, on tools. That also applies to the dynamics of creating and strengthening links, which occurs through the intervention of ad hoc transient communities. To these tools that jointly constitute the set aspect of a learning network, I will now turn.

3.3.3 Set Design

The book *Learning Network Services for Professional Development* (Koper 2009) distinguishes four kinds of tools, which he denotes as support services. They are as follows:

1. tools to support social interaction in the network
2. tools to support learner navigation through the network
3. tools to support (formative) assessment in the network
4. tools to contextualize the network.

Under different headings, Vassileva (2009) too discusses the first three kinds. She distinguishes finding the right people, finding the right 'stuff' and motivating learners. In the discussion of set design, I will restrict myself to the intersection of Koper's and Vasileva's categories.

Unlike the epistemic and social design sections, which worked from a theoretical perspective toward design guidelines, the discussion on set design will be conducted through the presentation of a few examples of each of the three categories. There are no hard and fast, set-bound design guidelines for tools or they should reside in considerations of interaction design. Interaction design, however, looks at how users can be helped or convinced to work with tools, much less to what may be achieved with tools (see, for example, Dron and Anderson 2009; Li 2010). Working by examples perhaps provides a less systematic but certainly well-elaborated view of the tools' functional aspects. After the discussion of each category of tools, I will draw some pertinent design lessons.

3.3.3.1 Social Interaction Tools

Tools that facilitate the formation of ad hoc transient communities are an example of social interaction tools. Such tools rely on finding knowledgeable peers with whom it is likely to be profitable to discuss a particular learning issue at some depth (Vassileva 2009). Peter van Rosmalen and co-workers elaborated this problem for the case of answering epistemic questions (i.e., 'why,' 'what,' and 'how' questions that cannot be answered through by search engines) (Van Rosmalen et al. 2006, 2008). They developed software (the ASA tutor locator) that couples one question-asking learner to a small team (three to four) of peers who are assumed to be able to answer the question asked. This team is selected from the larger network with the help of a computer algorithm that matches the question to the profiles of the network members, using latent semantic analysis (a statistical technique that essentially assesses document similarity through word frequency tables, see Landauer et al. 2007; Van Bruggen et al. 2004) to assess similarity. The algorithm also takes availability and past workload into account. The benefit of this approach is that all network members are considered, thus providing a mechanism to explore weakly and latently linked peers and serving them up as candidates for strong linking. Damon Horowitz and Sepander Kamvar discuss a similar tool—Aardvark, unfortunately now defunct—to which they refer as a social search engine. Aardvark searches through a person's extended social network, the social contacts somebody already has (Horowitz and Kamvar 2012).

Yet, another example of a social interaction tool uses a different set of criteria to form ad hoc transient communities. Remember that heterogeneity was one of the desiderata for such communities. Again using latent semantic analysis, Howard Spoelstra and colleagues applied Lev Vygotski's notion of a Zone of Proximal Development to ad hoc transient community formation. They did so in an attempt to set an upper and lower bound to the desirable degree of heterogeneity (Spoelstra et al. 2015; Vygotski 1978). As a further ingredient of heterogeneity, they also considered personality factors. Productive team formation was also the concern of Rory Sie and colleagues, but this time productivity of collaboration could be exchanged for increasing one's influence (Sie et al. 2012). Using social network analysis, Sie et al.'s COCOON tool helps a person to look for a centrally placed person in the network, i.e., the person that frequently is on the shortest path between two randomly chosen other network members (maximizing betweenness centrality); or, alternatively, he or she may look for network members similar to him or her. A partner with a high betweenness centrality is likely to boost the acceptance chances of jointly developed ideas, and partner similarity increases the chances of a productive collaboration.

Many other factors can be mentioned that impinge on tool design for social interaction in learning networks. To mention just two more examples that I am particularly familiar with, Ellen Rusman focuses on trust in virtual teams (Rusman et al. 2012); Adriana Berlanga considers profile and identity formation (Berlanga et al. 2011; Berlanga and Sloep 2011). All these factors—and there are no doubt others—should be taken into account when considering populating the set environment with tools for social interaction. The criteria for social design discussed can be used further to guide the choice of tools.

3.3.3.2 Learner Navigation, Recommender Systems

Learner navigation covers the second group of tools. It consists of recommender systems. In the world of technology-enhanced learning, recommender systems come in two flavors. In content-based recommenders, the user is recommended items similar to his or her past choices. Collaborative recommenders suggest items that people with similar tastes and preferences liked in the past. Content-based recommenders rely on a profile of user interests to base their recommendations on. Collaborative recommenders work through collaborative filtering: They predict a user's interest in some new item by filtering recommendations of other people with similar interests (Manouselis et al. 2012). Clearly, though one may use both types of recommenders in the context of learning networks, the emphasis on social learning suggests a preference for the second kind. Besides, classical, content-based recommenders rapidly yield unmanageably large numbers of recommended resources. The reason is that they are based on keyword searches. If the keywords lack specificity, so do the recommendations produced (ibid). It is for this reason too that the focus lies on social recommenders and collaborative filtering. Collaborative filtering-based recommenders, however, themselves face a problem too. It is called the sparsity problem. Since such collaborative filterers rely on the assessment by like-minded peers of potentially interesting resources, they need detailed recommendation profile data of such peers. Unfortunately, those data are often lacking. This holds true in particular for educational datasets (Verbert et al. 2011). To remedy this, approaches are underdevelopment that they rely on a kind of implied trust. They make use of social network analytical techniques to infer like-mindedness from shared peers (Fazeli et al. 2012). In this way, the sparsity of the learner by learner matrix may be lessened and thus the effectiveness of the collaborative filtering algorithms increased (Fazeli et al. 2014).

For the design of learning networks, this implies that the development of support for profiling matters much, as good profiles imply good recommendations. Profiles should be filled automatically, through educational data mining wherever possible and should be easily updatable wherever needed. Clearly, this touches on the growing area of learning analytics, from which, according to the present argument not only educational administrators and institutions but also the learners themselves should profit. Indeed, if the benefits of profiling become clear to them, they are also likely to be more willing to share their data more widely (Rahman and Dron 2012).

3.3.3.3 Assessment Support

Commonly, assessment is subdivided into formative and summative assessment. The latter measures whether some learner has achieved the goals set for him or her. Summative assessment is particularly important in formal learning; I will ignore it here. Formative assessment, however, matters in formal and informal contexts. It allows learners to gauge their progress, which could be measured against an absolute benchmark but also be compared with past performance. Obviously, when clearly delineated goals are missing as in learning for knowledge creation, only formative assessment will work. In such situations also learners will often have to perform the assessment themselves (self-assessment) as nobody else would have the required expertise to do so. Moreover, even if such people would exist, their availability in informal learning settings is always an issue. For all these reasons, tools for assessment support that do not necessarily rely on teacher interventions are needed.

In the context of their discussion on self-regulated learning in the workplace, Littlejohn et al. (2012) developed a charting tool. 'Charting supports self-regulated learning by guiding the individual in defining, sequencing and reflecting upon personal goals' (ibid, p. 232). Although the charting tool has ambitions that also cover social interactions and resource access ('The individual brings personalised collective knowledge to bear upon his/her learning goals, and importantly feeds the outcomes of his/her learning and charting back to the collective, for others to learn from, consume and build on,' ibid, p. 232), it is the assessment function that is of interest here. Through it, learners may gauge their progress, particularly in workplace contexts. The charting tool is under active development.

Thomas Markus developed a tool called TOMOFF, which allows 'automatic identification of a learner's level of conceptual knowledge' (Markus 2014, p. 153). Like the ASA and team formation tools discussed earlier, under social interaction tools, it also relies on the analysis of natural language. Texts produced by learners are compared with texts written by domain experts. Markus tested it in formal learning contexts and was able to detect a sizeable correlation (0.59) between a teacher's assessment of a student and the assessment produced by TOMOFF. This suggests that TOMOFF can also serve the informal learning situations of learning networks well.

The design of networked learning thus stands to profit much from the kind of linguistic analyses Markus carried out. Another example of such an analysis is provided by Kamakshi Rajagopal and colleagues, who discovered that when learners use tags to characterize a topic, their understanding of the topic can best be captured by collections (sets) of tags (Rajagopal et al. 2012). If this proves to apply generally, then tag sets could be used to help learners to gauge their own understanding of a topic relative to the understanding of others. The set design of a learning network should consequently stimulate the use of tags by learners. In spite of their apparent potential, tools for linguistic analysis that are ready for implementation in learning networks are still scarce, unlike tools for social interaction support and recommender systems. The designer of sets for learning networks should perhaps do best to focus on the latter two kinds of tools, at least for the time being.

3.4 Conclusion

In this chapter, I let the discussion of the design of learning networks be guided by Goodyear and Carvalho's distinction between epistemic, social, and set design. I discussed how networked learning is not necessarily restricted to informal learning, but only shows its true strength in settings for professional development, in which the knowledge creation metaphor or at least the participation metaphor of learning apply. My discussion of the three design types was geared toward such settings. Thus, I pointed out how the design principle of connecting learning goals via learning tasks and activities to learning outcomes is of limited use in the design of networked learning. In the words of Goodyear and Carvalho, learning networks cannot be designed, only designed *for*. And finally, in the spirit of that maxim I also discussed guidelines both for the social design and the set design of learning networks. Several guidelines and quite a few tools are available to the designer at his or her discretion. If this were to suggest that we have a full picture of what it takes to design for networked learning, then I should quickly add that there is much room for improvement and extension. I will give two examples. I only briefly discussed Peschl and Fundneider's (2014) notion of an enabling space, but I am convinced that the literature on innovation and creativity to which their paper belongs has much to offer to the designer of learning networks. Along the same lines, with my discussion of latent semantic analysis and the use of tag sets, I merely touched upon the value of linguistic analyses for automated learning support. Once such linguistic analyses are allowed to drive easily accessible tools, I am convinced the design of networked learning, both the social and set design, can be taken to another level. So, design for networked learning is still an area of active research and so it should remain for the foreseeable future.

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Author Biography

Peter Sloep (PhD) is a full professor of Technology Enhanced Learning at the Open University of the Netherlands. His research encompasses such topics as networked learning (specifically but not exclusively for professionals), learning design, learning objects, standards for learning technologies, and open educational resources, as well as knowledge sharing and creative collaboration in communities and networks. Sloep is an Honorary Professor at the Caledonian Academy of Glasgow Caledonian University. He co-authored more than 100 peer-reviewed publications in scholarly journals and conference proceedings and has co-authored or edited three books. Sloep is a frequent speaker at national and international conferences. He frequently reviews papers for various journals and conferences in the TEL field.

Chapter 4
Why Do We Want Data for Learning? Learning Analytics and the Laws of Media

Eva Durall Gazulla and Teemu Leinonen

Abstract With the increase of online education programs, learning analytics (LA) tools have become a popular addition to many learning management systems (LMS). As a tool for supporting learning in an educational context, LA has generated some controversy among scholars. Therefore, in this text, we aim to provide a theoretical and analytical understanding of the approach and its implications for teaching and learning. To achieve this, we apply McLuhan's semiotic analysis of media (1988). The "Laws of Media" questions are asked about LA tools: What do they enhance, make obsolete, retrieve, and reverse into. By answering these questions, we outline which practices of teaching and learning are more likely to become common when LA tools are taken into use more widely and which others will be relegated. In the analysis, we point out that LA tools enhance prediction and personalization of learning, while they displace certain teachers' skills, personal interaction between teachers and students, and qualitative interpretation and assessment of learning. Simultaneously, LA retrieves behaviourist views of learning and urges discussion about data literacy. Taken to the limits, LA reverses its effects and becomes a tool for supporting awareness and reflection in teaching and learning. We consider these contributions relevant for understanding and reflecting on the type of pedagogies that LA supports, the implicit values it holds, and the changes it introduces into educational practice.

Keywords Learning analytics · Teaching · Learning · Semiotics

E. Durall Gazulla (✉) · T. Leinonen
Aalto School of Arts, Design and Architecture, Department of Media,
Medialab, Learning Environments Research Group, Miestentie 3, 3100 Espoo, Finland
e-mail: eva.durall@aalto.fi
URL: http://legroup.aalto.fi/

T. Leinonen
e-mail: teemu.leinonen@aalto.fi

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4.1 Introduction

The use of analytics in an online education focuses on the collection, analysis, and reporting of data about students' online actions (Lockyer et al. 2013; Society for Learning Analytics 2013). Learning analytics (LA) has raised academic institutions and teachers' interest by displaying information that was not available before, enabling them to better understand how students learn and therefore take informed actions to support this process (Dawson et al. 2014). In this chapter, "learning analytics tools (LA tools)" refers to the software tools that aim to display information about how students learn.

The data sources used in LA tools may come from a range of academic systems such as student information, library services, learning management systems (LMS), student admissions, and grades (Lockyer et al. 2013). Among those sources, research on LA has tended to focus on the possibilities of using the data in LMS. Despite discussion about the uses of data in LMS, there is a wide consensus on the idea that monitoring and interpreting this information can benefit learning and teaching (Drachsler and Greller 2012). According to Verbert et al. (2012), potential uses of LA are connected to the following areas: (1) prediction of learner performance and learner modelling, (2) suggestion of relevant learning resources, (3) increase in reflection and awareness, (4) enhancement of social learning environments, (5) detection of undesirable learner behaviours, and (6) identification of learners' emotions. So far, these areas have been the most popular approaches adapted in the development of LA tools.

The LA research field is interdisciplinary, since it combines the aspects of educational data mining, social networks analysis, artificial intelligence, psychology, and educational theory and practice. In LA research, it is important to distinguish two closely related areas: learning practice and organizational development. Both of these make use of educational data, although with different interests. While in learning practice, analytics focuses on improving learner success, in organizational development the pressure has been on productivity and business-oriented solutions. In the organization domain, analytics combines learners' information with institutional data to improve managerial effectiveness (Siemens and Long 2011).

The literature on LA tools also suggests that it can be used to approach data from a variety of perspectives. Some of most prominent ones are social network analytics, discourse analytics (De Liddo et al. 2011; Ferguson and Shum 2011), content analytics (Drachsler et al. 2010; Verbert et al. 2011), disposition analytics (Crick et al. 2004), and student-centred analytics (Kruse and Pongsajapan 2012), among others. In all of them, LA tools are expected to improve teaching and support students' success.

Despite the high expectations placed on LA, a review of the literature indicates controversial views on whether this new technology will improve learning and teaching. One of most critical aspects deals with the type of data monitored. Although many LA tools tend to focus on learners' actions, there is little evidence about what data are more relevant and useful to track (Verbert et al. 2014). Another aspect that is problematic is that the promising future of LA in the development of learning technology eclipses rigorous analysis on the effects that LA uses might have on teaching and learning. The lack of more critical studies on LA may be due to the fact that the field is quite young, and education researchers are still exploring different designs for the tools. Given the current stage of the LA field, we consider it necessary to address issues dealing with the type of pedagogy LA puts forward, the possible embedded values of these tools, and the extent to which LA tools are changing the way we understand teaching and learning.

In order to understand the effects of LA on teaching and learning, we analyse LA technology as a medium. The adoption of this perspective enables us to enlighten some of the in-built assumptions related to the LA approach and LA tools. In addition, our aim is to identify their capability to foster new pedagogical approaches and understand how the new pedagogy could be. We adopt McLuhan's tetradic framework for conducting a semiotic analysis on the implications of LA tools for learning and teaching. In the following sections, we introduce, ask, and provide answers to the questions proposed by Marshall and Eric McLuhan in the "Laws of Media" (1988) by addressing them to LA.

4.2 McLuhan's Tetrad Framework

McLuhan's Laws of Media are based on the idea that all artefacts have effects on the people and the society that adopts them. From this perspective, every new tool that is introduced becomes an extension. The word "extension" alludes to the idea that by building new things, humans are augmenting their bodies and these changes are, in the long term, transforming the social and physical environment. By introducing the laws, framed as questions, McLuhan and McLuhan (1988) raise concern and call for reflection about the effects of media on society. The questions that the Canadian authors introduce for analysing a medium are the following:

- What does it enhance?
- What does it make obsolete?
- What does it retrieve?
- What does it reverse into?

These interrogations seek to shed light upon the relationship between media and the context and how this transforms understanding and views of the world. The laws of media questions are complementary and should be asked in parallel (Fig. 4.1).

Looking at the tetrad, we can identify two groups based on its complementary relation: enhancement versus obsolescence and retrieval versus reversal. In the first case, the emphasis is on the aspects that a new tool brings and the ways of working that are relegated. This process is simultaneous, and while it does not mean that old social practices or human faculties disappear, they lose its mainstream position. In

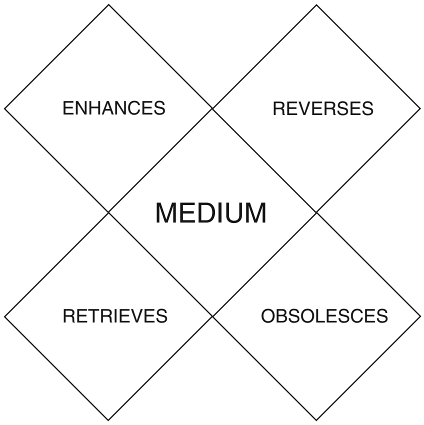

Fig. 4.1 Tetrad of media effects (McLuhan and McLuhan 1988)

the second case, the retrieve–reverse binomial refers to the power of new media in bringing back practices that were considered abandoned and for reversing their original meaning. This last effect is perhaps the most illuminating one. According to McLuhan, when a medium is pushed to its limit, it will become the opposite of what it was originally intended for. The quote “we become what we behold; we first make the tools, then the tools will make us” (McLuhan 1964, p. 23) illustrates the transformation that a medium goes through when it reaches its limit. At this turning point, the medium becomes the message in itself.

From the McLuhan and McLuhan perspective, the laws of media can be applied to any human artefact, whether hardware or software (1988). LA refers to software tools, but like any other medium, its effects go beyond technical solutions. To gain a better understanding of LA tools and their effects on teaching and learning, the following section examines the questions that compose the laws of media for a better understanding of the effects of LA tools on teaching and learning.

4.2.1 What Does LA Tools Enhance or Intensify?

Based on the McLuhan axiom that all media are extensions of people, we analyse how LA tools extend our senses as human beings. The fact that LA tools unveil “hidden” information connects with the idea of a sixth sense, in this case for perceiving learning behaviours that are not visible in any other way. By displaying these data, LA enables another view of what is going on when students engage in online learning.

The expectations of LA go far beyond just having a different view on teaching and learning. In this regard, education professionals and scholars have expressed their hopes that LA will help predict learning performance and identify learning models, customize and personalize learning, control teachers’ activity as well as the institution's performance, understand social interaction and participation, and engage students in their learning processes.

The prediction of student success or failure in learning, particularly in e-learning, has received considerable attention. Research in this area has led to the definition of profiles with the aim of modelling different types of learners, as well as the identification of different learning styles. Learning emotions have also been the subject of study since they have been used as an indicator of how students feel about learning and therefore the likelihood of successfully completing their studies. In this regard, we might argue that LA enables the development of customized learning environments that offer continuous support throughout the student's learning journey.

Customization and personalization are at the core of many LA approaches. The data collected about students' online behaviours inform decisions about what kind of learning resources or activities are more meaningful, given the student's current skills and knowledge about a certain issue. By taking into consideration individual aspects, LA tools enhance a wider view of learning that recognizes the importance of building on top of the learners' previous knowledge and competences. LA tools that seek customization are based on the idea that in learning there is not one way or path that works for everyone. Therefore, in order to ensure that students acquire the desired abilities, teaching practice has to adjust to the diversity of needs and challenges that the students face.

In many LA tools, in addition to individual performance, data about group activity are also available. This feature intensifies comparison between the individual and the group, and it indirectly pushes students to work harder when their activity falls behind the group average. The emphasis on student comparison connects with values based on the competition and selection. Educational institutions have used LA for recruiting students (van Harmelen and Workman 2012), and some voices speculate about the possibility that LA would be used by human resources departments in the future. Such a scenario forces individuals to compete in order to ensure access to college or the job market. Since nowadays societies need collaboration and cooperation rather than competition, the idea that education institutions need to prepare students for working in a competitive society has been labelled a myth (Combs 1979). One of the main effects of competition is homogenization: people need to share the same goals and rules in order to compete (Combs 1979). In learning, standardization implies that everyone should learn the same in the same amount of time. Continuous monitoring and pressure for meeting academic expectations can create anxiety and distrust among education stakeholders. Wesley (2002) has studied these phenomena at workplace learning, and he has reached the conclusion that monitoring online learning activity negatively affects workers' collaboration, communication, and knowledge exchange. Although formal education differs from workplace learning, the stress on students caused by complying with their curriculum on time while staying on the same level as the group does not support creativity and innovation (Wesley 2002). Therefore, to the extent LA tools do not recognize the value of experimentation and risk-taking, they intensify a view of learning based on efficiency, in which failure is penalized.

Digital data have become a key element in managerial techniques that are "evidence-based". Education institutions are subject to a similar logic as those of contemporary organizations, which are run based on the use of data and information. A good example of this trend can be found in the university, college, and school ranks, in which the emphasis on indicators has been questioned, since it can hide good practices in teaching and learning. From this perspective, the most critical voices claim that LA, especially academic analytics, intensifies the culture of managerialism in education (Selwyn 2014). From another point of view, some sectors of the academic community claim that analytics can enhance understanding of student engagement and performance (Graf et al. 2011). For teachers, the possibility to access student-generated data allows them to reflect on the instructional design and management of the courses they teach. In this case, LA is presented as a tool that advances educators' awareness and reflection about some aspects of their professional practice.

LA has contributed to research in Massive Online Courses (MOOCs) by collecting data about students' retention. One usual observation of studies on MOOCs is the high level of student dropouts. This information has attracted the interest of institutions and instructors who seek to understand why these courses have low completion rates, frequently between 3 % and 5 % (Coffrin et al. 2014). Even though the educational success of MOOCs is still under discussion, it is important to recognize the value of LA for identifying challenges regarding student engagement, performance, and retention. Thanks to LA, MOOCs have become a rich area for studying student motivation and its connection to engagement and performance. Coming back to the first question outlined in the Laws of Media, we might say that LA has intensified research on key elements affecting students' engagement in learning.

4.2.2 What Does LA Tools Displace or Render Obsolete?

Parallel to the question on what a medium enhances, we need to consider what it relegates. In this case, if we assume that LA extends various human faculties and social practices, we might also need to consider what aspects would no longer be dominant when LA is fully adopted in education.

LA is part of a trend based on decision-making informed by data. From this perspective, the automatic collection and analysis of the students' behaviour data are assumed to be relevant and reliable, or at least more trustworthy than subjective perceptions. The confidence devoted to computing algorithms is not exclusive of LA, and similar attitudes towards data can be found in business, health care, social services, sports, etc. Although education stakeholders recognize that LA enriches teaching and learning, we might question the extent to which LA is affecting the credibility we give to personal impressions. In a society driven by data, can we rely on subjective and qualitative data gathered through individual experiences?

LA modifies certain aspects of the teachers' role, especially in online education. Here, we might say that the reliance on LA data is closely connected to the appearance of fully online educational programs. As Mazza and Dimitrova note (2004), in e-learning courses, students face challenges dealing with, for instance, loneliness, experiencing technical issues, or losing motivation. In these cases, teachers' lack of visual cues that help them recognize when students are poorly motivated, anxious, or overwhelmed is compensated through LA. In the LA scenario, there is the assumption that if students have difficulties following the course, that information would be reflected in the monitored data. So one aspect that LA is killing is the teachers' ability to identify those students at risk of failing and the problems they face in their learning process. LA tools are not only affecting online teaching. In blended learning scenarios, LA impacts the teacher's capability to perceive group feedback since there is an increasing tendency to rely on information collected through back channels during large lectures. The final aim of these efforts is to enhance adaptation and improve teaching. But as McLuhan and McLuhan noted, the simultaneous effect is the disappearance of certain practices. In this case, the praxis that is being relegated is certain teacher's skills for detecting individual and group behaviours.

Excessive trust in LA data might diminish the perceived value of personal interactions between teacher and students. An example of this trend can be found in the approaches based on the personalization of learning, which directly inform decisions about how to best support learning. Since these systems rely on the models built from students' behaviours, further discussion with learners is relegated. Actually, decisions based on learner model data are very rarely contrasted and commented on with the students.

In e-learning, the high student ratio per teacher requires the development of tools that lighten the teachers' workload. Student modelling goes in this direction since the creation of profiles is a key for the design of systems that automate certain decisions, such as what learning resources are more useful for a student, given his current skills or knowledge. In this sense, LA and its different approaches are the result of efforts for coping with overcrowded virtual classrooms. The impossibility for developing a personal relationship between teacher and student and, at the same time, the need to offer a personalized service help to explain the high expectations placed on LA. Although LA might help solve the contradictions of a system that seeks customized mass education, it is making obsolete the need for personal interaction between teachers and students.

Like in many other fields, the automation of tasks questions certain roles and competences. In education, automatic data analysis challenges the role of educators and researchers. To what extent are they needed to interpret the data if a machine can efficiently do this? Given the current scenario, how can these professionals contribute to educational research? Certainly, LA does not make education researchers obsolete, but it demands of them new skills dealing with quantitative data analysis. Sense-making based on qualitative data analysis is not enough in a context where students' performance can be reliably measured with numbers. LA forces educational professionals to adopt quantitative data analysis methods in order to avoid being left behind.

The aspects mentioned in this section do not try to present a dystopian image of what the future of education might be once LA is a dominant practice. Every technology introduces new behaviours and attitudes and relegates other ones. This is not good or bad per se, but it must be acknowledged. Otherwise, we might end up assuming the intrinsic values of the medium without questioning the key elements in teaching and learning and how to best support them. In short, the medium would end becoming the message without us noticing it.

4.2.3 What Does LA Tools Retrieve that Was Previously Obsolete?

LA focuses on observable events of students' performance, specifically on students' behaviours. The monitoring and analysis of external actions enable using LA for building learner models and identifying learning styles and dispositions. This approach connects with behaviourist ideas, specifically with Skinner's radical behaviourism. Quoting an extract of Skinner's Review Lecture: The Technology of Teaching provides a good example of the close alignment with certain approaches to LA: "An effective technology of teaching, derived not from philosophical principles but from a realistic analysis of human behaviour, has much to contribute, but as its nature has come to be clearly seen, strong opposition has arisen" (1965, p. 438). The criticisms to behaviourism alluded by Skinner deal with behaviourist parallelisms between animal and human learning, the extrapolation of conclusions about learning based on laboratory situations designed with a strong emphasis on behaviour reinforcement and contingencies, as well as the inability to teach certain important things, such as learning to learn skills, from a behaviourist paradigm (Skinner 1965). Although LA has been used from very different pedagogical approaches, there is an important trend for designs that connect with radical behaviourist postulates. Considering that the golden age of behaviourist theories took place during the middle of twentieth century, we can state a revival of those ideas in many LA designs.

The type of data analysed when assessing learning performance indicates how learning is connected to certain values. In LA tools, the most commonly monitored metadata deals with (among others): frequency of logins, time spent on the LMS, and completion of activities and tests (Dietrichson 2013). Considering the type of information monitored, these learning environments privilege attitudes connected to perseverance, dedication, and hard work. We can state a character-building agenda in which discipline and commitment to the rules are key elements. The lack of spaces where students can discuss and question what and why certain data are monitored can be taken as an indicator of the top-down approach of these LA designs. This contrasts with socio-constructivist pedagogies, in which students were considered active and responsible for their learning process.

Once more, LA privileges quantitative data, in this case individually assigned marks by the teacher or the system, which are considered reliable indicators of students' effort and learning. This approach challenges socio-constructivist views of assessment, which call for students' active engagement and participation as key elements of successful feedback (Rust et al. 2005). In this regard, LMS that make use of LA tools privilege scores for student assignments, as well as other LA metadata, displacing other popular assessment techniques such as peer and self-assessment, rubrics, and portfolios.

Simultaneously, LA brings back discussions about literacy. The main concerns about data literacy deal with the gap between those who produce data, that is to say the ones who are (consciously and unconsciously) the subjects of monitoring activities, and those who are able to read and understand the data, and therefore use it (Manovich 2011). This has been labelled as a "data analysis divide" (Manovich 2011) and highlights unequal power relations in today's society. This situation has motivated the raising of voices that argue for recognizing the politics of data in education and for taking action against it (Selwyn 2014; Halford et al. 2013). Although the debate is not new, LA requires reflection and discussion among educational stakeholders about what literacy skills are relevant today.

4.2.4 What Does LA Tools Become When Taken to Its Limits?

We are presenting here a biased hyperbole of what the future of education might be if LA becomes the central element through which learning and teaching are defined and managed. Although this might not be a realistic scenario in the middle term, the last question included in the Laws of Media helps to identify the potential for any specific media, in this case LA.

Taken to its limits, LA brings to our homes dystopian scenarios based on data surveillance. "Dataveillance" refers to surveillance of digital data (Monahan 2010), and although it might not be perceived as a threat, it can support classification and predictive actions that enable "statistical discrimination" (Gandy 2012). Some scholars have already warned about the uses of data against those participating in education (Selwyn 2014; Slade and Prinsloo 2013). Certain practices in educational institutions indicate that these concerns are more valid than we might expect. For instance, as Rosenzweig (2012) explains, dataveillance of teachers' activity is an existing "condition of employment" in some schools. On the students' side, the normalization of surveillance in learning environments familiarizes them to high levels of control from a very young age (Taylor 2013). Over time, students become aware of LA continuous monitoring and they develop certain subjectivities and behaviours as a response (Knox 2010; Land and Bayne 2005; Leinonen 2012). In the end, as Knox (2010) highlights, these attitudes go against key issues in learning, such as collaboration and experimentation. In addition to these aspects, other ethical challenges regarding the use of data in LA deal with data analysis, acceptance of the terms of use, privacy and anonymization of data, and categorization and management (Slade and Prinsloo 2013).

LA usage that focuses on prediction connects with ideas of control—assigning to individuals a passive role. Learners' low agency can be connected with the behaviourist approach, in which behaviour is shaped by environmental stimuli. Thus, students learn according to the challenges, comprised of tasks, and learning resources that teachers or an intelligent learning environment present to them. The idea of a highly controlled learning environment based on behaviour prediction is quite an extreme view of LA, but it helps in understanding some current criticisms and fears of this media. In this regard, some authors have already noted the limitations of predictive models which portray "only a portion of the wide range of behaviours that constitute the universe of social interactions" between students and an institution (Subotzky and Prinsloo 2011, p. 182). Other concerns are based on the idea that LA can increase students' passivity by making them dependent on institutional feedback (Shum and Ferguson 2012).

Quite frequently, the idea of efficiency is embedded in LA designs. Actually, this is one of the main arguments used for justifying the monitoring and analysis of students' and teachers' data. Thus, the goal of LA tools is to support effective learning, which can be understood as, in addition to acquiring certain skills, successfully completing the course and the education curriculum. Even if the last goal is more connected to the academic analytics agenda, we might hypothesize that, taken to its limits, LA can be more focused on ensuring students' graduation rather than in helping them become successful learners.

Although some critical voices have warned that LA could disempower students, other authors have highlighted the potential for supporting awareness and self-reflection skills (Duval 2011; Durall and Toikkanen 2013). In fact, LA can enhance several key processes mentioned in Zimmerman's model for self-regulation (1989, 2000), such as self-control, self-observation, and self-judgement. From this perspective, LA can help students become aware of key elements in their learning activity and reflect on their performance. So, taken to its limits, LA tools can support self-directed and self-regulated learning (Durall and Gros 2014; Drachsler and Greller 2012). Views that favour this approach support placing student needs at the centre (Duval 2012; Clow 2012; Kruse and Pongsajapan 2012). Considering the students as active and autonomous subjects, able to take responsibility for their learning, is key for designing learning environments that empower its users. In learning, empowerment can be understood as a process by which individuals develop self-regulatory qualities dealing with self-efficacy and a sense of agency. According to Cleary and Zimmerman (2004, p. 542) "highly self-regulated learners will often feel empowered because of an underlying self-belief that success is largely dependent on one's skill in effectively using and adjusting strategies". LA tools can contribute to acquire a feeling of personal control by helping the students understand the relations and consequences of their actions in their study performance. In this regard, the visualization of LA data can support sense-making, as well as the identification of connections and the testing of hypotheses. LA tools with these features may empower students to see themselves as growing subjects who are facing obstacles but overcoming them through effort.

4.3 Concluding Remarks

LA challenges traditional ways of gathering information about learning and teaching and enables deeper and more complex analysis of the data. In this regard, LA has the power to transform educational institutions and teachers' pedagogical practices. The value that education professionals attribute to LA is a good indicator of the capacity of this medium for transforming education. Despite the grey areas, LA has come to stay, and its mainstream adoption will certainly affect how we understand teaching and learning.

As we have outlined when answering McLuhan and McLuhan Laws of Media questions, the high expectations placed on LA tools are due to what it enhances: access to data about students' behaviour and teachers' activity that was previously hidden, prediction and personalization of learning through student modelling, and better understanding of students' participation and motivation in learning. In terms of framing an emergent pedagogy, the main contributions of LA would deal with the development of adaptive learning environments.

According to McLuhan and McLuhan (1988), enhancement goes together with obsolescence. In this case, LA displaces certain teacher skills, direct interaction between students and teachers about study performance, and qualitative analyses of educational processes. At this point, we might say these changes should be inscribed in a wider context characterized by the rise of online education programs targeted to massive audiences. Rather than being the cause, LA is a symptom of this trend in formal education.

The main aspects that LA retrieves are behaviourist views on learning and discussions about data literacy. Dealing with the latter, LA creates another divide based on the ability to analyse data. At the core of some criticisms raised by the educational community are concerns about the power position of those who decide what data should be collected and for what purposes the data are used for. Although it might not be enough, most educational institutions have already created ethics boards in order to address the challenges that LA poses for privacy, ownership, and management of the data (Drachsler and Greller 2012). These issues are strongly connected to what LA might bring when taken to its limits.

Beyond warnings about the danger of dataveillance at the limits of LA, we can identify a reversal of the effects associated with this medium. This can be appreciated in LA's potential for supporting students' competences dealing with self-directedness and self-regulation of learning. From our perspective, this is the most relevant and transformative contribution of LA to pedagogical practice.

To sum up, we want to again mention McLuhan's view about the social impact of technology. As it can be observed in LA analysis, the effects are ambivalent, which makes irrelevant any conclusive judgments about the benefits or dangers of the medium. However, as Leinonen (2012) points out, "different media can make it easier or harder to perform some actions. When some things are easy to do, it is more likely that they will be done, whereas on the contrary, if something is hard to do with a medium, it is less likely to happen." (p. 58.) By developing a semiotic analysis of LA, we have outlined what aspects of learning and teaching are becoming easier and which ones are being relegated. In order to avoid going blind by the technology, we consider it necessary to do this type of analysis. In this regard, the McLuhan and McLuhan Laws of Media are still a relevant tool for reflecting on the social effects of a medium.

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Author Biographies

Eva Durall is a Ph.D. candidate at LeGroup and holds a MA in ePedagogy and Visual Knowledge Building (Aalto University). Her doctoral research is focused on the design of learning tools that, informed by critical pedagogy postulates, help learners develop awareness and reflect about their learning process. Main research interests are connected to data visualization, personal informatics, learning analytics, and critical thinking. Eva has participated in several projects dealing with the use of ICT in higher and primary education. She has also taken part in some innovation projects dealing with the design of collaborative tools and the coordination of the Iberoamerican Horizon Report.

Dr. Teemu Leinonen is a professor of New Media Design and Learning and vice dean of the School of Arts, Design and Architecture since 2014. As vice dean, Teemu Leinonen is responsible for directing the school's research (both artistic and scientific research) as well as communications. Leinonen has more than a decade of experience in research and development in Web-based learning. From 1998, Leinonen has headed the learning environments research group at the Aalto University Media Lab. As the leader of the research team, he has coordinated many international research projects. Leinonen is especially familiar with questions related to new media design and learning, computer-supported collaborative learning, online collaboration, design of learning software, education planning, and education policy.

Chapter 5
Articulating Personal Pedagogies Through Learning Ecologies

Marcelo F. Maina and Iolanda García González

Abstract The digital revolution enabled by social and ubiquitous technologies is constantly transforming macro- and microlevels of society including industry, organizations, and government as well as ways in which we communicate, we work, and we carry on our daily lives. Education is therefore also being challenged to respond to evolving societal demands by supporting the development of competent and engaged citizens. In this context, individuals' capability to get involved and exploit the affordances of networked environments for learning and development may condition their opportunities to cope with societal and labor demands. In this chapter, the metaphor of learning ecologies is proposed to provide a framework from which to analyze interactions between individuals and their environment, and the way their experiences across different contexts throughout life promote and shape learning processes. Learning ecologies allow us to explore frontier pedagogies connecting formal, non-formal, and informal educational contexts, acting as personal strategies that may orchestrate lifelong, life-wide, and life-deep learning. We start by defining and framing learning ecologies, providing the theoretical roots, and reviewing some recent studies in the field. Next, we propose constructs and models but also strategies and tools that may be of help to enhance and support personal ecologies for learning. Finally, the concept of personal pedagogies is proposed to refer to a set of autonomy and agency skills and attitudes that can be dynamically integrated by individuals to support an ecology for self-development and personal learning. We articulate from this perspective several trends in the area of self-directed learning located in the technological and pedagogical intersection: MOOCs, current awareness, e-portfolios, and social networks.

M.F. Maina (✉)
Department of Education, Téléunivesité, 5800, rue Saint-Denis, bureau 1105,
Montréal, QC H2S 3L5, Canada
e-mail: marcelo.maina@teluq.ca
URL: http://www.teluq.ca/siteweb/univ/mamaina.html

I.G. González
Department of Psychology and Education, Universitat Oberta de Catalunya,
Rambla del Poblenou, 156, 08018 Barcelona, Spain
e-mail: igarciago@uoc.edu
URL: https://es.linkedin.com/pub/iolanda-garcia-gonzalez/1b/704/378

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5.1 Introduction

Ubiquitous technology is rapidly transforming the ways in which we communicate, work, and carry on our daily lives. The digital revolution is impacting on all kinds of industry, organizations, and government institutions. Education in particular is being challenged to respond to evolving societal demands not only by adapting its own curriculum and modes of education delivery, but also more importantly by offering quality education that supports the development of competent people and engaged citizens.

In this chapter, rather than focusing on an institutional or teacher point of view, we situate ourselves within the perspective of the individual coping with constant challenges in every area of their life and requiring different ways of engaging with learning and development.

Through this privileged view, we explore frontier pedagogies connecting formal, non-formal, and informal educational contexts as a personal strategy that orchestrates lifelong (overtime competence development and knowledge acquisition), life-wide (across social settings), and life-deep (beliefs and values) learning (Heimlich and Horr 2010).

A humanistic approach to learning (Kanuka 2008) emphasizes a balance between individual and social commitment characterized by "freedom and autonomy, trust, active cooperation and participation, and self-directed learning" (p. 106). Networked technologies and social media are integral parts of this ecology where the person pivots their learning based on "intrinsic motivation, self-concept, self-perception, self-evaluation, and discovery" (p. 107).

Brown (2000) was a pioneer in using the ecological metaphor applied to learning: "ecology is basically an open, complex, adaptive system comprising elements that are dynamic and interdependent. One of the things that makes an ecology so powerful and adaptive to new environments is its diversity" (p. 19). The ecological metaphor provides a productive framework for observing and analyzing interactions between people and their environment, their experiences across different contexts throughout life, and the way these activities promote and shape learning processes. Lifelong learners, through their participation in diverse communities, weave their own learning ecologies, and in doing so, they construct and organize personalized and unique connections and interactions with objects and individuals.

From this perspective, the capacity to create and sustain a learning ecology increases personal opportunities for learning, development, and achievement (Jackson 2013). At the same time, the extent to which people achieve certain learning goals and personal development depends upon structural factors such as the actual availability of resources and the internal learning stimuli (Biesta and Tedder 2007).

In the era of social and ubiquitous technologies, hybrid, amplified, and enriched contexts provide individuals with multiple ways of getting involved and exploiting opportunities for learning and development. In this chapter, we argue that learning ecologies can sustain the articulation of different types of personal pedagogies that support self-directed learning itineraries and trajectories throughout life.

5.2 Defining Learning Ecologies: Theoretical Foundations and Frameworks

5.2.1 Approaching Learning Ecologies

The ecological perspective considers people as a part of a living and dynamic system with physical, social, and also virtual dimensions, located in a particular cultural and historic time and spatial frame.

Learning ecologies have been studied from diverse perspectives, most of them sharing a sociocultural view of learning, such as communities of practice (CoP) (Wenger 1998; Wenger et al. 2002), actor network theory (Law 1992), and activity theory (Engestrom 2000), but they have also been associated with alternative frameworks such as connectivism (Siemens 2005; Downes 2012) or Cormier's rhizomatic approach (2008). The basic assumption in all cases is that learning is socially and culturally constructed and that technology can be considered a tool that mediates our interpretation of what we experience within the world. In this sense, all kinds of connections and relationships, especially interpersonal ones, can be considered as fundamental resources for personal growth and development.

Nardi and O'Day (1999) first discussed the concept of information ecologies as the flows of information that circulate in organizations or in specific local environments and the system of people, practices, and technologies that participate in or contribute to this flow. Lemke (2000) advanced the notion of learning ecologies composed of temporal and spatial dimensions connecting past and present moments, and linking life actions to significant experiences. From this perspective, physical and virtual, and formal and informal spaces can be considered as potential environments for learning.

Siemens (2007, p. 63) emphasizes this wide spatial dimension of learning ecologies as "the space in which learning occurs," to the extent that a particular type of learning taking place in a specific space can be considered as a property of that space (Thomas 2010). Siemens also highlights the relational and informal nature of learning ecologies as "an environment that fosters and supports the creation of communities" (2003, p. 17). This author describes a learning ecology as informal, not structured, tool-rich, consistent and evolving along time, highly social, decentralized, and connected and experiential. His idea of a learning ecology is therefore very close to the concepts of community and network. Communities make up a learning ecology by acting as nodes in a personal learning network: "if ecologies are the spaces of learning, then networks are the structures of learning." Connectivism would therefore be the theoretical umbrella to understand networks as an organizing scheme of knowledge, and learning would be considered an activity that is mainly based on the creation and navigation of networks (Siemens 2008).

As Esposito et al. (2015) explain, the ecology metaphor also "sheds light on the entangled facets of socio-cultural activities and educational contexts" (p. 331). Formal educational settings and experiences are also constituents of learning ecologies: Institutions, teachers, and the foundational pedagogical model play an important role in structuring their components. Haythornthwaite and Andrews (2011) explore the interpretation of learning ecology within the e-learning domain. From their perspective, the metaphor is useful to understand e-learning as a complex and systemic phenomenon, where no processes can be predefined. Goodyear (1998) introduces the notion of "ergonomics of learning environments" to emphasize the importance of considering in e-learning design what the learner work entails in relation to his or her own environment.

The informal learning dimension completes the picture of a personal learning ecology. Kemmis et al. (2009) refer to this as ecologies of practice to name a set of particular practices that have an interdependent relationship and sustain and support each other. Practices are understood as "an organized nexus of actions that hold participants together and orchestrate them in relation to one another" (2009, p. 17). A series of principles define the type of relationship established among practices: networks, nested, systems, interdependent relationships, cycles, development, and dynamic balance.

A few number of learning ecology frameworks have been proposed in the literature so far. Richardson (2002) developed a holistic theoretical model for analyzing and interpreting a learning ecology. The model applies mainly to formal education. It is composed of two intersecting axes. The horizontal axis moves from a focus on the learning content to a focus on the learning activity. The vertical axis shows who drives the learning process: the learner (top) or a "guide"—human or machine-based agent—(bottom). The crossing of the axes creates four quadrants. While the upper quadrants target independent study (left side) and active learning experiences such as problem- or project-based learning (right side), the lower quadrants target learning experiences directed by an external guide, i.e., a lecture, or a guided discussion (left side), or guided practices and exercises (right side).

Jackson (2013) proposes an adaptation of this framework to include informal learning experiences. The vertical axis represents learning through autonomous and independent activities (top), and learning that is facilitated through significant people along individuals' life experiences, such as family, friends, and managers (bottom). The horizontal axis corresponds to the contexts in which learning takes place, including formal learning environments (left) and informally structured environments in which learning is an eventual result of engaging in diverse experiences or tasks (right). The crossing of the axes gives place to four different learning ecology scenarios, whether learning is partly or completely determined by an external provider or by the learner himself: (a) traditional formal educational learning ecology; (b) enquiry-, problem-, and project-based learning ecologies; (c) self-directed but supported learning ecologies; and (d) independent self-directed learning ecologies. In his model, Jackson introduces new elements, such as the use of open educational resources and open educational practices in the learning experiences determined by the learner taking place in informal learning contexts.

5.2.2 Networked Learning and Learning Ecologies

The new forms of mobile, social, and networked technologies and digital resources have amplified opportunities for flexible and self-organized learning practices. The role of technology is therefore a key element in shaping learning ecologies that blur the boundaries between formal and informal learning. As Frielick (2004) states "here we enter the zone of confluence between the emergent ecological idea and networked information technologies." The metaphor of a learning ecology is also used by Brown (2000) to describe how the vast amounts of available and interconnected resources on the Network provide an environment that fosters learning. This mainly refers to what Weller (2011) calls a "pedagogy of abundance" where collections of distributed resources are accessible, thus enabling emergent forms of learning, and where learner agency and social interaction merge. The Network becomes the playground where opportunities for learning are supported, enacted, and fostered. The network is a moldable and empowering environment where individuals may gradually develop learner-generated contexts (Luckin et al. 2010). These contexts are a set of Network configurations for learning of variable stability, yet flexible enough to support different learning purposes.

Networked learning, as a "genre of technologically-mediated learning" where "social media and web technologies are used to promote connections between learner, human resources, content resources and learning communities and keep continually dealing with ever-increasing amount of digital information" (Saadatmand and Kumpulainen 2012, p. 268) is another concept akin to the notion of learning ecology. From this perspective, learning happens in a multi-directional, multimodal, and dynamic way facilitated by Web 2.0 socio-technical infrastructures bounded by the learner's choice of spaces, tools, contents, social interactions, etc., which configures what has been called a personal learning environment (PLE). PLEs are in fact an approach to learning through social and participatory media applications based on learner configuration and self-management as opposed to learning management systems (LMS), which are spaces controlled by the teacher or the institution (Attwell 2007; Downes 2007). The concept of PLEs closely corresponds to that of a learning ecology, in which learners organize their set of resources, applications, and services as well as personal contacts that may be useful to learn based on their own interests and preferences. To some extent, PLEs could be considered as a resource that every learner could use to connect, organize, and take advantage of the different social communities and networks that integrate their learning ecology. The PLE has sometimes tended to focus on the technological perspective based on the availability of tools that are chosen, configured, and managed by learners themselves. Several authors have preferred to use alternative concepts such as personalized learning ecologies (Rongbutsri et al. 2012) or personal learning network to emphasize the technical, personal, social, and intentional dimensions of learning.

5.2.3 Driving Personal Ecologies for Learning

The purpose of this chapter is to focus on the individual learner perspective of learning ecologies. Barron's learning ecology framework (2006) explains how learning takes place across settings, identifying the possible synergies and barriers between them, including the role of technology in making boundaries more permeable, and allowing for new levels of agency in learning. The individual is "the organizing central node in the system" (Barron 2004, p. 6) and therefore responsible for its particular configuration: "each context comprises a unique configuration of purposes, activities, material resources, relationships and the interactions and mediated learning that emerge from them" (Barron 2006, p. 195). Unlike other authors, she focuses on how people contribute to their own development through self-initiated learning activities and by appropriating and adapting resources within and across contexts. She builds her learning ecology framework on three assumptions (Barron 2006, pp. 200–201) within any life space: (1) a variety of ideational resources can spark and sustain interest in learning; (2) people not only choose, but also develop and create learning opportunities for themselves once they are interested, assuming they have time, freedom, and resources to learn; and (3) interest-driven learning activities are boundary-crossing and self-sustaining.

The idea of intentional activities and processes is also brought up by Barab and Roth (2006) who explain that perceptual and cognitive affordances collectively form a network for particular goal sets. From this perspective, an ecology is intentionally created by individuals or groups in order to achieve their goals. There is an inherent purpose that gives meaning to our interactions with the world, although the process of shaping our learning ecology is "part planned and deliberate, and part intuitive, accidental and opportunistic" (Jackson 2013, p. 7).

This individual view of learning ecologies considers the learner as the main actor in the network, responsible for maintaining social relationships and creating meanings throughout physical and virtual contexts (Haythornthwaite and Andrews 2011). In a more or less conscious and intentional way, the person is in command of their own learning context, by connecting people, objects, and environments that support their learning. This approach requires self-directed skills that allow new learning models supporting personal learning and development to be envisioned and put into practice.

Williams et al. (2011, p. 43) propose the term "emergent learning" to designate this type of self-organized, open, and collaborative knowledge generation that is mainly distributed by learners themselves within digital communities and networks. Emergent learning is unpredictable but retrospectively coherent since it takes place in complex-adaptive domains as opposed to predictable ones. This "emergent behavior" is sustained by the new generation of technology-mediated dissemination and communication, where interest is mainly directed toward the interaction and collaboration at scale through social media and networking. It also requires adequate monitoring and a speedy response. In order to avoid any negative effects, the authors suggest that emergent learning should ideally be integrated into a wide and inclusive learning ecology that also includes other types of prescriptive learning.

5.3 Studies of Ecologies for Learning

Recent studies focus on better understanding the nature of learning processes, activities, and how knowledge is created in open, social, and networked learning environments. The metaphor of learning ecologies is often evoked in a more or less direct way as a framework to analyze and to explain personal learning and development processes. For example, Saadatmand and Kumpulainen (2012) explore open learning practices mediated by networked technologies and Web 2.0 applications. Their study analyzes the type of learning activities and experiences that result from participating in these environments, the perceived values that participants assign to them and how they conceptualize personal learning. They apply virtual ethnography as a research design in the context of a MOOC. The main results refer to the type and ways in which participants choose and customize the available tools (Facebook, blogs, Twitter, YouTube, and RSS) depending on their goals and needs. The opportunity to connect across different platforms is perceived by participants as facilitating access to resources and experts. The possibility of being involved in simultaneous activities and using many different tools is motivating and enhances their learning autonomy, but it can otherwise be overwhelming, time-consuming, and too disruptive, especially if learners are not "armed" with the necessary digital and informational competencies to manage time, tools, and information. Openness might also be experienced as a not fully comfortable context, where some participants may feel too exposed to others and pulled away from their own focus of interest. The research concludes that learning resulting from open and networked environments is self-organized, emergent, and disruptive. In this sense, many learners may experience tension between the liberating feeling of greater agency and autonomy, and the confusion or frustration encountered when they are not capable of managing their learning. In a different study, Bonzo (2012) analyzed the perceptions and experiences of learning technology professionals regarding what he calls their Social Media Networked Learning Ecology (SMNE), as they engage in professional development and learning experiences. Using a phenomenographic research approach, he analyzed the individuals' different levels of awareness and their conceptions of the connections and the relationships they established in their respective learning ecologies. He also explored how useful they perceived these relationships and connections to be in supporting their professional development and learning.

From a slightly different perspective, Luckin (2008, 2010) has carried out a number of studies to develop and give empirical ground to the Ecology of Resources framework. In this case, the learning ecology fundamentally takes into account the resources with which an individual may interact. These resources, namely knowledge and skills, tools and people, and the environment itself, act as potential forms of assistance that can facilitate learning.

5.4 Enhancing and Supporting Personal Ecologies for Learning

If we consider the Network as a ground for learning, it might be of interest to analyze the specific properties that contribute to supporting and enhancing a learning ecology. Looi (2001) provides an insightful analysis pointing out that the relationships that develop on the Network—while people participate and shape their own ecologies— provide an identity and a social value for tools, spaces, and content. In this way, people also contribute to the evolution of the Network by becoming active participants and knowledge producers. The increasing availability and easiness of authoring and delivery mechanisms has greatly facilitated the creation and maintenance of a learning ecology by any individual. Looi also draws attention to the need to "move towards the creation of learning content objects that can be reused, searched and modified independently on their delivery mechanism" (2001, p. 17). This necessarily demands the development of applications and systems that are truly interoperable. In this respect, many authors have advocated a shift from the delivery of high-quality content toward open informal content that can be manipulated, recreated, and repurposed (Thomas 2010). Another strategic development Looi mentions for enhancing ecological systems' individual support is to provide them with mechanisms to track others' actions, capturing the interaction history or mapping and trailing itineraries that may help others to suggest where to find good information, interesting connections, or simply how to solve technical problems. The affordances provided by social media for (audio) visual- and verbal-rich representations that can also be annotated by others enrich the possibilities for providing multiple perspectives of a phenomenon, contextualizing it and focusing through discourse on particular aspects. Finally, the use of tools supporting participatory storytelling combined with creative content involving entertainment, education, and aesthetics can also contribute to making a learning ecology more engaging.

From an approach based on supporting digital devices, Tabuenca et al. (2013) analyzed adults' learning practices in order to recognize patterns of lifelong learners. The aim of the study was to shed light on new ways to support lifelong learners with technology and specifically with devices that allow for ubiquitous learning across different physical spaces and learning tasks. They defined patterns based on aspects such as the day of the week, duration, location activity, and the type of device chosen by the learners whenever they take the initiative to learn. Some of the findings revealed that ownership of a smartphone may enhance not only opportunities but also motivation to learn during the day. Furthermore, the study showed certain associations between the types of learning activity performed and the location and situation where it mainly took place. Smart objects that can be found in both formal and informal learning environments through a variety of applications are generally perceived in an isolated manner, which means they are rarely interconnected or integrated in a "personalized seamless learning environment." Their educational purpose or possibilities are in most of the cases not obvious. Thus, the authors conclude that there is a need to orchestrate technologies that augment learning opportunities in physical spaces, so that they can be better integrated and managed in a personal learning flow.

Considering the educational perspective, we may identify some trends emerging from open, networked, and social learning that necessarily intersect with many of the aspects we have put forward in the technological domain.

The idea of "limitless dimensions of learning" (Siemens 2008) leads us to consider and recognize the value of the broad spectrum of learning situations and modes of personal and collective development that may arise inside but also outside formal education institutions.

The rise of social computing based on social production and mass collaboration has caused a shift toward cultures of participation, where individuals have the opportunities and the means to contribute actively in content creation but also in addressing issues and tackling problems that are meaningful to them (Fischer 2011). What has been called a "participative" or "participatory Web" with "user-created content" as one of its main characteristics raises the need for a "participatory pedagogy." From this perspective, pedagogical models would not be fully defined in advance but in the process of interacting with learners, thus including multiple perspectives and active creation on the part of learners (Siemens 2008).

The diversity of learners with different and evolving needs poorly addressed by formal education calls for personalized and flexible learning. This reality, together with the wide variety of possible learning situations, should result in the recognition of multiple itineraries and methodological approaches to support learners, some of them based on structured pathways and others more flexible and based on individual or collective self-directed exploration of subject matters, real-life problems, or projects.

Finally, enlarging the concept of accrediting learning and knowledge also seems to be a necessary step in this context. Siemens (2008) advocated a broad and holistic accreditation approach relying on multiple learning opportunities and trajectories throughout life, both in formal and informal contexts.

5.5 Toward the Articulation of Personal Pedagogies Through Learning Ecologies

5.5.1 The Self and the Pedagogies

Managing one's own personal development is an ongoing process based on self-awareness, reflection, goal setting, and defining a course of action. A "personal development plan" (Nixon 2013) calls for conscious and intentional planning directed toward envisioned educational, professional, or life accomplishments and based on thoughtful decisions regarding learning and development connecting educational contexts, workplace, and everyday life. Moore's theory of transactional distance highlights that "learner autonomy involves the learner's ability to create a learning plan, find resources that support study, and self-evaluate" (Andrade and Bunker 2009, p. 48).

Biesta and Tedder (2007) propose an ecological understanding for the concept of agency that may also be useful to frame the idea of personal pedagogies. In their perspective, agency is defined as an achievement, enabled by individuals' engagement with temporal-relational contexts-for-action. So it has mainly to do with people's capacity to shape their responses to the situations they find in their lives, as the interplay of individual efforts, available resources, and contextual and structural factors in particular situations. According to these authors, learning to recognize one's "agentic orientations and constellations" (p. 137) and how to reframe them can facilitate one's responsiveness, so it is important for individuals to distance themselves from their actions in order to be able to explore and evaluate them.

Different authors (Holec 1979/1981; Scharle and Szabó 2000; Smith 2003; Wenden 1998) characterize autonomy as persistent involvement and deliberate choice. The main autonomous traits point to the following:

- Setting individual goals.
- Selecting appropriate and accurate materials according to their own learning styles.
- Selecting activities according to their learning objectives.
- Selecting learning methods and techniques.
- Establishing self-pacing within external constraints.
- The conditions for monitoring progression.
- Adopting an active approach vis-à-vis their responsibilities over the learning process.
- The predisposition to take risks.
- The conditions for self-evaluation as regards their learning expectations.

The development of autonomous skills and attitudes should be intentionally addressed in formal education design and improved by individuals in their self-directed learning to take full advantage of social Web and Web 2.0 affordances. Building a dynamic ecology for self-development may then be possible thanks to the rich and diverse set of learning opportunities available in the digital era.

5.5.2 *Personal Pedagogies*

Is it contradictory to talk about a personal pedagogy when pedagogy is traditionally defined as a method or practice of teaching? Pedagogy involves a certain degree of awareness not particularly of what is to be learnt, but an emphasis on how to facilitate learning. While attempting to question this clear-cut division of presupposed roles and responsibilities between teachers and learners, we could mention the different levels of student involvement in pedagogical decisions that already exist within formal education. We have found examples of formal learning where spaces for pedagogy discussion are possible: negotiated curriculum (Williams et al. 2011), learners-and-teacher course codesign (Garcia 2014), open content courses (Bruce and Zheng 2011), personalized learning (Redding 2013), and learner-generated content (Pérez-Mateo et al. 2011).

In this section, and in line with the idea of personal pedagogies, we explore trends in Web enabling services and technologies supporting learning ecologies that permeate formal, non-formal, and informal learning, paying special attention to emerging or renewed pedagogies that allow autonomy and self-direction in personal learning trajectories. Discussion and specific policies recognizing non-formal and informal learning (CEDEFOP 2009; European Commission et al. 2014; Werquin 2010) are positive incentives that encourage people to become actively involved in seamless lifelong learning.

This list is not exhaustive, and in some cases, items may overlap and intersect in the way in which they are approached. The trends comprising technologies, pedagogies, and strategies illustrate a whole landscape of choices of autonomous learning in the digital era. Technology affordances have multiplied and simplified opportunities for learning. We are fully aware that creativity will provide new ways of combining them and generating new ones.

5.6 MOOC

MOOC stands for massive open online course. These are courses offered to large numbers of students worldwide and usually for free. Since the first experience in 2008 with the “Connectivism and Connective Knowledge” MOOC (Bell 2010), this phenomenon has grown exponentially in number (Shah 2014) and new MOOC formulas are being tried out. However, the primary pedagogical approach rests on what Rodriguez (2012) calls AI-Stanford-like courses. AI-Stanford was another highly successful pioneering MOOC on artificial intelligence offered in 2011 by Stanford University. This denomination is also known as xMOOC, which emerged to differentiate it from the connectivists’ cMOOC. Even if this binary classification is a simplification, it is useful for explaining a whole spectrum of MOOCs in-between these two poles.

The xMOOCs are predominantly courses developed using cognitive and behaviorist principles. The teacher constitutes "the most relevant and reliable source of knowledge and information" (Guàrdia et al. 2013, p. 2) and establishes a mediated "presence" in a series of short lecture videos. Additional learning resources (usually freely available on the Web), a set of learning tasks or exercises, and automated assessment, such as quizzes, complete the basics of an xMOOC. Participation in discussion forums and some forms of peer support and evaluation are common in many xMOOCs. On the other hand, cMOOCs implement connectivist principles where the nodes and the network are reified. Learners are empowered in multiple ways by contributing to building a network of participants, creating their personal learning environments, choosing, aggregating, and sharing learning resources, coevaluating, and providing peer support. The premise is "knowledge creation and generation" (Siemens 2012).

The MOOC as a phenomenon is rapidly evolving, and the learning opportunities it offers may become a significant part of a personal learning ecology. As recent research (Liyanagunawardena et al. 2014; Zheng et al. 2015) has shown, the number of participants registered on MOOCs who complete the entire course is low (under 10 %) (Gütl et al. 2014), but there is also evidence that this is not necessarily caused by dropouts due to poor course quality or the participant's lack of motivation. Participants are declaring an interest in "bits" of information in the MOOC or in specific sections of the course. This is congruent with individuals who have clear learning goals that choose from the available educational resources that best fit their needs. Since MOOCs are organized educational pieces designed and planned by teachers and faculty, identifying and matching the explicit learning objectives of the course and the implicit or less clearly defined personal ones is relatively easier. MOOCs provide the opportunity to benefit from more experienced peers and contribute to social learning. They offer the additional motivation of interacting with people with similar interests. Furthermore, people concerned with gaining recognition for their learning may also benefit from MOOC accreditation where statements of accomplishment and badges are commonly granted. Coursera's (http://www.coursera.org) initiative known as a "signature track" is already offering "specializations" consisting of a series of interrelated courses signifying another step in the open educational offer, this time, for a small fee. Badges and completion certificates from recognized educational institutions and prestigious universities can enrich a personal e-portfolio, whether this is used for learning or other purposes.

5.6.1 Current Awareness

Current awareness techniques support updating, upgrading, and even foreseeing any particular topic as it evolves and allow a person to oversee a subject of interest. The idea of keeping up with relevant and up-to-date information is not necessarily new. University libraries usually offer this service to their faculty by providing recently published literature in a specific field or subject. However, Web 2.0

("prosumers" Web) and Web 3.0 (semantic Web) are offering a much broader array of services that provide user self-sufficiency and customizing options as never before. If we explore some of them, we can see how they may be an extraordinary ally of motivation and self-development. The benefits of automatic alerts like the ones we describe below are enormous compared with the required unique action of "subscribing" or a set of actions for configuring a current awareness space within a personal ecology.

Mailing lists together with news groups and newsletters are probably the best-known ways to receive new information from specialized Web sites, companies, or groups of people interested in the same issues. Mailing lists are a collection of names and electronic addresses used to distribute information to multiple recipients (e.g., Instructional Systems Technology mailing lists at Indiana University Bloomington: http://education.indiana.edu/about/departments/instructional/email-lists.html). This collection of addresses can also be used to send electronic bulletins, also known as newsletters (e.g., E-portfolio European project and portal newsletter: http://www.europortfolio.org/newsletter), which are periodically distributed by an organization or business. Mailings lists and newsletters are a more passive action whereby we receive e-mails about ongoing events related to our concerns. Newsgroups are Internet-based discussion forums where participants with common interests engage in debates (e.g., ITF forum: http://itforum.coe.uga.edu/). As the definition shows, newsgroups are horizontal, allowing each subscriber to voice their own opinion. They usually have a moderator who ensures a respectful and productive exchange and may, in some cases, filter messages in accordance with the newsgroup rules.

However, RSS (Rich Site Summary, also known as Really Simple Syndication) has actually enhanced the way in which we can stay informed. It is a technology that allows users to keep track of regular changes in Web content by subscribing to feeds (a data format used to distribute Web sites' recently added content). This Web content may also come from selected bloggers the user has chosen to follow because of their expertise or the opinions they share. New content also includes new issues of academic journals, the appearance of specialized magazines, or any other Web site that has enabled this function. There are numerous ways to set up an RSS feed.

Applications like Flipboard (www.flipboard.com) or Feedly (www.feedly.com) allow users to aggregate RSS feeds from diverse Web sources all in one place. They support visual display, customization, and sharing. These RSS readers simplify the way in which we organize and keep track of the information we gather and read. They leverage the new affordances of the social Web as they integrate advanced sharing options in any type of social network, such as Facebook (www.facebook.com), Google+ (www.plus.google.com), and LinkedIn (www.linkedin.com). They are cloud-based and developed using responsive design, allowing them to be viewed from any device.

Bookmarking and other forms of archiving Web content are other techniques of current awareness. Bookmarking is way to record and organize any kind of Web content for future access. Popular bookmarking applications such as Delicious (www.delicious.com), Diigo (www.diigo.com), and Zotero (www.zotero.org) have evolved by supporting different ways to build personal or group bookmarks, annotate links, and share them on multiple platforms. Tagging options allow a more dynamic way of organizing and reorganizing resources according to specific or immediate use of needs. Applications such as Evernote and Google Keep are cloud-based note-taking services that allow users to collect, organize, classify, tag, and share almost every content available on the Web. One way to stay in tune with the constant fluidity of knowledge is to be a curator or subscribe to curators of specific subject matters or topics. Publishing platforms like Scoop.it (www.scoopit.com) support easy ways to create boards and participate in a criterion-based strategy for keeping track of the state of the art of a content problem.

All the available applications and services tend to integrate new functionalities and are converging into fully functional, flexible, and customizable ways to support current awareness.

5.6.2 E-Portfolios

E-portfolios or electronic portfolios are digital versions of the traditional portfolios found in educational or professional contexts. There are several definitions of e-portfolios, most of them highlighting one aspect, usually the context of use or the purpose of this broad digital solution. The e-Portfolio European Network (www.eportfolio.org) has adopted an inclusive definition as follows: "ePortfolio is an umbrella term for a structured collection of self or cocreated digital artifacts, recognitions, and accreditations where the owner has enough freedom to arrange their presentation according to specific purposes and audiences." Digital or electronic portfolios also represent a significant improvement thanks to Internet affordances and increased connectivity. The emphasis in the history of portfolios, in the phase of digital networks, has shifted from collecting to also communicating and exchanging.

There are numerous applications for building an e-portfolio. In most educational institutions, existing LMS or dedicated software (e.g., Mahara—mahara.org, PebblePad—www.pebblepad.co.uk) is used to support e-portfolios for teaching and learning at the course and the program level (Downs et al. 2013). Programs designed according to competency-based learning usually deploy a competency profile where a set of clustered competencies help articulate the courses and provide program consistency (Wassef et al. 2012). Competencies serve as logical organizers for collecting evidence in intelligible and communicable ways. They also support transition e-portfolios connecting student life to work life. Ownership is a key issue for institution e-portfolios. The more transferable they are, the better for the student's lifelong learning and career development. They should provide e-portfolio portability.

From an individual perspective, developing a personal e-portfolio may become an integral part of a self-development strategy. Whether started within a formal learning situation while taking part in a program or initiated on one's own, e-portfolios are flexible enough to support a variety of purposes (JISC 2012). They support learning and reflection and are a valuable option for formative assessment. They may also be used for showcasing one's achievements for professional projection or job seeking. They may contribute to the creation and management of a digital identity. In summary, e-portfolios support a "personal development planning" (PDP) understood as "a structured and supported process undertaken by an individual to reflect upon their own learning and achievement and to plan for their personal educational and career development" (Strivens 2007, p. 3). Studies in PDP and e-portfolios for career success are showing promising results (Faulkner et al. 2013).

Web 2.0 and social Web technologies and practices have substantially increased the ability to integrate applications and services for e-portfolio implementation as well as the opportunities for opening it up to interaction, discussion, and feedback. Wikis, blogs, and cloud-computing services together with social networks such as Facebook and LinkedIn can be seamlessly connected to build a multimedia-rich environment with social affordances. All kinds of digital assets—digital certification from recognized institutions, badges from MOOCs, videos or digital presentations or productions from learning or work, documents of all kinds, etc.—can be easily stored, organized, and published through an e-portfolio on the Web (McKenna and Stansfield 2013).

5.6.3 Social Networks and Communities

For authors such as Siemens (2005) and Downes (2012), traditional learning theories of behaviorism, cognitivism, and constructivism do not provide fully explanatory power for learning in the digital era. They propose the "connectivist" learning theory which emphasizes that learning is the capacity to establish meaningful connections to nodes, whether human or not. This approach situates networks at the core of social and personal knowledge creation.

Dron and Anderson (2014) advance a typology of social forms for learning, namely "groups," "nets," and "sets." These different configurations allow any individuals to "benefit from one another's knowledge and actions" (p. 73). While "groups" are usually formed within formal education (classes, tutorial groups, seminar groups, workshops, cohorts, etc.), "net" learning consists of nodes (e.g., people, objects, ideas) and edges (the connections between them) that usually emerge and consolidate at the initiative of the participants themselves. They tend to be stable and support fluid horizontal communication and exchange between members regarding changing or evolving common subjects or concerns. Finally, in "sets," people establish less perennial ties with regard to particular interests. Sets are more defined by "picking up" things than on the social exchange with others.

The interest in participating and socializing has precipitated the rise of differentiated network systems. From a technological perspective, network systems are services that provide any individual with ways to connect and establish social relationships for groups, networks, or sets configurations. Although any taxonomy is somewhat reductionist, the best-known social networks have recognizable orientations and attract people for different purposes: Facebook (www.facebook.com) gathers all kinds of individuals sharing personal life events and general interests where participants are recognized as "friends"; LinkedIn (www.linkedin.com) assembles people seeking to establish professional liaisons or connects prospects with potential employers; Academia.edu (www.academina.edu); ResearchGate (www.researchgate.net) is research-oriented spaces connecting faculty and researchers; and Twitter (www.twitter.com), the microblogging application par excellence, either for personal or professional ends, is characterized by disseminating instantaneous short messages and providing streaming communication capabilities. On-top services like TweetDeck (www.tweetdeck.twitter.com) for Twitter provide additional functionalities for improved visualization of streamed information through custom timelines or track of lists, searches, and activities.

But there are also many networks that form around media (video, pictures, images, texts, etc.) sharing services like YouTube (www.youtube.com), Flickr (www.flickr.com), Pinterest (www.pinterest.com), Instagram (www.instagram.com), Issu (www.issu.com), and to name just a few. As the Pee Wee report (Duggan et al. 2015) shows, there is a growing number of users participating in more than one social network.

Networks are plastic and may support learning in more or less engaging ways. CoP, a type of group–net intersection, are identified by an active and persistent involvement of "practitioners" with similar goals that exchange and produce meaningful knowledge resources within a shared repertoire and improve practice (Wenger 1998). Participants' experience and expertise are crucial and define membership and role status within the community and build a collective identity. They are domain-oriented and they share common concerns for meaning-making and personal development. According to Bates (2015, p. 129), "A large part of the lifelong learning market will become occupied by CoP and self-learning, through collaborative learning, sharing of knowledge and experience, and crowd-sourcing new ideas and development." CoP are common in medical, education, software engineering disciplines, and within companies.

While CoP are a more homogenous domain-oriented type of grouping, communities of interest (CoI) constitute a heterogeneous group of people with different backgrounds and experiences (Fischer 2001). They are, in terms of Dron and Anderson (2014), a type of group–set intersection. In CoI "members take part in the community to exchange information, to obtain answers to personal questions or problems, to improve their understanding of a subject, to share common passions or to play" (Henri and Pudelko 2003, p. 478). Learning is more a personal effect of a shared enterprise that does not require the development of an artifact as in CoP. The involvement is more dissimilar since individual needs are the primary motivation for participation.

Even if networks for learning have existed for a period of time, new social networks are shaping the way in which people communicate, exchange information, and even socialize. Networks intersect personal and professional life, including learning. Both individuals and educational institutions and organizations are being challenged to make the most of them.

5.7 Conclusions: Ecological Setting for Learning

The technological landscape of applications and services has matured to a point where adoption, appropriation, and use are no longer a barrier. Opportunities for collecting, creating, and sharing content and knowledge are multiple. Furthermore, efforts are being made to facilitate methods for recognizing non-formal and informal learning (Cedefop 2009; Souto-Otero et al. 2014). Formal learning offered by higher education institutions and non-formal education from a variety of providers in the private and public sectors are being rethought in order to leverage emerging technologies and in accordance with the principles of open accessible education. The response is enabling all kinds of learning scenarios and personalization opportunities for learning. We could conclude that the setting is sufficiently grounded to support lifelong learning and personal and professional development.

The self is the key and the challenge to face in the coming years. Autonomous learning supposes some forms of self-regulation. Self-regulated learning is demanding since it assumes that people are "metacognitively, motivationally and behaviorally active" (Zimmerman 1989, p. 329) in their own learning process. But there is also a crucial role played by others (teachers, peers, experts, etc.) in the successful development of self-regulation (Zimmerman 2000). The distinctive characteristics of autonomy in learning are congruent with the twenty-first century competency framework, particularly those related to "self-direction, adaptability, flexibility, and collaboration" (Wolters 2010, p. 18). Substantive theory, enabling technologies, educational change, and self-dispositions are making it possible to draw up a comprehensive framework in which individuals may build personal trajectories of learning and development in flexible and organic ways, where they can enact personal pedagogies.

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Author Biographies

Marcelo Maina is associate professor of Educational Technology. He has a long experience in teaching undergraduate and graduate courses about online learning, learning design innovation, and e-learning management at the Department of Education (Unité d'Enseignement et de Recherche en Éducation) de la Téluq, Université du Québec and at the Department of Psychology and Education of the Universitat Oberta de Catalunya. He is the member of the Edul@b group at the l'eLearn Center and of the LICEF research laboratory at Téluq.

He has participated in numerous European projects regarding technologies, education, and lifelong learning. His research encompasses such topics as learning ecologies, learning design methods and tools, emerging digital pedagogies, personalized learning, and open educational practices. He has participated as invited speaker in several conferences and published his research in conference proceedings, journal articles, and book chapters. He serves on numerous committees (e.g., International Seminar UNESCO Chair in Education and Technology for Social Change) and review panels (e.g., International Review of Research in Open and Distance Learning). He has participated in conference scientific committees (e.g., Annual Conference European Distance Education Network), as well as a reviewer in teaching innovation symposiums (e.g., International Symposium of University Teaching).

Iolanda Garcia has a Ph.D. in Education and is an associate professor in the Department of Psychology and Education of the Universitat Oberta de Catalunya (UOC). She develops her research within the UOC's eLearn Center and as a member of the EMA research group at the University of Barcelona. She has been responsible for the innovation area of the UOC's eLearn Center and a lecturer at the University of Barcelona.

Her academic background is associated with the study of the processes of educational innovation through the use of digital media, the analysis of social knowledge building processes, and the design of learning environments and resources mediated by technology.

She has published several articles and book chapters on these topics, and she coordinated the development of the Horizon Report 2010 on educational and technological trends in Latin America, in collaboration with the New Media Consortium. She has also participated in and coordinated several international and national research and innovation projects. Her current research focus is the study of the processes of self-directed learning in social and open learning environments, and the analysis of student participation in the design and regulation of their own learning.

Part II
Learning Designs for Emerging Pedagogies

Chapter 6
Conceptualization of Multimodal and Distributed Designs for Learning

N. Staffan Selander

Abstract In this chapter, we will focus on articulations of teaching and learning and relate these to technological shifts and social paradigms. We will briefly describe the changes of technology of learning from SYSTEM 1, which is characterized by rather stable structures, national curricula, classroom teaching, printed school textbooks, and assessment standards (developed during 1945–2000), to SYSTEM 2, which is characterized by dynamic (global) change, the development of digitized media, cognitive systems, mobile learning, and the idea of individual agency (2000→). During these two periods of time, quite different teaching and learning strategies can be articulated: "designed information and teaching" versus "multimodal and distributed designs for learning." However, most current theories of learning are still founded on theories of meaning developed in an era constituted by SYSTEM 1, and the assumptions of stable systems and the reproduction of forms, processes, and actions. Today, different kinds of platforms, tablets, games, apps, and collaborative problem-solving design have contributed to individual production, new communicative patterns, and information access to such a degree that we could say that "information is no longer the problem." Information is ubiquitous and cheap. What is at stake is rather to connect people in meaningful communicative settings. The formation and transformation of knowledge and the role of multimodal and distributed designs for learning as a theoretical approach will then be discussed in relation to SYSTEM 2.

Keywords Designs for learning · Multimodal knowledge representations · Distributed learning · Transformation of knowledge · Cultures of recognition · Paradigmatic thinking

N. Staffan Selander (✉)
Department of Computer and Systems Sciences, Stockholm University,
Post Box 7003, 164 07 Kista, Sweden
e-mail: staffan.selander@dsv.su.se

N. Staffan Selander
Liljeholmsv. 12, 117 61 Stockholm, Sweden

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6.1 Introduction

When Bourdieu and Passeron (1977) published their book on reproduction, their idea was that society was reproducing itself as 'the same.' This idea—with its view of rather stable social reproduction—was embedded in the industrialized era with a school system that aimed at sorting out people and reproducing the class society. Today, in our Late-Modern society, we would rather claim that only digital media reproduces "the same" according to logarithms, but also that humans never reproduce "the same." Repetition in habits and in communicative acts means that new selections are made over and over again, adding aspects that little by little, all the time, produce changes. For example, when repeating festivals year after year, we never do the same. We establish a new order of resemblance—we "repeat the unrepeatable" (Deleuze 2001, p. 1).

Looking at education and learning is looking at society and technological changes—as well as existential conditions—from a point of view that includes such aspects as: resources for meaning-making and communication, power relations, and, as I will claim here, design. Seen in a longer perspective, we could identify two late "types" of teaching-and-learning environments, which I will call SYSTEM 1 and SYSTEM 2. Briefly, these "systems" have the following characteristics (Selander, in progress)[1]:

- **SYSTEM 1** (1945–2000): The logocentric principle of learning, introduced at the end of the nineteenth century, still prevails and could be characterized as a monological and authoritarian way of conveying information. At the beginning of the period, learning was still based on verbal texts (even though illustrations more and more were used as a complement). Behaviorism became a leading paradigm, focusing on the control of manners, and content learning was seen as the result of stimulus–response activities. However, new paradigms based on Piaget's (constructivism) and Vygotkij's (sociocultural perspectives) work were established at the end of the period.
- **SYSTEM 2**: Here, an applicatory, multimodal, and distributed principle of learning is emphasized. Learning is seen as sign-making activities and is recognized from its use-value. Learning is related both to social theories on communication, including the social-semiotic, multimodal turn during post-modernity,

[1]Earlier phases can be described as follows: (1) SOCIALLY DISTRIBUTED EDUCATION (to 1850). For many centuries before industrialization, education was socially distributed in relation to clan and feudal societies, where the mimetic principle (to learn by doing like others and "memorizing" by heart) and the rhetorical tradition (to develop the capacity to speak well according to different social arenas) were the dominating practices; (2) PROTO-SYSTEM (1850–1945), the construction of nations, the beginning of mass education built on logo-centric principles in school textbooks (the verbal language as the way of representing knowledge) and class hierarchies at the beginning of the industrialized era.

and to neuropsychological and neurophysiological research on the brain (2000→). Teachers and students have the opportunities to be both producers and consumers of information. Teaching and learning activities are (among other perspectives) discussed in terms of "design."

6.2 System 1

During the second half of the twentieth century, different "grand theories" in the field of learning can be noticed: from behaviorism (Skinner) and constructionism (Piaget) to social constructivism (Vygotskij). Each one of these theories relies on substantial empirical findings, even though the constructed objects of knowledge are very different. They also seem to have functioned as social legitimations of educational policies, in terms of the ways in which teachers and students have been positioned, how content has been materialized and represented, and how the organizing principles of the dominant culture of recognition have been articulated and put into assessment standards.

In the 1950s and 1960s, there was a strong focus on behavior modification, on how behavior could be reinforced or extinguished by way of classical (Pavlov) or operant (Skinner) conditioning. The iconic person of this research was, of course, Skinner (1965, 1988), but also Gagné, Bandura and Walters, and many others. The focus of this research was on behavior modification, on the relation between stimulus and response (S–R), and on the ways different responses could be reinforced and lead to a favored behavior. The organism itself (O)—with its specific characteristics—was of no interest. It was rather seen as the "black box" or as a necessary transmitter of outer impulses/stimuli. However, today we can notice a new interest in explaining language and cognition by using behavioristic theory, in terms of the relational frame theory (Hayes et al. 2001).

In the 1970s and 1980s, another paradigm was highlighted, and the focus shifted from the outer stimuli to the inner (for example biological) changes of the organism and the development of cognitive skills and higher order thinking. The work done by Piaget became central, not least in an educational context (Piaget 1992). The interest shifted to the individual's inner growth, and later on to cognitivist-oriented research, which focused on understanding and the learning of key concepts, as well as the capacity to store information (memory).[2] It seems that this development emphasizes the individual's capacity to conceptualize the world and solve problems rather than respond to different kinds of stimuli in a correct way and, bit by bit, developing correct behavior. A cognitivist approach still dominates much of

[2]Today, we can notice a vivid discussion about metaphors such as "storing" in relation to memory. Critics see memory as an active practice to produce meaning rather than a passive practice to "store and retrieve" memories. And some would rather talk about "remembering/memorizing" than "memory."

psychological research on learning, not least because of new advantages in the neurosciences.

Still another perspective—the sociocultural perspective based on Vygotskij's work—focused on such aspects as meditating tools and the role of artifacts for learning, the development of collective memory, but also on the complex relations between situated learning and institutional framings (Wetsch 1997).[3] Vygotskijs own main interest was to understand the role of language in the development of thinking (Vygotskij 2001).

Besides these three "grand" theories, we can notice other interesting approaches. The understanding of learning can, as Hutchins (1995) described it, focus on the development of capacities to engage in complex chains of information and communication, in human–artifact-related (tools, machines, computers, etc.) environments. The complex learning process from peripheral to central participation has also been described by Lave and Wenger (2002).

Koschmann (1996) argued that comparable paradigms could be identified in computer-supported learning. In the beginning, the focus was on efficient learning, and for example, the CAI-paradigm (*Computer Assisted Instruction*) was constructed on a behavioristic perspective on learning. Each application was designed in relation to a specific set of predefined goals. These goals were divided into small learning objects, and the role of the student was to act as a passive receiver of predefined information. The role of the teacher was to check that the student had learned the different steps correctly. The feedback process was integrated in the program as a randomized feedback with phrases such as "Well done!" or "Not so good, try again." "Rapid e-learning" applications can still be referred to this paradigm.

Related to this was the ITS-paradigm (*Intelligent Tutoring Systems*, influenced by *Artificial Intelligence*), which was based on the proposition that education could be globally improved by providing every student with a "personal" digital tutor. These applications were similar to those in the CAI-paradigm. The difference was mainly that it was the interaction between the computer and student, and not between the teacher and the student, that was in focus.

The second paradigm, *Logo-as-Latin*, was built on a constructivist perspective of learning, inspired by Seymour Papert's (1998) use of the computer programming language *Logo*, which he tried out with young children. The students could themselves play the role of the teacher, and the program was also directed toward more general educational objectives.

The third paradigm, c*omputer-supported collaborative learning* (CSCL), was based on sociocultural theories. The focus shifted toward the understanding of language, culture, and aspects regarding the social context. The applications were open and designed for the student's different aims and ways of using them. This paradigm also characterizes the shift from SYSTEM 1 to SYSTEM 2.

[3]Vygotskij himself used the term "historical/cultural" perspective, which later was changed to a "sociocultural" perspective in the West.

6.3 System 2

The development of digital media—from *writing and book* to *image and screen*, as well as the emergence of new *mobile communication* devices—seems to have profound consequences for both meaning-making and learning wherever it takes place and for institutional arrangements of education (Kress 2003; Selander and Kress 2010). The digital technology, which started out as an add-on to existing technologies in the 1980s and 1990s, is now so developed and so smart that it has actually changed not only the ways we stored information, but also the ways we communicate.

It has also been noted (in educational settings) that digital media make it in many ways easier to visualize and explain complex structures (Säljö 2005). Also, the students' possibilities to develop their own ideas and become inspired by others increase (Holm Sørensen et al. 2011), and the medium may inspire them to have fun during their work, even if "having fun" is not linked so much to learning as to play (Alant et al. 2003). However, during this period, we can notice a blurred boundary between "learning" and "play/gaming." What during SYSTEM 1 was understood as different and separate kinds of activities are now rather conceptualized as aspects of engagement and meaning-making activities (Selander 2008c; Steinkuehler et al. 2012).

The changes we address here do not mean that everything about teaching and learning is more efficient thanks to the digitized technology or that we do not face any kind of problem (such as distraction, loss of focus, and not to talk about technical obstacles). But, besides these critical experiences (or irritating obstacles), what is important is that we are living in a society under constant change, which will put at least the following demands on teaching and learning (also see Collins and Halverson 2009):

- A need to develop a new paradigm for the future curriculum, as well as new cultures of recognition and assessment practices (and standards)
- A need to understand learning in relation to multimodal designs
- A need to understand the role of digital media for the organization of school work at scale

Such a re-orientation has partly been carried out in terms of twenty-first century skills (21st CS)[4]—or twenty-first century competences (21st CC). The focus here is on such aspects as self-directed (Gibbons 2002) and collaborative learning (Nouri 2014). A step further would be to discuss teaching and learning as design activities.

The design-for-learning perspective relates to a Scandinavian tradition of project-oriented and problem-based learning and also to historically strong traditions of evening courses, re-education, and further education. In the design sphere, inter-action design has been rather strong (Löwgren and Stolterman 2004) and has also later been an important source of inspiration. The design-theoretic approach

[4]http://atc21s.org/index.php/resources/white-papers/.

was from the beginning shaped out of an inter-sectional reading of sociocultural theories and multimodal social semiotics (Selander 2008a, b, c).[5] The idea was that new conditions for communication and learning in society at large (including non-formal and semiformal learning environments) had to guide anew both the conceptualization and the assessment of teaching and learning in formal education (Kress and Selander 2012; Selander and Kress 2010).

Next, I will underline two aspects that in different ways are important for the understanding of a design-theoretic approach to learning during System 2: the development of mobile as well as game-oriented learning and collaborative problem-solving design, and a dialogic understanding of communication.

6.3.1 Mobile Learning, Game-Oriented Learning, and Collaborative Problem-Solving Design

During the last decade, the visual representations of information have increased in focus and become more and more important in our society. Digitized media, different applications, and games/simulations[6] are becoming important resources for learning. Mobile devices support learning as activities that can take place in different places, also within the frames of classroom education (Eliasson 2013; Nouri 2014). These devices are also flourishing outside the formal educational context to such an extent that new ways of meaning-making and new kinds of social communication are developing rapidly (Ito 2010). This, in its turn, also leads to new demands on schools to change the teaching format (see, for example, Steinkuehler et al. 2012; Stocklmeyer et al. 2010).

Even though gaming and simulation for learning and training as such are no new phenomena—one early example is the RAND corporation's logistics simulator modeling activities of the US Air Force supply system with players acting as inventory managers (Jackson 1959)—the situation today leads to, qualitatively speaking, new demands. One of many examples is the use in education of both the commercial version *Minecraft* and the educational version *MinecraftEdu* (Miller 2012; Bos et al. 2014; Shaw 2014).

Still another interesting development is what I would like to call CoProD—collaborative problem-solving design. This is a new development of virtual cases for students to train social skills (collaboration, negotiation) as well as cognitive skills. The idea is that two students work together. They share a problem, but do not

[5]I have been inspired by the French philosopher Ricœur (1983). His reading of time in Augustine and poetics in Aristotle resulted in the volumes about time and narrative.

[6]Both games and simulations may be seen as representations of the real world. However, there are some specific differences between them: *games* are based on a rather coherent organizing principle, while *simulations* often are based on a representation of *a part* of something.

have the same information. This means that they have to collaborate to become aware of the total information and resources available for solving a task.[7]

Gee (2004) has listed a number of important learning principles that games offer, which could also be relevant in collaborative problem-solving activities, such as the *Practice Principle*, where learners become engaged in stimulating practices. Another noteworthy principle is the *Achievement Principle*, as when learners at all levels of skill receive intrinsic rewards from the beginning. A third is *The Ongoing Learning Principle*, where the distinction between learner and master is blurred. Finally, the *Probing Principle* is of importance because the gamer can reflect in—and on—their action and form a new hypothesis. We can also notice that hard tasks seem to be one of the strongest factors promoting player collaboration (Hämäläinen et al. 2006, p. 59).

There are many arguments claiming that games are good for learning (Gee 2004), but the question of what kind of learning is supported by games and by mobile devices still remains valid. In a school context, games must be meaningfully integrated into the curriculum, and on a more practicable level, the lesson and the teachers must be supported in this development. But, whatever standpoint we take, it seems obvious that the development of game-oriented learning evokes radical new questions of curriculum, practices, and assessment standards (Barab et al. 2009; Gee and Shaffer 2010; Squire 2011; Steinkuehler et al. 2012). For the last two decades, there has been extensive research on video games for learning, but there has been limited research on analyzing the *game design* of educational video games in relation to learning, and a didactic focus is required for serious games design (Åkerfeldt and Selander 2011). Thinking in terms of designs for learning is a theoretical approach to understanding the possibilities also in relation to games and simulations for learning in more formal contexts (Egenfeldt-Nielsen et al. 2011; Ramberg et al. 2013; Selander 2008a, b, c).

6.3.2 Toward a New Approach to Communication and Learning

A traditional view of communication that had a great impact in schools is the model developed by Shannon and Weaver (1948/1998), despite the fact that its aim was to describe and understand communication in terms of the conveyance of information in military technical systems. Their model is based on the structure of a sender who

[7]See, for example, *Collaborative Assessment Alliance*, which started after the development of twenty-first century skills and the new PISA directives. In Sweden, Stockholm University is one of the partners, working with different communities where teachers collaboratively develop different (virtual) tasks in relation to the curriculum. Also here, we can make a distinction between the design *for* learning (making the virtual cases) and the design *in* learning or the students' design of their collaborative problem-solving activities.

encodes a message, a channel, a contact, and a receiver who decodes the message. The underlying assumption is that if the message is clear, if there are no distortions in the channels, and if the receiver has the right code, the message will be understood according to the intentions of that message. Putting this into the classroom, the teacher should do nothing more than focus on creating a clear message, appropriate for the students' level of knowledge. The model might do for technical information, but as a metaphor for human communication, it is misleading (Sheridan and Rowsell 2010). Human communication can rather be articulated as follows (Selander and Kress 2010):

- Setting
- Context/resources
- Affordance
- Meaning-making
- Transformation and redesign
- (New) representation

Here, communication is seen as a process of meaning-making with the help of different (multimodal) resources. Transformation and redesign seem to be a more adequate way to talk about teaching and learning activities than are metaphors such as the transportation of messages.

6.4 A Design—Theoretic, Multimodal Approach to Learning

Design enhances the perspective on learning as a creative act of transformations and redesigns. Design also highlights the question of signs of learning and cultures of recognition. As a consequence, the resources (modes and media) used in learning activities are crucial for the ways in which the world is represented.

Design is understood in terms of form and function, where form is an integral part of the message, which also takes into consideration an aesthetic aspect of communication and learning. The medium itself, its materiality and affordances, becomes of importance for the expression of the content. Furthermore, design is understood in terms of "interactive" design—inspired by the interaction design paradigm and design for the purpose of (i.e., organizational) change. This conceptualization of design has its focus on the dialogical, collaborative, and rather open-ended process of negotiations, problem-solving, and meaning-making. Design from this point of view underlines the importance of acting with the users (as in inter-action design). Designing an artifact (for learning or in the very process of learning) is also a matter of designing a social praxis.

We will start with some notes on the social semiotic and a multimodal approach to communication and then continue by describing the designs-for-learning perspective.

6.4.1 A Social-Semiotic and Multimodal Approach to Communication and Learning

Social-semiotic, multimodal theory (c.f. Kress 2010) highlights aspects such as the social construction of meaning by signs and thus the role of sign-making in different modes and media. Communication is understood as a multimodal enterprise where not only the verbal interaction, but also the whole range of gestures, pictorial elements, sounds, and other kinds of modes plays a role in meaning-making. The multimodal approach gives us both a theoretical grounding and analytical tools for studying learning as an aspect of communication. What the multimodal approach does not emphasize that much is the role of institutional framing, the setting, and the learning sequences (partly because communication and not learning has been the focus of attention). These questions are central in a design-theoretic perspective, a perspective that underlines the creative aspects of designing conditions *for* learning (space, texts, time, etc.) by, for example, authors, producers, architects, and teachers and designing paths *in* learning in concrete learning sequences. A design-theoretic approach underlines the importance of understanding how situated learning is framed by institutional norms and power relations, even though we (often) study communication in micro-settings[8] (Rostvall and Selander 2008).

The multimodal approach underlines the importance of understanding the *ensemble* and the *orchestration* of different modes and media (Kress 2010). When using a *multimodal framework*, several *modes* must be taken into consideration, such as verbal texts, (moving) images, sounds, gestures, gazes, and the like. Modes are shaped and used in social communication and are culturally and institutionally embedded and recognized.

6.4.2 Designs for Learning

Different didactic design aspects, which relate to the student's activities and the teacher's choices of resources in different educational settings, highlight how different learning resources are *sequenced* and how the user *makes meaning* from these resources. The student has to *interpret* the resource (e.g., the game), transform the information presented, and—by way of testing, probing, and, for example, sketching—form a new representation of his or her understanding. A design-theoretical approach underlines that form and content cannot (except analytically) be separated (Selander 2008a, b, c). When digital recourses—such as games or collaborative problem-solving tasks—are used, the educational setting becomes complex, and the multimodal character of the game "raises important questions

[8]In doing multimodal-oriented empirical research, we can focus on different kinds of material, for example, the communicative processes, but also the representational artefacts/texts.

about the choice of the mode used in the design of educational software" (Jewitt 2006, p. 53).

The concept of designs for learning refers to the material and temporal conditions for learning as well as the learning activity itself. The use of (digital) resources in processes of interpretation and identity construction is central to the understanding of learning activities. Learning is seen as a sign-making activity in which signs in different media (information) are elaborated and transformed into new configurations, and in which the forming of new signs in different media (re-contextualization) takes place. In this way, learning and the reconfiguration representation of knowledge can be traced, as signs of learning. "Knowledge" is here seen as a capacity to use and orchestrate signs and to engage in the world in a meaningful way. "Learning," consequently, is understood as an *increased* capacity to use and orchestrate signs and engage meaningfully in different situations (Selander 2008a).

Games and simulations, as collaborative problem-solving design, are example of resources designed *for* learners, with a focus on affective, cognitive, and social aspects. Learning is dialogic, both as (personal) meaning-making and as social/collaborative communication. The design of games and simulations does not enhance (traditional) textual knowledge as much as knowledge in use to handle challenges and/or solve problems. The use of games and simulations in education, as well as collaborative problem-solving activities, supports teaching as *distributed design* where many different sources and tools may be used (Åkerfeldt and Selander 2011).

From the learner's point of view, games and simulations as well as mobile devices support individual ways of learning, even though it is within the frame of a communicative and collaborative environment. Design *in* learning is a way to conceptualize how the individual learners develop their paths or ways of organizing the learning or problem-solving activities (Selander 2008a, b, c; Selander and Kress 2010).

Games and simulations also support learning as *interactive design*, i.e., the individual way to interact with other persons and/or with the digital artifact (Kjällander 2011; Selander forthcoming; Wiklund and Ekenberg 2009).

6.4.3 Signs for Learning—Signs in Learning

To understand learning as an activity is not only a question of focusing on *what* is learned, but also *how* it is learned. The sign-making, the sketching activity, the decisions that are made, etc., are the instances or fixing points, which can act as hints or leads for us to understand the individual learning path.

Signs, and configurations of signs, are like rhizomes, with great varieties of possible meanings. Signs are embedded in social relations and what we could call signifying practices. This means that the sign acquires its information value and meaning in social communication in specific contexts.[9] In a learning context, the reading of signs is both situated and institutionally framed. Even though situated practices in many cases are "open" and not predefined, the situation itself is embedded in a social setting with its aims, goals, tools, and more or less open assessment standards.

Learning is also from this perspective understood as *sequences* of activities related to transformations and formations of signs. When a person engages in something, he or she has different resources at hand. The offered systems of signs are configured by way of modes (letters, sounds, gestures, pictorial elements, colors, moving images, etc.) and media (such as a book or computer interface). To understand something is to be capable of using signs and forming new combinations. Being able to show "how" one understands is a key issue. "How" and "what" one understands are intertwined entities.

6.4.4 "Designed Information and Teaching Sequences" Versus "Learning Design Sequences"

"Designed information and teaching sequences" is a concept that captures the world of prefabricated learning resources (mostly printed verbal texts), formalized work and strict timetables (lessons) in System 1. The role of the teacher is to "bring" knowledge to the student, and the student's role is to learn by heart and to learn specific skills. The learning resources are developed in relation to teaching practices with well-defined roles (positions) and power relations. The content is embedded in teaching and assessment routines to such a degree that the knowledge representation is seen as the self-evident content. These resources are defined as "the objective material" and need to be scrutinized critically.

In System 1, "the didactic triangle" captures those aspects taken for granted: the teacher, the student, and the content. The problem with this triad is that it is based on concepts on different epistemological levels and also that the *content is taken for granted as an undisputable entity*.

"Learning Design Sequences," on the other hand, is a theoretical map for the purpose of analyzing crucial moments in (a creative) process of learning/meaning-making, which is central to learning in System 2. Here, we have a wide range of distributed resources (not only printed verbal texts but also games, mobile devices, computers, films, etc.). The variation of resources makes it more necessary than earlier to discuss information value and truthfulness, to critically read and make use the different multimodal resources. It becomes obvious that content is shaped in mutual interaction with different kinds of sources. The power relations are not fixed, and we find an on-going attempt to redefine taken-for-granted positions.

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[9]This differs from a structuralist view of the sign, where the sign acquires its meaning from its place in a grammatical structure.

In System 2, we could rather talk about the didactic triangle in terms of designs for learning and designs in learning, and in terms of distributed knowledge. The nodes in this model would be (a) the master plan (the curriculum), (b) teachers and students in mutual cooperation, and (c) multimodal and distributed (mostly digital) resources. Then, it is in the interplay between these nodes that we can define *content as a result of work/negotiations/transformations*, not as something that can be taken for granted as a given starting point.

6.4.5 "Learning Design Sequences" as the Basic Units of Learning

In semiformal and formal learning, a learning sequence starts when the learner is confronted with an articulated purpose, as in a museum exhibition or in a classroom context. The idea of a museum exhibition is to present a such themes as a technical solution (the steam engine), a historical time (a prehistoric period with dinosaurs), or a specific period of art (such as minimalism) by way of exposing original/authentic objects for a non-specialized public. However, these authentic objects play a central role for meaning-making. Also, the very design of the exhibit room and the show-cases, the lightning and the colors, the soundscape, the central and the marginal places, the selection and the narratives related to these objects, etc., are to be seen as signs that, by way of their orchestration, have an impact on meaning-making and learning (Insulander and Selander 2009). Likewise, the school is an example of a formal learning environment, but with a curriculum, a timetable, tests, marks, and ranking of activities. And here, it is not the object, but (still in most cases) the verbal text that is the source of engagement, even though visual texts, games, and artifacts are used as well (Elm Fristorp 2012; Kjällander 2011; Åkerfeldt 2014).

The model "Learning Design Sequences" is constructed so as to make it possible to follow the "learning paths" and focus aspects such as communication and interaction (between students, between students and computers, and between students and teachers), negotiations, decision points, sketching, and transformations of information to the final design of the representation of knowledge. In this kind of process, signs of learning and signs of knowledge can be identified. This will be illustrated by Fig. 6.1.

In a formal educational setting, we not only have purposes on different levels, as defined by curricula, course plans, and tests, but also strong institutional norms concerning such aspects as how to behave and what kind of learning resources, knowledge representations, and assessment criteria are accepted. The learning process, with its activities to transform signs and form new signs and representations, is embedded within formalized horizons of expectations and assessment of outcomes, where different kinds of multimodal—formative and summative—assessment procedures take place (Björklund Boistrup 2010).

A sequence starts with the "setting," i.e., when the teacher—or the computer software—introduces a new task and sets the conditions for the work. Then the

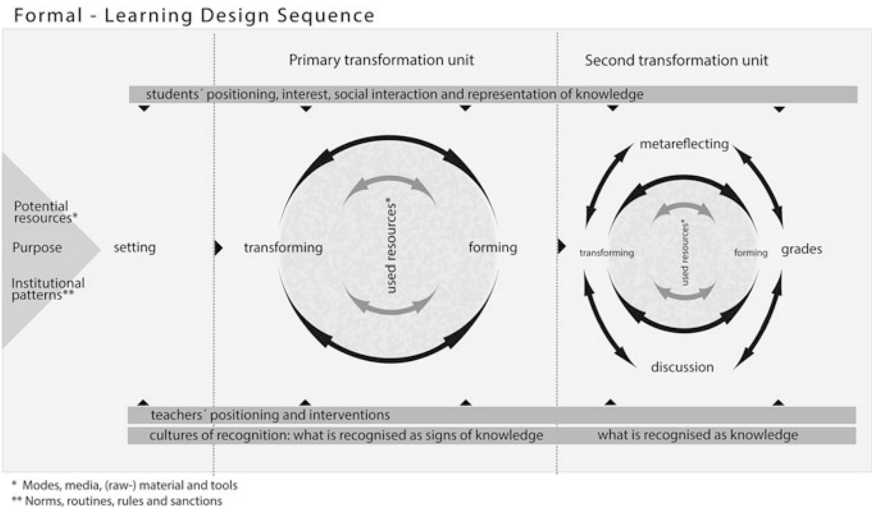

Fig. 6.1 The LDL model: learning design sequences (in Åkerfeldt 2014; after Selander 2008a, b, c; Selander and Kress 2010)

process—the primary transformation unit—begins, where the students have to interpret the task, the situation, and the expected outcome of the activities. The students use different sources and transform the information to design anew their understanding of the knowledge area. Then, the secondary transformation unit starts, when the students present their work, which will be evaluated, perhaps also discussed, within the frames of the existing culture of recognition.[10]

In this model for learning in *formal* settings, the production of some kind of final and assessable representation is obligatory. One critical aspect here is that, if students are allowed to work with digital media and other kinds of resources, it seems important that they will be tested by using the same kind of resources, not only by way of paper and pen. Even though schools today allow for a variety of learning resources, the dominant idea of how to represent, and assess, knowledge in an adequate way is still dominated by the thinking in SYSTEM 1.

6.5 Conclusions

There is a need to understand how we can design for the unknown (Bergström 2012[11]). To understand learning in terms of System 2 is to change focus to meaning-making activities and transformative acts by way of visual and interactive

[10]This model makes a clear analytical distinction between the primary and secondary transformation unit. Of course, in reality, these two processes can be blurred in different ways.

[11]See also Werler and Wulf (2006) and their research about “hidden dimensions in education.”

(multimodal) resources and knowledge representations. The development of mobile resources for learning and game-oriented learning designs, as well as collaborative problem-solving designs, calls for a dynamic, interactive multimodal, and design-oriented understanding of distributed learning.

The main purpose of this article has been to introduce a set of interrelated concepts that will bring new insights to how we can arrange *for* learning, as well as *in* learning. Learning is a broad term for many different and complex kinds of activities, such as the change of behaviors, the development of new skills, the increased capacity to solve new problems, to use new terminology, or to communicate with others. One crucial aspect of the LDS model concerns how *sign-making* can be documented. By focusing on *signs of learning*—as instances or fixing points of knowledge and learning—in learning sequences, we have to clarify which knowledge and learning aspects that (in a certain instance) are the most important. It is also a way to identify what kind of support or supervision is most needed and important to scaffold.

A design-theoretic, multimodal perspective highlights some of the critical instances of the learning process. By studying "Learning Design Sequences," and the students' designs of their representations, we will gain a deeper understanding of how collaborative learning practices are formed in complex digital and social environments. An interesting aspect to develop further is to understand learning in *interactive, multiple, and open-ended learning loops*, as is the case in game-oriented learning, where, for example, the activities affect which knowledge levels will be represented. The design-oriented perspective on knowledge and learning will, hopefully, extend our understanding of such aspects as signs of learning and meaning-making, the role of material (and virtual) resource in different learning environments and cultures of recognition.

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Author Biography

Staffan Selander has since 1996 been a professor in education, and since 2013 has worked at DSV—the Department of Computer and Systems Sciences, Stockholm University (SU), where he also is the head of the unit IDEAL—Interaction Design and Learning. He is honorary associate professor at the Academy of Turku, Finland, and visiting professor at the University College of Arts, Crafts and Design in Stockholm. He has been visiting professor at different universities in Denmark, Norway, Australia, Brazil, and Chile. He has also been the president of IARTEM (www.iartem.no).

Selander has tutored 40 doctoral students, and 21 licentiate students, and has for several years been a member of the committee for educational science at Vetenskapsrådet (the *Swedish Research Council*), and for praxis-oriented research at the *Norwegian Research Council*. He has organized three *international "Designs for Learning" conferences* and is the chief editor of the e-journal *Designs for Learning*.

Selander's *research interest* focuses on designs for learning, technology enhanced learning, self-regulated learning, multimodal texts and knowledge representations, games for learning and simulations as well as rhetoric and interpretation theories/hermeneutics. Earlier he was engaged in professionalization studies, curriculum theory, and textbook research.

Chapter 7
Ecologies of Open Resources and Pedagogies of Abundance

Allison Littlejohn and Lou McGill

Abstract Learning exists in diverse places—education, work and interest-based activities—and in many different forms. The move towards opening access to learning courses provides learners with the possibility to bring together learning opportunities from diverse sites. However, there is a danger in narrowly viewing learning as the acquisition of resources. This view restricts benefits of open resources to experienced, self-regulated learners. This chapter analyses diverse pedagogies that enable learners to capitalise on digital, open resources. It calls for a fundamental rethink of our cultural view of learning and teaching, focusing attention on how we encourage learners to create and navigate their own pathways, placing the self-regulation of learning as the norm.

Keywords Open educational practice · Open educational resources · Open courses · MOOCs · Open resources · Open pedagogy · OER

7.1 Introduction

This chapter examines the opportunities for learning afforded by use of open resources. Our vision of pedagogies of abundance extends beyond traditional conception of open access to distance learning to encapsulate the idea of learning fluidly across different contexts of life, from formal education, to workplace learning to interest-based learning (Littlejohn and Pegler 2014). Our reason for

A. Littlejohn (✉)
The Open University, Walton Hall, Milton Keynes MK7 6AA, UK
e-mail: Allison.littlejohn@open.ac.uk
URL: http://open.ac.uk/people/ahl69

L. McGill
Lou McGill Consultancy Ltd., 118 George Street, Whithorn DG8 8QA, Scotland
e-mail: lou.mcgill@gmail.com
URL: http://loumcgill.co.uk

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examining pedagogy in this way is because the idea of learning in a single, closed context, such as a degree course at a university, does not reflect learning in modern society (Tynjälä et al. 2014). Learning exists in diverse places—education, work and pastime activities—and in many different forms—as formal educational courses, informal study and sometimes even through unintended and serendipitous learning experiences. Digital, networked technologies have become an integral aspect of learning, transcending contextual boundaries—whether geographical, disciplinary or across sectors. The chapter is structured around three questions:

How do learners use open resources for their learning?
How do people learn through using knowledge resources?
How is open learning represented in diverse practice settings?

7.2 How Do Learners Use Open Resources for Their Learning?

Learning can be viewed as the acquisition of knowledge or skills through study or experience. The experiences that produce learning have been described using three metaphors: learning through the acquisition of information, learning through participation (Sfard 1998) and learning through knowledge creation (Paavola et al. 2004).

The first of these allegories, *learning through acquisition*, is based on the idea that knowledge is communicated from a teacher to the learner (or learners). The most common manifestation of this metaphor in higher education is the lecture, where information is communicated from a teacher to masses of learners in real time. This approach to education has become prominent as education has been expanded and commodified. The commodification of education, in particular the World Trade Organization's General Agreement on Trade in Services (GATS[1]) has had a positive influence on cross-border agreements on student mobility, content sharing, quality assurance and the recognition of education across borders. In calculating the cost of education, *access* and *delivery* are factors that are easier to measure than *learning*, which is cognitive, invisible and measured indirectly (e.g. by observing changes in practice). Borrowing from business service delivery measures, central to the quantification of education delivery*, is the student experience*, where learners are considered to be consumers of education and other services. Factors measured through national surveys focus on commodities and services, for example the UK National Student Survey,[2] examines teaching, organisation, learning support, resources and assessment and feedback, with little

[1]http://www.wto.org/english/tratop_e/serv_e/gatsintr_e.htm.
[2]http://www.thestudentsurvey.com/.

recognition of concepts such as learning agency, expertise development or knowledge building.

This idea of the 'commodification of education' is most visible where 'learning' is viewed as the *delivery of content*, rather than as a psychological process involving the development of different types of expertise. There are numerous scenarios in education and lifelong learning where it is assumed that people learn through exposure to content, most notably in the following educational domains:

Initiatives producing Open Educational Resources—digital materials that can be used, reused and repurposed for teaching, learning or research. These resources are made freely available online through open licences, such as Creative Commons.[3] Most OERs have been designed to be used by teachers or instructors for teaching. However, an intensive area of use of OERs is by learners themselves. Social media sites such as YouTube and Flickr allow students to build and share their own resources. Consequently, there has been a marked diversification of who creates resources for learning, shifting from teachers and experts to include not only learners, but also companies, professional bodies and third sector organisations (McGill et al. 2013). OER production has been funded through philanthropic and government funds, for example TESS[4] (India), TESSA[5] (Africa), Khan Academy[6] (USA), Hewlett Foundation[7] (USA and UK), Gates Foundation[8] (USA), JISC[9] and the Higher Education Academy[10] (UK). These resources generally are released under a Creative Commons licence.

OpenCourseWare Initiatives—course resources that are openly available free of charge from universities. The first major OCW initiative was started at MIT in 2003.[11] Now, many universities make their course resources available to teachers and learners around the world.

Massive Open Online Courses (MOOCs)—courses aiming at large-scale interactive participation and open access via the Web. MOOC differs from OCW and OER in that it opens up opportunities for learners to participate in learning activities, rather than making resources or courseware openly available. The main MOOC providers are edX[12] (USA), FutureLearn[13] (UK) and Coursera[14] (USA), though some

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[3]http://creativecommons.org/.
[4]http://www.tess-india.edu.in/.
[5]http://www.tessafrica.net/.
[6]https://www.khanacademy.org/.
[7]http://www.hewlett.org/.
[8]http://www.gatesfoundation.org/.
[9]http://www.jisc.ac.uk/.
[10]http://www.heacademy.ac.uk/.
[11]http://ocw.mit.edu/about/our-history/.
[12]https://www.edx.org/.
[13]https://www.futurelearn.com/.
[14]https://www.coursera.org/.

academics choose to run their own MOOCs without using one of these mainstream MOOC platforms.

The investment of government and philanthropic funding in these resources is changing public attitudes on whether and how educational resources and courses are openly available (Littlejohn and Pegler 2014). The expectation is that course materials and courses should be freely and openly available to all. However, those who benefit from the opening up of resources and courses primarily are those who are able to use these resources to learn—people who have developed good levels of relevant expertise, such as self- and socio-regulative expertise. In general, these people already have experienced a good level of education (many tend to be graduates), rather than the wider groups of people that OER, OCW and MOOC initiatives purport to be targeted towards. Therefore, while the availability of open courses and resources has an impact on opening up access to education, the focus of many open courses on content delivery could result in missed opportunities for learning and expertise development through active engagement and participation of the learner.

There are other ways of viewing learning that extend beyond that narrow view of learning through exposure to content. For example, ***learning through participation*** involves the development of an individual's knowledge and expertise through active participation in an activity. Here, the focus is on learners interacting through shared activities. Historically, learning has been embedded *in* human activities, such as work (Fiedler 2014). Learning was, therefore, viewed as a process that learners actively engaged within. It is only fairly recently that learning has been viewed as a specific type of activity '*directed towards the acquisition of societal knowledge and skills through their individual re-production by means of special learning actions upon learning objects*' (Lompscher and Hedegaard 1999).

Many providers of open courses and open educational resources view learning as a special kind of activity. This view simplifies problems of learning design by narrowing the focus of learning to a set of objectives predefined by (and usually assessed by) teachers or experts. The learner's motive to carry out this special type of activity is likely to be different from the motive to engage in an activity which is part of everyday life where learning is embedded in an activity. For example, a health professional's motive to complete an online course and gain a certificate is likely to be different from her motive to accurately diagnose a patient's condition. In the first activity, interaction with others may be optional, whereas in the second, interaction with other experts could be crucial for learning and accurate diagnosis.

Some open course providers are taking steps to encourage learner collaboration with course facilitators or other learners. However, the activity is often not embedded within students' everyday activities, even when there are opportunities to do so. There is evidence that some open courses for health professionals may not encourage learners to actively self-regulate their learning. Even students with high self-regulated learning ability may limit their activity to reading and interacting with course content, overlooking opportunities to align and embed course activities with work practice and use the theory learnt on the course to improve work practice.[15] A study examining how health professionals learn in Massive Open Online Courses (PL-MOOC[16]) observed that some learners prioritise activities such as watching videos and taking tests. There was little evidence of learners relating new knowledge to practice, or of connecting to their peers through the discussion board. Even those learners who said they wanted to improve their professional practice did not integrate the scientific knowledge they learnt through the MOOC with practical, on-the-job learning.[17] Students reported that the MOOC was a positive student experience, even when their actions were likely to limit their learning. They appeared to view the open course content as 'edutainment', rather than as an opportunity for deep learning.

In some cases, the course and platform design may discourage interaction. Some mainstream MOOC platforms include unthreaded discussion areas designed to support learner interaction. However, the forum design can discourage participation: if students cannot find their original contributions among long threads of discussions (which they have to browse through), they are discouraged to contribute further. Students report frustrations with this sort of design and often give up or stop participating in this element of the course (http://littlebylittlejohn.com/professional-learning-in-moocs/).

The solution, however, is not to accredit more dialogue in the discussion forum, but to help students understand that learning requires their active agency. Therefore, open courses that embed learning activities in everyday activities for work or interest would appear to have more potential for learning. However, to participate effectively in these sorts of courses, students have to have a well-developed level of digital literacy (Littlejohn et al. 2012a).

Well-developed digital literacy is critical for students to participate in shared activities with other learners. Social technologies, for example wikis, blogs, microblogs (e.g. Twitter, Yammer) and social networking sites (e.g. Facebook, LinkedIn), disrupt the usual hierarchy of 'teaching and learning', where the teacher sets the direction. This approach is based on new social organisations of learning, where learners may be interacting in groups, networks, sets or collectives (Dron and Anderson 2014). In addition, other tools that are freely available on the Web can support educational activities and provide powerful collaborative opportunities. These may not be developed as social networking tools but can be utilised to create content that may be shared, remixed and reused. Examples include services such as SoundCloud,[18] CC Mixter[19] or video editing software such as MPEG Streamclip.[20]

[15] http://littlebylittlejohn.com/professional-learning-in-moocs/.

[16] http://www.gcu.ac.uk/academy/pl-mooc/.

[17] http://www.gcu.ac.uk/academy/pl-mooc/outputs/.

[18] https://soundcloud.com/.

[19] http://ccmixter.org/.

[20] http://www.squared5.com/.

When individual learners learn through connecting via social media, it generates a new paradigm for learning in which the individual and ‘the collective’ are indivisible. When people learn through social knowledge, they collaboratively develop new knowledge resources. People learn by both drawing on and, *at the same time*, contributing to the collective knowledge (the knowledge which is encoded in media artefacts, in networks and in other people), which leads to a third metaphor for learning: learning through knowledge creation.

Another way of viewing learning that extends beyond content delivery is ***learning through knowledge creation*** (Paavola et al. 2004), where people learn together by ‘*deliberately creating and advancing knowledge*’ (ibid, p. 11). Here, learning is not always planned and can be opportunistic and dynamic (Paavola 2014). Learning might take place in a structured course, or it could be through everyday work activities or interest-based learning.

Instead, the focus is on learners interacting around an ‘object’. This object could take many forms. For example, an object from health care could be a patient record used as a focal point for healthcare learners to problem solve (Edwards 2010); in science, the object could be an open notebook (Bradley 2007); the object of activity for engineers could be a design. Knowledge creation may involve boundary crossing—across disciplinary or sectorial boundaries—bringing together multiple perspectives in ways that allow the learner to learn.

This metaphor is similar to learning through participation, though the focus here is on a knowledge artefact being produced as a by-product of learning. This form of learning is suited to a world in which there is a marked escalation of social interactions around online learning resources, mediated by technology tools (Littlejohn and Pegler 2014). Social media tools, such as open documents, wikis, blogs and microblogs (e.g. Twitter), are useful for learning through creating knowledge. This form of learning removes conventional controls and boundaries around learning environments, encouraging learning across different contexts and sites (Littlejohn and Pegler 2014).

Learning in these sorts of environments and using technology tools involves making sense of the available knowledge and reinterpreting it in a way that fits with the learner’s knowledge framework, described by Saljo (1979) as learning by ‘seeking meaning’. Meaning making involves making connections—connecting, disconnecting and reconnecting knowledge fragments through knowledge creation. While learning through social knowledge creation, individuals connect with relevant knowledge resources and with other people who share a similar learning goal (Littlejohn et al. 2011). ‘Clusters’ of learners within a network travel a learning pathway together, navigating and making sense of the available knowledge resources. People learn together through connecting and making sense of knowledge fragments within a large pool of collective knowledge (Siemens 2005). As they learn, people connect across the networks to bring together the knowledge and expertise they need.

Here, learning is characterised by processes of discovery, sense-making, synthesis and sharing of (previously fragmented) knowledge resources. Since each individual learner encounters a learning situation with a unique combination of knowledge, values and culture, they create unique, multiple learning pathways.

7.3 How Do People Learn Through Using and Creating Knowledge Resources?

There has been extensive research on how knowledge workers in organisations learn through building knowledge during everyday work tasks (see e.g. Eraut 2000, 2004; Paavola et al. 2004). A study of the ways knowledge workers learn through creating and using knowledge resources gives insight into the ways learners use resources. This study was carried out in a global organisation in the energy sector (Margaryan et al. 2009a, b). Data were collected in 2008–2009 through a mixed-methods approach: a Web-based questionnaire survey[21] followed by semi-structured interviews.[22] The survey was posted to the knowledge networks. These networks are large (with a combined membership of more than 30,000 members), though only a fraction of users are active. A total of 462 people responded to the survey from locations around the world. The respondents represented a broad range of job profiles and experience levels, suggesting that it is broadly representative. Of these respondents, 29 took part in semi-structured, telephone interviews lasting one hour to elicit information about how they learn in the knowledge networks. The survey data were tabulated, coded and analysed. An initial set of conceptual codes were defined and refined through four iterations.

The study identified four general learning actions representing different ways in which learners interact with and make sense of knowledge as they learn: consuming, connecting, creating and contributing knowledge.

Learners ***consume*** relevant knowledge resources, other people, and with the 'cumulative actions' of others—for example recommendations, tag clouds or connections. Connections can be loose and serendipitous, or can be targeted, for example searching for and connecting with an expert or peer with specific expertise. Connections may be reciprocal or unidirectional. Through these connections learners continually refine their view of the collective knowledge.

Learners also ***connect*** with—or use—knowledge resources. Each individual has to use knowledge to be able to reinterpret it, taking into account their current knowledge. Learners may discover new knowledge through their personal network, or more actively, through online searching.

While using knowledge, learners ***create*** new knowledge as resources that may be contributed back to the network. These resources may be in a variety of media, such as articles, podcasts, and so on. They may be finished products or 'work in progress' resources, such as blogposts or microblogs (tweets). They may be implicitly contributed, such as 'actions' and 'choices' that help other people (choices, tags, and so on). These new knowledge structures created represent a dynamic and individually-focused view of the knowledge and understanding learners have on a given topic, and how different topics interrelate. Structuring knowledge adds a layer

[21]The quantitative survey is available at http://dl.dropbox.com/u/6017514/survey.pdf.

[22]The interview script is available at http://dl.dropbox.com/u/6017514/interviewscript.pdf.

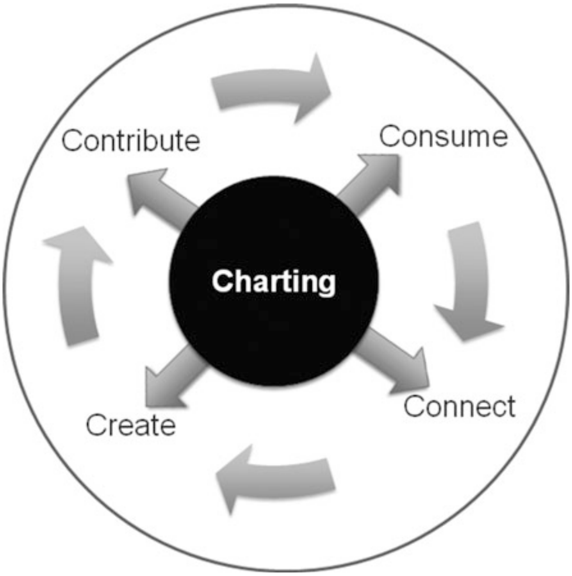

Fig. 7.1 The charting model by Littlejohn et al. (2012b)

of value that other learners can benefit from. This sense-making process is continual, and ensures that the knowledge space evolves with the ideas of the individual, their network and the whole collective.
Sometimes learners ***contribute*** resources back to the collective. Knowledge can be contributed formally (as reports, publications, and other standalone artefacts) or informally (reflections, ideas, ratings and other context-dependent content).

These four learning behaviours—*consume, connect, create and contribute*—are complex and interrelated. They are a set of intertwined activities rather than discrete linear steps (Littlejohn et al. 2012b). Together, they represent the ways in which an individual learner develops (factual) scientific knowledge and experiential knowledge, gained through practice. These are influenced not only by the environment, but also by the learner's motivations and goal-setting processes that determine their learning pathways. These meta-cognitive processes encompass self-regulative knowledge, or knowing how to learn (Zimmermann 2002; Sitzmann and Ely 2011) as well as relational knowledge, or knowing who to learn with and from (Edwards 2010). The charting model is illustrated in Fig. 7.1.

7.4 How Is Open Learning Represented in Diverse Practice Settings?

There are diverse contexts in which people can learn through using available knowledge resources. Learning can be in structured (formal) or unstructured (naturalistic) settings. Learning may be solitary (e.g. self-study) or can involve social interaction with others (Fig. 7.2).

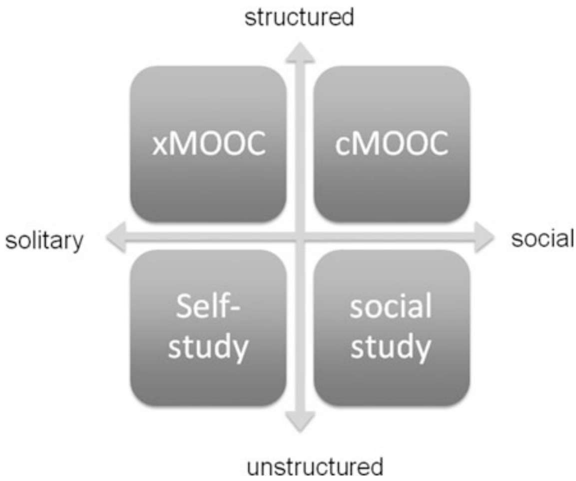

Fig. 7.2 Diverse learning contexts

7.4.1 Structured and Solitary Learning: Massive Open Online Courses

One open course design that has gained prominence in recent years is termed an ‘xMOOC’. These are large-scale, freely available courses, often provided via commercial platforms that support ‘content delivery’ via broadcast of videos, sound files, quizzes, unthreaded discussion forums, transcripts and downloadable documents. These courses are often self-contained, though they also offer links to further content. The courses sometimes offer a certificate of completion but tend not to provide any accreditation or formal awards. This kind of course can provide high-profile marketing opportunities for educational institutions and can utilise parts of existing courses to provide tasters of the formal accredited courses that the institutions offer. xMOOCs would seem to be, therefore, a relatively low-cost investment; once a course has been developed, it may not require much input from teaching staff, but has the potential to present a strong brand in a global marketplace. Therefore, although the initial development cost is high, the running cost per student is relatively low and the reputational enhancement for the university offers a return on investment.

These MOOCs are designed as conventional courses, similar to lecture-based models of education. Therefore, the design fits with the conventional organisation of most universities, thereby sustaining rather than disrupting current practice that leans heavily towards didactic presentation of knowledge and testing/quizzing of factual information. Some of the courses employ facilitators or tutors to guide or help students. However, many courses do not offer students any interaction with experts: many courses are structured to guide learners through content and computer-marked assessment towards completion. These courses are open to anyone, regardless of nationality, age, gender or ability. Learners can ‘dip-in’, follow the whole course in a linear fashion to a set timetable or just participate with specific elements as they desire. Learners can take part in an active or passive way and need to 'self-regulate' their learning in terms of managing their learning and levels of participation. These courses tend to experience very large registrations (into the thousands) but also significant dropout rates, often related to the length of a course, with longer courses (5 weeks or longer) having greater dropout rates.[23]

In relation to the 4C actions in the charting model (Fig. 7.1), xMOOCs lean heavily towards the activity of 'consuming' the content presented by the expert lecturers and tutors. The motivation to work with an expert may be a significant part of the learner's motivation for joining the course. For example, the opportunity to experience content produced by world's leading experts in Harvard emerged as a significant motivator for learners taking part in the edX course 'Fundamentals of Clinical Trials'[24] offered in 2013–2014. A recent study found that even students with high 'self-regulated learning ability' limited their activity to reading and interacting with content rather than taking opportunities to integrate theory with practice. Interaction in the discussion areas was low for most participants with several participants perceiving that this was outside the core of course activity. Students downloaded content for future reference but tended not to create new content themselves as an outcome of their learning activity. Even highly motivated course participants (those who set goals to use the course as a way to improve their work practice) made an active decision to engage with course content in this way, choosing not to take advantage of any interactive elements of the course. The causal effects are unknown but could be related to the course design or the social norms around education and formal learning (Fiedler 2014).

7.4.2 Structured and Social Learning: Open Courses

In contrast to xMOOCs, there are other models for open courses that focus more on social and collaborative learning. One model is the cMOOC which are connectivist MOOCs. They are sometimes described as chaotic which implies a lack of structure, but what they offer, in contrast to an xMOOC, is an opportunity for the learner to apply their own learning goals and to choose the kind of engagement that suits them. The focus is less on consuming content but on participating in learning activities in a very personal context. These courses do tend to have an overlying structure but rely on learners having the capacity, and understanding of their own learning needs, to take advantage of learning in a networked way. The key for these courses is the connectivity which, in turn, emphasises learners actively creating and contributing content to share with others.

[23]http://nogoodreason.typepad.co.uk/no_good_reason/2013/12/completion-data-for-moocs.html?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+TheEdTechie+(The+Ed+Techie).

[24]http://www.gcu.ac.uk/academy/pl-mooc/.

There is unlikely to be only one 'platform' where activities take place—emphasising that learners use technology platforms where they feel most comfortable. Discussions may take place on a social network such as Twitter as well as in a Google Hangout or on a Facebook group space. Therefore, the course is distributed across the Web and encourages participants to aggregate content, remix and/or repurpose it (create) and share it back (contribute). An example of this course was the Change 11[25] course around instructional technology which took place from September 2011 to May 2012.

There are also smaller models of open courses that are structured around an existing validated course. These bring together paying registered students studying for accreditation with open students participating at no financial cost. This kind of course challenges and disrupts traditional models, requiring teaching staff to redesign curricula, take on new and different roles and change the relationship between learner and teacher. Two courses that adopt this model are Digital Storytelling[26] (DS106) at University of Mary Washington in the USA and the Open Media Classes[27] at the Coventry University in the UK. Both of these courses involve open students and professionals from around the world who take part in creating, sharing, remixing and reusing content in collaborative activities using open technologies. This adds an extra dimension for the registered students who are campus-based who have opportunities to collaborate with working professionals around the world, create new personal and professional networks and engage in 'authentic' real-world activities.

The open courses described here present challenges for students and faculty as participation requires good digital literacy and active use of a range of digital technologies (Littlejohn et al. 2012a). Well-developed digital literacies are critical for the exploration of digital identity and management of Web presence, digital storytelling, licensing as well as curation of content. In these circumstances, learner/teacher roles change and faculty (sometimes) do not behave as experts but learn alongside students. In the DS106 course, anyone participating can create tutorials or guides when they introduce a new technology, anyone can submit an assignment idea. All are expected to contribute and provide feedback to others. A recent iteration in 2013 of the DS106 course was called #headless—no guru, no method, and no teacher with set weekly course assignments as scheduled blog posts. This course design embeds all of the 4C actions. However, this design can present a significant challenge to faculty and learners who are used to conventional forms of learning based around lectures.

[25] http://change.mooc.ca/about.htm.

[26] http://ds106.us/about/.

[27] http://openmediaclasses.covmedia.co.uk/.

7.4.3 Unstructured Solitary Learning: Self-study

Many learners utilise Web technologies to support unstructured learning in a similar way to when people used to use physical libraries for this kind of activity. This type of approach lends itself well to having a personal interest or need and wanting to learn more without the input of others. This choice may indicate a preference for working alone, may be a result of other work/life commitments that make a more structured formal approach impossible or may just seem to be more appropriate for some subjects. For example, someone who wants to learn how to build a bookcase may simply need to watch a few videos, or download a few designs; someone who wants to broaden their understanding of poetry may just find them online and then follow this up by reading critiques and essays available online. They may not have the confidence to interact with others on the subject they are studying, preferring to develop an initial knowledge on their own. Even if a learner chooses not to engage or interact (connect or contribute) with others, they can still learn by reading what other people contribute or conversations between others in discussion forums, Facebook blogs, etc. Unstructured solitary learning may still make use of structured course content as appropriate.

The key aspect of this type of learning is an active choice by the learner to learn on their own, to their own structure if they want one, and by making choices about which sources to use and how they use it. This approach may be an initial step towards a different kind of learning; for example, their initial learning may lead to them signing up for a structured approach (either open or closed) or may lead to them ultimately engaging with others as they become more knowledgeable and confident. Some learners may just prefer to learn in this way and find that this approach suits them best. Although it appears that learners may focus mainly on consuming knowledge in this model, they may actually also create content as they learn, although they may never share it with other learners.

Learners choosing to study in an unstructured and solitary way may still benefit from structured and social participatory learning activities that are readily available on the Web. The idea of a 'passive' learner or 'lurker' has negative connotations that hide a range of benefits of vicarious learning. Although not actively engaging in dialogue with other learners, students may learn vicariously (Mayes and Fowler 1999). While this form of participation is valid from the learner's point of view, other students may expect a reciprocal 'give and take' of interaction and knowledge exchange (Milligan et al. 2013). 'Active' learners sometimes feel short-changed by those who are 'passive' or 'lurkers'. However, 'lurking' is a form of vicarious learning.

7.4.4 Unstructured Social Learning: Social Study

Some learners may choose an unstructured approach for similar reasons as described above, but prefer to engage with others to support their learning. Social networking technologies support this approach by offering opportunities for groups of individuals to establish online spaces or communities to share content, collaborate, create new content and discuss areas of interest. Some services, such as Flickr, have existed for several years and include diverse groups of people who share a range of visual content, support learning, produce collaborative works, and support members to learn new techniques and approaches (Rennie and Mason 2008). Services like Flickr have played a significant part in widening public knowledge around Creative Commons licences as it has allowed people to share their content using these licences for many years. One of the elements of this kind of learning is that the social aspect may be as important, or more important, as a motivator than the learning itself.

This type of learning may be about active participation as well as being about learning through knowledge creation around an object. It may relate to professional or work-related knowledge or around personal interests.

Unstructured social learning may lead on to more structured learning as social interaction encourages people to join more formal learning opportunities, where participants share experiences of formal courses and refer group members to useful courses. An example of this is the UK Open University (OU) iSpot initiative[28] where people interested in ecology and nature join an unstructured community to share their observations to create new knowledge and connect with others who are interested in the same subject. The community has groups for specific geographical areas and species, forums, spaces to share and identify species, and quizzes, and is building a community-created resource. iSpot also includes international communities concerned with recording observations in their own area, thus creating a global research mechanism and database. The OU also run a MOOC on the FutureLearn platform that connects in with iSpot which provides a free structured learning opportunity for iSpot[29] community members to join. The iSpot community also functions as a place for people to go to after the structured course to continue participating with the broader social network linked to the course.

Unstructured social learning environments may tend to become more structured as communities establish themselves around specific technologies; for example, creating wikis to share and manage content results in people organising the content to ensure that members can find it. They may also begin to establish rules and conventions for the group or may even become more exclusive as they develop. So, although the learning of individuals may be unstructured, the contents (or objects) that are created and shared may become quite structured.

The social aspect of this type of learning lends itself to creating, connecting and contributing new knowledge as well as consuming. People learning in unstructured

[28] http://www.ispotnature.org/.

[29] The iSpot community existed before the FutureLearn platform and was already a well-established community, supported by the UK Open University.

learning contexts, whether social or not, may not be aware of issues around openness, in terms of formal licences, but they do regularly utilise free open resources for their learning.

7.5 Conclusions

Digital social technologies are both supporting and shaping the emergence of new types of ‘open learning’. These new forms of learning move beyond conventional distance learning to enable students to actively chart their own learning pathways, embedding authentic activity across different areas of their lives. Faculty are beginning to understand the importance of moving from viewing open educational resources as content to understanding resources as a focus for learning activity that can be embedded into other authentic life activities, as illustrated by the following observation from one of the UKOER project teams (McGill et al. 2013):

> Whilst making resources such as lectures, seminars, professional master-classes, skills workshops and assignment tasks freely available is an important step in ‘opening our educational practices, giving an open window onto what we do, a more significant aspect of these Open Classes is the extent to which they are actively networked and connected - and the new kinds of relationships and activities this enables. (COMC Project Report, Coventry University, UKOER Programme)

However, this new form of open learning is constrained by a range of factors ranging from cultural norms around teaching and learning activities and roles, limitations of the design of platforms and learning environments to limitations in digital literacies. Future directions in learning through technology are uncertain, though conventional approaches to teaching and learning, focused around the broadcast or delivery of content in different media forms, are likely to continue for some decades, missing alternative opportunities to enhance learning.

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Author Biographies

Allison Littlejohn is professor of learning technology and academic director for learning and teaching at the UK Open University, where she leads research in professional learning and directs organisational change in learning and teaching. Her work drives forward change in technology-enhanced and professional learning through tight integration of research, practice and knowledge transfer. Allison's research is driven by real-world problems, focusing on understanding how people learn at work and how they can learn better. She has been principal investigator or senior scientist on research in higher education, adult and workplace learning investigating digital learning, innovative pedagogies with ICT and open educational resources. She has published around 200 academic articles, including four books. Her text on reusing online resources: a sustainable approach to e-learning (Routledge 2003) was widely cited for over a decade. Professor Littlejohn's research has been funded by the European Commission (EC), the UK Economic and Social Research Council (ESRC), Shell International, British Petroleum (BP), the Higher Education Funding Council for England (HEFCE), the Scottish Funding Council (SFC), the UK Joint Information Systems Committees (JISC), the UK Higher Education Academy (HEA) and the Energy Institute (EI). Allison leads industry–academic research with multinational companies, most notably Royal Dutch Shell, for whom she was senior researcher 2008–2010. Allison is a fellow and former scholar of the Higher Education Academy and has received international fellowships from ASCILITE (Australasia) and the Churchill Trust (UK).

Lou McGill is an independent consultant with over 20 years of experience around resources to support learning and teaching. Originally a professional librarian in the field of education, she moved into the area of learning technology in the early 2000s to work with digital repositories. Later as a programme manager on the JISC eLearning Team, she was responsible for managing several large-scale programmes, including X4L (eXchange for Learning), DLITC (Digital Libraries in the Classroom), Scottish eLearning Transformation and ReProduce.

As a consultant, Lou has worked with a wide range of educational bodies providing evaluation, synthesis and writing services. She worked on the synthesis and evaluation teams for the HE Academy/JISC UK OER programme, the curriculum delivery and design programmes and the digital literacies programme. She led the 'Good Intentions: improving the evidence base in support of sharing learning materials' study which examined a range of business models and outlined business cases for open sharing for various stakeholders. Recently, Lou has worked with the UK Open University on Open Badging, FutureLearn MOOC evaluation and a user requirements study and with Glasgow Caledonian University on MOOC studies. Her most recent work was an evaluation of Open Media Classes at the Coventry University.

Chapter 8
Educational Design and Construction: Processes and Technologies

Susan McKenney and Thomas C. Reeves

Abstract There are no one-size-fits-all steps for tackling different design challenges within the context of education. There are, however, processes and activities that are often useful. Developing a repertoire so that designers can select and use the most fruitful and fitting approaches for specific situations is the focus of this chapter. After discussing this phase in relation to those of analysis and evaluation, attention is given to how both analytical and creative perspectives can serve the work of design and construction. The body of the chapter is devoted to presenting specific activities that can be undertaken during design (exploring and mapping solutions) and construction (actually building the solutions). This chapter presents ideas in linear fashion, which loosely approximates the order in which these activities might logically be carried out. However, each design project is different. Not all activities described here are useful in all projects, others are likely to be added, and several activities described in this chapter often take place simultaneously.

Keywords Educational design · Construction · Development

S. McKenney (✉)
Department of Instructional Technology, Faculty of Behavioral Sciences,
University of Twente, 217, 7500 Enschede, AE, Netherlands
e-mail: susan.mckenney@utwente.nl
URL: http://educationaldesignresearch.org

T.C. Reeves
The University of Georgia, College of Education, 325C Aderhold Hall,
Athens, GA 30602-7144, USA
e-mail: treeves@uga.edu
URL: http://www.evaluateitnow.com/

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Lecture Notes in Educational Technology, DOI 10.1007/978-3-662-47724-3_8

8.1 Introduction

During design and construction, solutions to educational challenges and problems are created. Solutions can take many forms, including booklets, software, training programs, or learning activities. During design, potential solutions are explored and then mapped using a variety of techniques. In this stage, the core ideas underpinning the solution are articulated, which enable them to be shared and critiqued. In addition, guidelines for actually building the solution are delineated. Construction refers to the process of taking design ideas and applying them to actually manufacture the solution. This generally takes place through a prototyping approach, where successive approximations of the desired solution are (re-)built.

Throughout this phase, ideas about how to address the design challenge tend to start off rather large and vague, and gradually, they become refined, pruned, and operationalized. The work is guided by theory, as well as local expertise and inspiring examples. During design, potential solutions are explored by generating ideas, considering each, and checking the feasibility of ones that seem the most promising. Once a limited number of options have been identified, potential solutions are gradually mapped from a skeleton design to detailed specifications. As the mapping matures, construction of the actual solution begins, usually through a process of prototyping. Early prototype versions of the intervention tend to be incomplete; sometimes several are tested. Later versions are usually more detailed and functional. Table 8.1 shows the main processes within this phase, each of which is described in the body of this chapter.

8.1.1 Positioning Design and Construction in a Larger Process

The phrase, design, and construction as used in this chapter refers to work that takes place *after analysis* and *before* evaluation, in a larger development trajectory. During design and construction, a coherent process is followed and documented to arrive at a (tentative) solution to a specific challenge or problem. To do this, the work described in this chapter requires two fundamental inputs, which are typically derived from analysis of the existing situation and stakeholder concerns: (1) a clear problem statement, which describes the challenge to be tackled and explains the reasons why the challenge exists; and (2) a long-range goal. These inputs are essential to focus the work of design and construction and also form the criteria against which solutions will be later be evaluated.

The design and construction process can lead to several outputs. Exploring and mapping potential solutions can yield documents that describe potential designs to be created. These can range from broader descriptions of the skeleton design to more detailed design specifications. The construction process yields the solution itself, which may lend itself to actual representation in a physical form (e.g., a

Table 8.1 Main processes of design and construction

Phase		Step
Design	Exploring solutions	Generating ideas
		Considering ideas
		Checking ideas
	Mapping solutions	Requirements and propositions
		Skeleton design
		Detailed specifications
Construction	Building solutions	Creating initial prototypes
	Revising solutions	Revising prototypes

teacher guide, educative software) or indirect representation (e.g., process guidelines for a particular approach to teaching). Any of these outputs can be the subject of evaluation. For example, field testing or expert appraisal may take place to ascertain and improve how well the long-range goal is (being) met.

8.1.2 Analytical and Creative Mindsets

The design and construction of teaching/learning resources, Web sites, activities, and programs is systematic and intentional, but also includes inventive creativity, application of emerging insights, and openness to serendipity. In other words, the work is served by both analytical and creative perspectives. From the analytical side, it is necessary to weigh off the quality of ideas being proposed, to seek ways to make solutions rational and practical, and to keep a steady focus on the long-range goal. From the creative side, weird and out-of-the box ideas may be needed, and this may require pushing commonly accepted boundaries and tinkering to ascertain what is really possible (or not). Taken together, the activities presented here might aptly be described as what Walt Disney called 'Imagineering.' Disney visionaries use this patented term to describe the master planning, design, engineering, production, project management, and research and development undertaken in their creative organization. We find the blend of the words imagination and engineering useful to emphasize the need for both creative and analytical viewpoints throughout educational design initiatives.

8.2 How to Design

8.2.1 Exploring Solutions: What Shall We Design?

As mentioned previously, prior analysis yields several products that provide starting points for design: a problem statement which is both descriptive and explanatory and a long-range goal. For example, a descriptive problem statement could be: *Teacher use of technology frequently constitutes mere replacement of existing (less complicated and expensive) materials, and sometimes even a decrease in the quality of learning interactions; only one of every eight middle school teachers in this district uses the tablet computers provided to them and their students in ways that are transformative with respect to how instruction is planned, implemented, and evaluated.* Explanations for why this situation exists could come from literature, e.g.: *It is well-documented that teachers struggle to align technology use in general and tablet use in particular with other dimensions of their lesson planning (e.g. objectives, instructional activities and assessment).* Additionally, explanations may come from previous investigation, which revealed that: *Several teachers are disinclined to learn how to integrate the tablets because colleagues at another school in the district have reported unfavorable experiences*, and/or: *Half of the teachers are concerned that the time needed to integrate the tablets will distract from instructional preparation for high-stakes tests; and they worry that their students would not perform well on these assessments,* and/or: *Technical issues such as recharging the tablets and breakage are a major concern for teachers*.

In some cases, the ultimate design goal may relate closely to the original problem statement. For example, related to the situation above, the long-range goal of the project may be: *To have all of the district's teachers sufficiently knowledgeable, comfortable and confident in using tablet computers in ways that move instruction from a teacher-centered model to a learner-centered model*. In all cases, it is sensible to ensure that the descriptive and explanatory statements are clear and accurate before commencing design and construction.

8.2.1.1 Idea Generation

Once the problem statement and long-range goals are clear, the first step in design is to generate ideas, often called *ideation*. The most common approach to generating ideas is brainstorming. In brainstorming, ideas are spawned with the intense burst of a storm, the wilder the better. Building on ideas is encouraged, and judgment is to be reserved for later. It is often useful to start off with a brief warm-up, maybe involving a humorous element, to set the mood. For example, free association can stimulate the imagination. In free association, symbols or words are either written or spoken. Starting with one word/symbol either written for all to see or spoken aloud, each person draws/writes/speaks the first thing that comes to mind. Below are some useful techniques for enhancing brainstorming.

- **Synectics**: Rooted in the Greek word *synectikos* which means 'bringing forth together,' this technique stimulates new and surprising ideas through (sometimes outrageous) analogies, prompted by a question like 'If your course on statistics were a television show, which one would it be and what would it be like?'

- **Scamper**: Asks questions to generate additional ideas from an existing list, prompted by each word in the acronym SCAMPER: Substitute (e.g., Different ingredient?); Combine (Combine functions?); Adapt (e.g., Can this be like a previous idea?); Magnify/modify (e.g., Grow? Add?/Change?); Put to other uses (e.g., Repurpose?), Eliminate (e.g., Simplify?); and Rearrange/reverse (e.g., Shuffle?/Transpose?)
- **Slip writing**: People write ideas on slips of paper and pass them around; ideas are changed or augmented along the way; contributors may be named or anonymous; the same or a different group sorts and evaluates the ideas.
- **Picture taking**: Using (cell phones with) digital cameras, participants leave the meeting area to take pictures of novel or familiar objects from creative angles, the more unusual the better; projected images are then shared with the group, who engages in free association and then uses the associations as starting points for new ideas.

Other techniques for idea generation tackle the process in a more analytical and systematic manner. For example, based on a clearly specified design goals and requirements for the solution, a morphological chart can be employed to list solution functions and solution components. It can be used in either direction, but is most

Table 8.2 Sample morphological chart

Broad propositions	Mid-level propositions	Specific propositions (multiple options)		
Clarify real world relevance	See career opportunities	Invite guest speakers	Use real cases	Show job postings
	Motivational	Concrete tasks	Fun tasks	High yield projects
Develop improved planning skills	Address study and time mgt.	Offer reading and note-taking tips	Explain about time budgeting	Teach backwards mapping
	Adjustable pace	Reading	Guided self-study	Individual work
	Offer practice opportunities	Mini-thinks to apply study skills	Exercises during classes to address study skills	Map week, month and semester planning
Foster student relationships	Encourage interaction	Buddy system	Poster fair, online forum	Team prepared presentations
Clarify personal growth	Feedback	Expert-coaching	Peer-review	External review
	Reflection	Journal	Presentation	Videotape

often helpful when taking big ideas and operationalizing them into specifics. The usefulness of this technique hinges on the quality of any initial design ideas the team already has. This technique is thus usually more useful once after initial brainstorming has taken place. Table 8.2 shows a sample morphological chart. The chart was developed in response to the question, 'Given your understanding of the failure/drop-out problem in this master's program, what are potential solutions?' Similar to distinctions given elsewhere in educational design literature (cf. Linn et al. 2004; McKenney and Van den Akker 2005), it shows design propositions of three grain sizes: broad (dark gray), mid-level (medium gray), and specific (light gray).

Tip: Supportive software for *generating ideas*
=> Concept mapping tools like MindMan, Inspiration or MindMaple

8.2.1.2 Idea Consideration

Once ideas have been generated, the next task is to sift through, consider, and judge ideas, to identify the one(s) that has the power to live on. During idea consideration, critical thinking is essential. Critical thinking is greatly enhanced when a robust set of conditions or boundaries into which the design must fit. Ideas that cannot work within those will be discarded, and feasible approaches will be compared in terms of their risks and benefits.

There are many ways to compare potential solutions to problems. Four techniques that are often useful to stimulate critical thinking are as follows:

- **De Bono's hats**: Participants take turns considering ideas from one of six roles, each of which focuses on different aspects: White hat—facts and information; red hat—feelings and emotions; black hat—being cautious; yellow hat—being positive and optimistic; green hat—new ideas; and blue hat—the big picture. Considerations are captured aloud or on paper.
- **Courtroom challenge**: The two best ideas are represented in a mock courtroom. Their 'cases' are made by opposing teams, who try to convince the judge that one is superior (or guilty/not guilty of a particular design flaw).
- **Strengths/weaknesses matrix**: Design requirements are listed vertically, and design options are listed horizontally. As the matrix is completed, each design option is ranked in terms of its perceived ability to meet each criterion. Rankings can be +/−, +++/−, numerals, happy/sad faces, etc. When numerical rankings are used and tallied, this is called the Pugh method.
- **Weighted ranking**: This is an extension of the strengths/weaknesses matrix, in which each of the criteria is given a weight of importance. A design that scores equally well on 'cost' and 'reliability' will have a higher score for 'reliability,' if the feature of reliability has been weighted as more important.

While decision-making is fed by rational, analytical perspectives, such as those generated using the methods above, these perspectives do not drive the endeavor alone. As stated before, a limitation of some of the more systematic approaches (e.g., weighted ranking) is the quality of the design requirements being used. If decisions are made based only on what is known, there is a risk of overlooking the fact that educational designers cannot know everything. There should be a voice of instinct, intuition, and positive thinking. Also, decision-making (in initial design or later) will rarely involve consideration of one factor at a time. Very often, trade-off decisions will have to be made (e.g., the most effective option is not very feasible; the ideal scenario is insufficiently practical; the practical option might not be effective enough and so on).

> **Tip**: Supportive software for *considering ideas*
> => Spreadsheets and table-making tools like GoogleSheets, Excel, Word

8.2.1.3 Idea Checking

Once a limited number of ideas have been deemed worthy of pursuit, it can be useful to check their inner logic and potential viability in the target setting. This entails comparing the new ideas with what is already known about the reality of the situation, including the people involved. To facilitate the comparison process, it can be helpful to map out how a particular intervention is intended to work, by explicating its underlying assumptions. One powerful way to do this is through the creation of a logic model. Logic models describe inputs, processes, outputs, and outcomes of an intervention. While logic models can be developed at various stages in the design process, they are often most useful after a potential solution has been decided upon and before it has been mapped or constructed.

Logic models depict the solution and its outcomes, showing the assumed ‘if-then’ relationships that yield the desired outcomes. As such, they represent the theory of change underlying an intervention. Logic models portray inputs (including, but not limited to, the designed intervention), processes (implementation of the designed intervention), outputs (evidence of implementation), and outcomes (benefit or change that results). Logic models can be basic, showing the four elements described above, or elaborate, depicting great detail or additional influences on the intervention, such as contextual factors. There are many formats and templates for logic models, showing relationships and feedback loops, with varying levels of detail and even nested layers of concepts. Table 8.3 shows an example of a logic model for an intervention that aims to develop teacher’s sensitivity and ability to meaningfully engage with children in multicultural classrooms, with the overall goal of improving pupil learning gains during collaborative projects. Additional resources and information about the logic modeling process are available online and in print (Kellogg 2004; Mayeske and Lambur 2001).

Table 8.3 Logic modeling template and example

Inputs	Processes	Outputs	Outcomes	Impact
What is needed	Activities	Immediate results	Effects	Measurable change
• Lesson materials • Teacher awareness • Pupil motivation • External expertise • Financial support • Cultural expertise	• Hire facilitators Develop materials • Professional development • Awareness campaign • Secure grant	– Materials made – Facilitators hired – Workshops held – Teachers trained – Children reached	• Increased educator sensitivity to cultural differences • Improved climate of multicultural classrooms • Higher learning results on collaborative projects	– Teacher interviews and questionnaires – Classroom observations and – Pupil assessments

Tip: Supportive software for *checking ideas*
=> Visualization tools for flow charts and diagrams, like draw.io, lucidchart, gliffy

8.2.2 *Mapping Solutions: When Fundamental Understanding Is Applied*

8.2.2.1 Refining Design Requirements and Design Propositions

To start mapping out the chosen solution, a first step is to reflect on and articulate the design requirements and design propositions. Design requirements are criteria to which the design must adhere, like '*the design must require only the materials found in a typical classroom environment or brought in for virtually no cost,*' or '*the design must require only basic operations of a tablet as pre-requisite knowledge,*' or '*enactment/use of the design must fit within the normal school day and not require additional class or preparation time.*' Typically, design requirements pertaining to boundary conditions, opportunities, and constraints would have been identified in a previous phase of analysis. But now that the solution is known, it may be necessary to gather additional inputs from an(other) analysis. For example, if the solution chosen is technology-based, but no data on technology infrastructure, attitudes toward technology use, or technological expertise and support were initially collected, the literature may give some guidance, but it would probably make sense to revisit the field to learn more about such aspects in the context in question.

In contrast, design propositions suggest how things can be done and why. For example, '*the design should be web-based, because this allows schools with varied* *technological platforms to access the materials*' or '*Teacher workshops should be tailored to take place during one of the two regularly scheduled monthly team meetings.*' Design propositions are typically generated through the literature review, discussion in the team, and discussion with stakeholders. During the literature review, questions are posed and answered concerning the overall solution and/or its key ingredients (e.g., *What are effective strategies for increasing learner engagement?*). In educational design literature, many terms have been used to describe the integrated, theoretical underpinnings for design, such as conjectures (Sandoval 2004), principles (Linn et al. 2004), and frameworks (Edelson 2002).

Design requirements and propositions help sharpen the focus of an intervention and provide solid grounds upon which design choices can be made. When captured, they also help to document and track the evolution of design insights. Earlier requirements and propositions tend to be more sketchy and written for internal audiences. Careful establishment, articulation, and refinement of (integrated) design considerations, followed by empirical testing, can inform the work of others. For example, building from ideas about teacher pedagogical content knowledge, Davis and Krajcik (2005) presented a set of design propositions (they use the term heuristics), to further the principled design of materials intended to promote both teacher learning and student learning. As another example, Edelson (2002) presents an integrated set of design propositions (he uses the term framework) for designing technology-supported inquiry activities.

Tip: Supportive software for *requirements and propositions*
=> Tools can help identify and save guidelines and inspiration, such as referencing software (e.g., Endnote, Mendeley) and visual bookmarking (e.g., Pinterest, Tabs Outliner)

8.2.2.2 Skeleton Design

As described above, design requirements and design propositions are first articulated so they can be critiqued and elaborated. Next, these ideas are put to use when potential solutions are mapped. This is generally a gradual process, which starts off identifying the main lines, or skeleton of a solution, and increasingly fleshes out details. Constructing a skeleton design is important because it helps designers identify core design features and distinguish these from supporting ones. As the design and construction process ensues, the temptation for 'feature creep' increases (i.e., adding features to the design that were not originally planned). The skeleton design, along with design requirements and design propositions, can help weigh the costs and benefits of proposed additions.

There is no set format for a skeleton design, but generally, attention is warranted to at least materials/resources; activities/processes; and participation/implementation. Materials/resources include the physical artifacts that will be part of the intervention.

Table 8.4 Five examples of content areas to be elaborated in a skeleton design

Design task	Materials/resources	Activities/processes	Participation/implementation
In-service program	Worksheets	Expert coaching	Individuals (coaching)
	Guidebook	Peer observation	
	Workshop agenda	Workshops	Pairs (observations)
	Videos		Groups (workshop)
After school science program	Science toolboxes	Children conduct semi-independent inquiry activities	Children (groups)
	Workbooks		Facilitators (individual)
	Facilitator guide		
University-level course	Reading lists	Online lectures	View lectures out of class
	Online lectures	Face-to-face working group meetings	
	Discussion threads		Small group in class meetings
	Assignment descriptions	In and out of class assignments	Individual and pair assignments
	Assignments	Take examination	Individual exam
	Examination		
E-learning environment	Software	Teacher meetings	Meetings in teams
	User guide	On-computer activities	Children do on- and off-computer activities during regular class time
	Informative Web site	Off-computer activities	
Curriculum materials	Printed booklets	How-to courses	Individuals and teams of teachers
	Worksheet masters		
	Digital tutorials		Administrators

Activities/processes describe the main events through which the intervention will be carried out. Participation/implementation gives additional detail on how actors will engage during those events. Through the skeleton design, it should be clear which components are new, and which components, if any, already exist within the target setting. For example, the skeleton design may mention that teacher meetings will be held. It should also specify if those meetings are separated from, or integrated into, regularly scheduled ones. Table 8.4 gives examples of the kinds of content areas addressed in the skeleton design.

The skeleton design may also indicate the scope of the project, defined primarily in terms of goals, people, time, and budget. Linking the long-range goal to specific components in the design can help establish and maintain focus. Often, writing and rewriting the project goals succinctly help researcher/designers to separate out long-range and interim goals. The people bearing mention in the skeleton design can include the target group, the researcher/designers, experts, and additional stakeholders, who will, directly or indirectly, be involved in creating or implementing the design. Time lines should indicate the start and end of the project, as well as the anticipated flow of the project, indicated by milestones. A cautionary note: Project time lines tend to be chronically over-optimistic, with the (re)design and construction phase usually being the most drastically underestimated. Finally, the budget indicates the anticipated project expenditures. It usually provides an estimate of people hours and material costs.

Skeleton designs are generally created for internal audiences only, although they may be described for external audiences in project proposals. They can be used as a kind of organizer for identifying components that require further specification. Before doing so, it may be useful to evaluate the skeleton design. Feedback (e.g., through expert appraisal) on a skeleton design could crush or affirm initial ideas or, more likely, refine them. Taking the time to refine skeleton designs can save valuable resources that might otherwise have gone into detailing ill-advised components. If not subjected to formal appraisal, the skeleton design should at least be checked for alignment with the design requirements and design propositions.

> **Tip**: Supportive software for *skeleton design*
> => Tools to capture (collaborative) sketching, drawing and outlining, like Digital Camera, Cosketch, Flockdraw, a Web Whiteboard, Webspiration, Quicklyst, Knowcase

8.2.2.3 Detailed Design Specifications

Once the skeleton of a design has been set, it is necessary to further specify aspects of the entire intervention and/or of specific components of the intervention. This may happen in one fell swoop, but it is usually a more gradual process, eventually resulting in detailed design specifications which provide the information needed to begin crafting the intervention. There are usually clusters of ideas about the substance of the intervention (the design itself), as well as the design procedures and processes (how it gets created). If design is compared to cooking, substantive specifications describe the finished cake in careful detail, so well that the reader ought to be able to imagine it quite clearly. Procedural specifications, on the other hand, are like the cooking steps in a recipe. For example, substantive specifications for educational software will likely describe the content, learning supports, and interface design. This might include screen mock-ups, with comments printed in the margins, highlighting certain aspects or describing certain functions. Procedural specifications for educational software will likely include timing of developer team meetings, indication of how often and through which mechanisms feedback is collected, and procedures for making revision decisions. As with the skeleton design, it is strongly recommended to evaluate detailed specifications before commencing with construction. Here too, even if not subjected to formal appraisal, the detailed design specifications should be assessed for alignment with the design requirements and design propositions.

Tip: Supportive software for *detailed specifications*
=> Collaborative, hyperlinked media like GoogleDocs, DropBox, FirstClass

8.3 How to Construct

After solutions are designed (above), specific components of the actual intervention are constructed. For example, the worksheets needed for a learning activity are made; the agenda for a teacher workshop is drawn up; or the pages of a Web site are created. Returning to the culinary metaphor above, construction is akin to the act of cooking (as opposed to meal planning, which is more similar to design). We like this metaphor because cooking, like powerful educational design, is best served by a blend of systematically planned action (based on sound knowledge of the ingredients) and creative inspiration at the time of concoction.

Tip: Supportive software for *constructing solutions*
=> This varies highly as it is dependent on the specific solution envisioned (e.g., word processing software for documents; video-editing software for clips and movies; HTML editors for Web sites; or social networking services for awareness and implementation campaigns). Regardless of the final medium used, simple interim technologies are sometimes helpful for creating initial prototypes (e.g., PowerPoint slides can be used to mock up a user interface). Prototyping is discussed further in the next section.

8.3.1 Building Initial Solutions

Prototyping has traditionally been associated with engineering and is a well-established, systematic approach to solving real-world problems in many fields, including education. For example, Newman (1990) described a process he calls formative experiments for exploring how computers can be integrated into classrooms. Reinking and Watkins (1996) describe how a series of experiments was conducted to both investigate the effects of and redesign a unit to promote independent reading of elementary students. Nieveen (1999) describes a prototyping approach based on consecutive formative evaluations, along with the framework that was used to evaluate three different quality aspects of those prototypes. This section describes what is meant by prototypes in educational design and the forms that they may take. Suggestions on how to orchestrate the prototyping process and prototype in teams are also provided.

8.3.1.1 Prototypes in Educational Design

The term, 'prototype' is used to describe draft versions of the *constructed* solution. During construction, many detailed decisions must be made. These are largely steered by the design requirements and design propositions and guided by the skeleton design and detailed design specifications. However, since it is virtually impossible to specify every single detail ahead of time, a substantial number of design decisions will be made during actual construction. As such, construction typically ensues in phases, and not all at once. NB: While the design ideas mentioned above (requirements, propositions, skeleton design, detailed specifications) do go through iterative refinement, they are not considered prototypes, because they represent the *planned* solution, not the constructed one.

Prototypes can encompass a wide range of artifacts, such as software, books, and Web sites. While some parts of the solution cannot be created ahead of time (e.g., the interaction that occurs during classroom enactment), prototypes can be made directly for some components (e.g., learning resources or written policies) and indirectly for others (e.g., tools that guide classroom routines or program structures). Examples of components that can be prototyped include:

- Product component (direct): Semi-functional learning software
- Policy component (direct): Organizational documentation or memo
- Process component (indirect): Guidebook for teachers to plan, enact, and reflect on their own lessons
- Program component (indirect): Agenda and activity descriptions for school leadership development.

8.3.1.2 Forms of Prototypes

Prototypes range from partial to complete components of the desired solution. They often contain samples of what the finished product might look like, and they may exhibit 'functional' or 'dummy' features. For example, a visual prototype of a software program can be created in PowerPoint, just to illustrate the interface design and operationalize the 'look and feel.' It might be done for the entire program, or for several components. Different forms of prototypes have been identified in the literature, including throwaway; quick and dirty; detailed design; non-functional mock-ups, and evolutionary (Connel and Shafer 1989). For example, a paper prototype of a software program would constitute a non-functional mock-up.

There are several ways in which initial prototypes differ from more mature ones, and these are represented as a continuum in Table 8.5. First, the components that are elaborated in early prototypes generally do not represent all elements of a solution. This is often intentionally done (e.g., 'we wanted to pilot the first module before developing the whole series/course/program'), but not always (e.g., 'once we began prototyping, we realized we had to build in a whole new section with support for second language learners'). Second, prototype functionality tends to increase

Table 8.5 Maturing prototype features

	As intervention matures, prototypes grow and stabilize →		
	Initial	Partial	Complete
Parts elaborated	One or few components	Several components	All components
Functionality	Mock-up	Semi-working	Fully working
Permanence	Throwaway	Mix of throwaway and evolutionary elements	Evolutionary

over time. This is particularly common for technology-based interventions. Third, prototype components gradually transition from temporary versions to more enduring ones. Earlier on, it can be much more sensible to throw away (pieces of) the prototype (e.g., distracting features in an interactive learning environment; activities that did not function as anticipated), but as approximations of the desired solution become increasingly successful, more and more of the solution becomes stable. Rather than starting over or trying new alternatives, refinements are made to a solution (e.g., interface tweaks; resequencing learning tasks), the essence of which remains constant while detailed fine-tuning and embellishments continue over time.

An example of prototyping in educational design is described by Williams (2004). She explored the effects of a multimedia case-based learning environment in pre-service science teacher education in Jamaica. Her dissertation provides a detailed account of both the design and formative evaluation of the prototype learning environments, and the effects of its use on pre-service teacher learning. Williams' design and development account clearly described how design propositions related to cooperative learning were initially conceived and integrated into three prototypes of the learning environment, before arriving at a final version. The description also addresses how empirical findings and other considerations prompted revisions in prototypes of the tool.

8.3.1.3 How to Manage Prototyping Processes

The range of solution types that could be constructed is vast. It is therefore impossible to address them comprehensively here. Instead, attention is given to orchestrating the process. The prototyping process may be accomplished by individuals, working with a sketch pad or a computer. But teams can also build prototypes, sometimes using computers but often using pens, posters, or large display boards to create mock-ups.

It is possible, though not so likely, that the design endeavor will feature the development of one, single, prototype component. But given the interventionist nature of design, it is more likely that several components of a solution will be prototyped. For teams, but also for individuals working on design, it is quite common for development of different components to be going on simultaneously. For example, in developing a technology-rich learning resource for a university-level course on geometry proofs, prototype components could include lesson plans, an online proof tool, learner assessments, and a workshop with teachers. Overseeing all this requires masterful orchestration.

Being able to see the project like a jigsaw puzzle and plan for the construction of its constituent parts is extremely helpful. Many strategies and tactics that apply to generic project management can be useful during the prototype development in educational design. For example, project management reminds us to pay careful attention to how our resources are allocated. An over-allocated resource is one that has more work demands than the time frame allows. We often find that designers (especially teachers and graduate students) could be well described as over-allocated resources. This should give pause, as overall project productivity is threatened when resources are over-allocated. Below, several tools are described to help with orchestrating design prototyping.

- *Critical path*: Flowchart style representation of main activities (elaborate ones include supporting activities), where bold lines indicate essential tasks and trajectories, and thin lines represent preferred, but not required, tasks and trajectories.
- *Gantt chart*: Convenient, straightforward, two-dimensional overview of project development and supporting activities, with components shown vertically and time shown horizontally.
- *Milestone map*: Target dates for completion of certain elements, which can be listed separately or integrated into a Gantt chart.
- *Rasci matrix*: Clarifies roles and responsibilities in projects as those who are Responsible (who does the work, often the lead designer), Accountable (who is ultimately accountable for thorough completion, often a PI or graduate supervisor), Consulted (with whom there is two-way communication), Supporting (who helps the person responsible, like a research assistant), and Informed (who are kept up-to-date on progress through one-way communication, like funders).

Tip: Supportive software for *managing prototyping*
=> Many books and electronic tools provide insightful and practical support for project management. Microsoft Office Project and the online tool Basecamp are two widely used electronic tools for project management.

8.3.1.4 Prototyping in Teams

Aside from lesson planning, few educational design projects are undertaken as a one-person show. Most successful design projects involve varied expertise on a (multidisciplinary) team. Yet even in the case of projects undertaken by a single individual, there will be moments when additional expertise is needed. In some cases, outside experts will actually construct elements of the design (e.g., a computer programmer builds software). In other cases, project collaborators will co-construct design components (e.g., teachers and designers collaboratively plan lessons). And still other elements will be created by the core project members themselves with critical input from outside experts (e.g., subject matter specialists give guidance or examples). In addition to the project management techniques listed above, it can also be useful to create a document that plans and tracks who is creating what and the envisioned time line from start to completion.

Each project demands its own range of specific expertise. In educational design, it is common to seek out expertise related to the media being used, the content being addressed, the intended pedagogy, and those with a strong sensitivity to what may be accepted in the target setting. Media experts include those who put prototype components into publishable form, such as desktop publishers (some clerical staff members are wonderful at this), software developers (ranging from hobbyists to professionals), and Web site designers (many institutions have these people in-house). Content specialists include subject matter experts, who often work in research, practice, or both (e.g., faculty in a university department of mathematics education often conducts their own research and supervise teaching practice). Pedagogy specialists may also have more of a background in research (e.g., researching the use of serious games as a learning strategy) or practice (e.g., a corporate trainer with expertise in adult learning). Many experts will possess a combination of specialties (e.g., pedagogical content knowledge experts specializing in inquiry learning in science). It is extremely useful to have practitioners on the design team, with their sensitivities to the affective and practical aspects of the target context being high among the many contributions they can make to a design team. Practitioners often help ‘keep it real’ by being able to voice interests and concerns that are likely to be shared by others, and determining what is (or is not) feasible, in the target setting. For educational designers working in or from a university, it may be possible to expand project resources at little or no costs by providing internships or learning opportunities to students from other types of programs. For example, students from graphics design courses might be able to produce artwork for e-learning environments and students in computer science courses might be able to do initial programming.

8.3.2 Revising Solutions

Design ideas and constructed prototypes can be evaluated through various strategies and methods. The evaluation of designs and constructed (prototype) interventions generally concludes with revision recommendations. This can include suggestions on what to add, what to remove, what to alter, or even what to repeat in a design. This section briefly discusses the use of such recommendations to revise design documents or prototypes. It starts by describing different kinds of findings and then discusses considerations in reaching revision decisions.

8.3.2.1 Different Kinds of Evaluation and Reflection Findings

The stage and focus of an evaluation will set the boundaries for how far-reaching revision recommendations may go. Both design ideas (e.g., design requirements, propositions, skeleton design, or detailed specifications) and constructed prototypes can be evaluated, although it is less common to conduct anything other than an informal critique of design requirements and propositions. But even if only a prototype is evaluated, the findings are quite likely to have implications for the design ideas, especially the design propositions. For example, the formative evaluation of a prototype learning environment may yield specific recommendations regarding the prototype itself, which could then be incorporated into new versions of the skeleton design and detailed design specifications.

The empirical testing of prototype features may yield findings which are more prescriptive, showing how to move forward with design. But more often, evaluation activities will reveal descriptive findings. While these may clearly warrant consideration when revising the intervention, they are not likely to specify exactly how the design should be improved. For example, observation and interview data from an evaluation of a classroom e-learning activity could provide more nuanced insight into how large or small of an innovative jump an intervention is, in comparison with current practices. Or it may reveal more about user characteristics (e.g., most of them have never seen this kind of tool before; teacher beliefs about this topic are highly varied; or children have some, but not all of the prerequisite skills). The evaluation could also reveal participant preferences (e.g., they are happy to do this, but mostly after school), or contextual factors that were not examined in the initial phase of analysis. In fact, an evaluation may point to the need to revisit the fiend and gather new analysis data. For example, in testing a professional development program where teachers bring learner assessment data to meetings and learn how to plan lessons to meet specific needs, designers might come to question the quality of the assessments teachers bring with them. Before redesigning the program, it may be necessary to analyze currently available assessments and explore what other assessment options might be feasible.

8.3.2.2 Considering Revisions

In considering how to proceed with the findings from evaluation, some design teams use established procedures for logging feedback, systematically reviewing it, and creating a written trail of how it was addressed or why not. Often, it can be useful to sort problems on the basis of their complexity. Some evaluation findings will be rather straightforward and easy to use (e.g., correction of typographical errors). Some will not be easy, but the pathway to revision will be clear. Many will pose complex challenges. Complex challenges are those for which a solution is unclear or not readily available; for which numerous options for solutions exist; or for which the logical revision(s) would be beyond the scope of the project. Very often, complex challenges are prompted by tensions between differing design goals. For example, what is practical for users might make it easier to implement, but less effective; or what has been shown to be effective is not sustainable. In some cases, insufficient practicality is a barrier to even studying effectiveness. To illustrate, if an online learning environment has poor usability, it may have low effectiveness not because of the content or learning activities, but because of the inadequate human–computer interface (Reeves and Carter 2001). Revisiting design requirements and design propositions can sometimes help to weigh off options in such cases. Consulting experts (in person or through literature) may also help.

In dealing with complex redesign challenges brought into focus by evaluation, it is important to remain distanced and open-minded. It is also critical to stay in touch with the main goals to ensure that revisions reflect responsive evolution (e.g., redesign to better meet the stated goals) and not 'mission creep' (e.g., redesign changes goals without realizing it). In particular, those intensively involved in the project might do well to take a break after analyzing the results and before determining revision suggestions. In some teams, the agreements are made that design authority changes hands at this point. The idea behind this is that designers can become so attached to their work that they are unable to do what is sometimes necessary in prototyping: 'kill your darlings.' In some cases, it can be productive to concentrate (partly) on other issues, while looking to see if a solution may be found indirectly, through working on the related problems.

It is wise to plan the revision process, just as it is wise to plan the initial development. A general rule of thumb for the timing of revisions is that it pays off to tackle simple issues that take relatively little time immediately, using the 'touch it once' principle. That is, if it takes a relatively short amount of time to do, it is more efficient to do it immediately than to carry it around on the 'to do' list. It is also important to initiate changes in a timely fashion, so that those which take a long time, even if they require little monitoring, do not hold up development. Complex problems should be sorted into those that will be tackled in the redesign; those that can or will not be solved prior to the next evaluation but will be addressed; and those that will be left unaddressed. Documenting each of these is extremely important to help reconstruct events when reporting on the process. Bulleted lists or tables of issues/actions work very well; these can be sent around to the design team for review and comment. It is also important to ascertain if the changes are more superficial (e.g., constituting improved actualization of the design propositions) or more substantial (e.g., altering the underlying design propositions). Planning the revision process may also include building in time to consult the literature, especially when more substantial changes seem necessary.

Table 8.6 Examples of supportive software for each step in design and construction

Phase		Step	Supportive software examples
Design	Exploring solutions	Generating ideas	Concept mapping
		Considering ideas	Spreadsheets, tables
		Checking ideas	Flowcharts, diagrams
	Mapping solutions	Requirements and propositions	Reference, visual bookmarking
		Skeleton design	Sketch, draw, outline
		Detailed specifications	Multiauthor, hyperlinked docs
Construction	Building solutions	Creating initial prototypes	Varies per solution, e.g., word processing, presentation, video-editing, HTML editing, social networking
	Revising solutions	Revising prototypes	

8.4 Summary

8.4.1 Overview of the Process

As described above, the process of design may feature parallel activities, but typically evolves from exploration of possible solutions to mapping of chosen ones. Thereafter, construction typically entails an iterative process of building initial prototypes and then revising them. Along the way, technologies can support the work in each step. Table 8.6 offers an overview of supportive software that may be helpful when tackling educational design and construction.

8.4.2 Outputs of the Process: Products Describing and Embodying Design Ideas

This phase consists of two main activities: designing and constructing. Similarly, two main kinds of results emerge: products describing and embodying design ideas, respectively. Products resulting from design activities describe potential solutions (generating ideas; considering ideas; and checking ideas) as well as chosen ones (refining design requirements and design propositions; establishing a skeleton design; and setting detailed design specifications). Design requirements delineate functions, criteria, opportunities, constraints, or conditions to be incorporated into the solution. Design propositions are based largely on the literature and constitute the mechanisms that will enable designs to work. The skeleton design and the design specifications bring the solution closer to reality, and when design requirements and especially propositions are explicated, contributions can be critiqued and shared with others. Products resulting from construction activities embody the design ideas. These are often successive prototypes of the desired intervention.

8.4.3 After Design and Construction

Working to develop the products of this phase, which either describe or embody design ideas, may give rise to the conclusion that additional analysis is needed before redesign and/or testing should take place. For example, in constructing an intervention that includes use of social media, designers may conclude that they require additional understanding about how and when the target group currently uses specific social media tools and functions. But more frequently, some form of evaluation and reflection takes place next. Even early products describing or embodying design idea can be evaluated. Thereafter, evaluation findings can lead to new insights, design considerations, and/or ideas for (re)design.

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Author Biographies

Susan McKenney is associate professor at the Department of Instructional Technology within the Faculty of Behavioral Sciences at the University of Twente and also at the Welten Institute of the Open University of the Netherlands. Dr. McKenney is currently chair of the International Society for Design and Development in Education (ISDDE) and was previously editor of the society's journal, *Educational Designer*. She also serves on numerous committees (e.g., International Society of the Learning Sciences Publications Committee); boards (e.g., Dutch Educational Research Association Curriculum Board); and review panels (e.g., Educational Technology Research & Development). In addition to tailor-made training programs, she has designed, delivered, and/or taught over a dozen courses on the bachelor, master, and doctorate levels, most of which were related to (computer supported) curriculum development; educational design (research); technology integration in the curriculum; and/or teacher and school development. Her research focuses on these same themes and is frequently conducted in close cooperation with educational practitioners. Dr. McKenney has collaborated in over fifteen externally funded research and/or development projects for various organizations, including Netherlands National Institute for Curriculum Development (SLO); the Netherlands Science Foundation (NWO); the (American) National Science Foundation (NSF); the European Union (EU); and the World Bank.

Thomas C. Reeves is a Professor Emeritus of Learning, Design, and Technology in the College of Education at The University of Georgia. He is former Fulbright Lecturer in Peru, and he has been an invited speaker in the USA and more than 30 other countries. In 2003, he received the Fellowship Award from the Association for the Advancement of Computing in Education (AACE); in 2010, he was made a Fellow of the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE); and in 2013, he received the Lifetime Award from the International Association for Development of the Information Society (IADIS) as well as the David H. Jonassen Excellence in Research Award from the Association for Educational Communications and Technology (AECT). His books include *Interactive Learning Systems Evaluation* (with John Hedberg), *A Guide to Authentic E-Learning* (with Jan Herrington and Ron Oliver), *Conducting Educational Design Research* (with Susan McKenney), and *MOOCs and Open Education around the World* (with Curt Bonk, Mimi Lee, and Tom Reynolds). He consults with the World Health Organization on the development of authentic task-based e-learning for public health personnel, and he frequently serves as an external evaluator for funded research and development projects.

Chapter 9
User-Centered Design: Supporting Learning Designs' Versioning in a Community Platform

Jonathan Chacón-Pérez, Davinia Hernández-Leo, Yishay Mor and Juan I. Asensio-Pérez

Abstract Community platforms and repositories enable educators to share and reuse Learning Design solutions (resources, activities, patterns, courses, etc.) The Integrated Learning Design Environment (ILDE) is a community platform that integrates Learning Design tools allowing not only sharing but also (co-)editing designs of resources and activities and their implementations with technologies. ILDE features open new scenarios for reuse, since Learning Design solutions can be duplicated and modified within the platform. These scenarios include basic reuse, creative modifications and refinements, revisions based on diverse types of feedback (from students, other educators, own reflections), and particularizations derived from contextual needs. The scenarios lead to the creation of multiple versions of an original solution. Tracking versioning of Learning Design solutions is interesting from a practitioner perspective (inspiration by exploring variations of the same design) and educational research perspective (understanding how educators design and reuse). This chapter describes the model implemented in ILDE to support scenarios that originate several versions of Learning Design solutions as well as the visualization offered to dig into the versioning. Their use is illustrated with three examples extracted from real practice in different contexts.

Keywords Learning Design · Co-design · Reuse · Versioning · Family-tree visualization

J. Chacón-Pérez (✉) · D. Hernández-Leo
ICT Department, Universitat Pompeu Fabra, Tànger, 122-140, 08018 Barcelona, Spain
e-mail: jonathan.chacon@upf.edu

D. Hernández-Leo
e-mail: davinia.hernandez@upf.edu

Y. Mor
Independent Consultant, Mecklenburg Sq., Regne Unit, London WC1N 2AN, UK
e-mail: yishaym@gmail.com

J.I. Asensio-Pérez
School of Telecommunication Engineering, Universidad de Valladolid,
Paseo de Belén, 15, 47011 Valladolid, Spain
e-mail: juaase@tel-uva.es

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9.1 Introduction

The Learning Design (LD) field studies the representations, tools, and methodologies that can support educators in the creation of potentially effective Learning Design solutions, of diverse types or granularities (activities, courses, etc.) (Mor et al. 2013). The application of LD approaches conveys a documentation of the designed learning solutions, which is a key factor that helps educators revise and share their Learning Designs with other educators in order to refine, improve, and reuse them (Conole 2012; Mor and Winters 2007; Mor 2013).

Educational community and repository platforms serve as a space for educators to share and retrieve Learning Designs (Hernández-Leo et al. 2011). If the designs need modifications for their (re)use in a specific educational situation, the editions have to be done with the appropriate authoring tool—in most cases not available within the community/repository platform. One of the platforms that embed Learning Design editors is the Integrated Learning Design Environment (ILDE). As its name suggests, this is an environment that integrates multiple editors for Learning Design. These support the creation of design representations associated with different phases of a Learning Design life cycle (from conceptualization to authoring and later implementation), following diverse design methodologies that may require different combinations of design tools for various pedagogical approaches (Hernández-Leo et al. 2014). By collating these various tools in a single platform, ILDE enables educators to explore and reuse designs of different nature. The ILDE also supports educators in mixing and modifying existing designs (Chacón et al. 2014).

Therefore, ILDE features facilitate various scenarios involving Learning Design reuse. For example, they may entail iterative revisions/adaptations of designs used in previous academic years by the same educator. Or, refinements proposed by several educators involved in a design team or teaching the same subject to different groups of students whose conditions require adjustments to the Learning Design. In co-design processes, educators may also invite students to propose ideas for the revision of Learning Designs before their implementation (Könings et al. 2011). These scenarios lead to the creation of multiple versions or replicas of the same design that may be edited; replicas, which in turn, may be duplicated and refined as new designs.

This chapter presents an overview of ILDE, emphasizing the features that support reuse. The chapter elaborates on a particular feature that enables keeping track of the versions that originate from an "original" design (replicas, modifications, authors reusing and editing, etc.), which is interesting from a practitioner's perspective. Educators can explore the multiple versions of a design: to remember how they used it in previous editions of a course, to compare variations of the same design used with different groups of students, to learn how other educators have changed it, etc. Moreover, tracking Learning Design versioning can be also an interesting tool to support educational research, for example, to study how educators reuse and adapt designs. This feature is based on a model that represents the relationships between versions of designs of multiple types, as supported by ILDE and created by the same or different educators. Besides, the feature provides a visualization of the versioning inspired by a family-tree metaphor for an accessible navigation and exploration of the designs.

ILDE is being used in diverse educational sectors, including adult education, vocational training, and higher education institutions in the context of the METIS project (http://www.metis-project.org) as well as in wide teacher professional development massive open online courses (MOOCs) as initiative of the HANDSON project (http://handsonict.eu) and in the small professional design and development community of the learning layers' project (http://learning-layers.eu/). The activity of educators in ILDE communities is originating versioning of designs at different levels: refinements of conceptualizations analyzing the target learners in adult education actions, duplications of authored designs to be implemented with different technologies with several groups of university students, or integration of ad hoc templates structuring design thinking in particular design activities.

The remainder of this chapter is organized as follows. Section 9.2 introduces the ILDE platform, the model for tracking multi-user Learning Design versioning and the family-tree metaphor-based visualization. Section 9.3 explains three examples, using ILDE and the versioning feature, extracted from real practice in the previously mentioned contexts. A discussion about additional scenarios and perspectives provided by ILDE are discussed in Sect. 9.4. Finally, Sect. 9.5 summarizes the main conclusions of the chapter.

9.2 Learning Design Versioning in ILDE

Learning Design versioning is implemented in ILDE, as a community platform that enables not only sharing and duplication of Learning Designs but also their edition in the integrated conceptualization, authoring, and implementation tools. The model behind ILDE versioning and its visualization are explained in this section after the following overview of ILDE.

9.2.1 ILDE

ILDE is an online platform that supports the collaborative (co-)creation and sharing of Learning Designs within practitioner's communities (Hernández-Leo et al. 2014). This platform is built on top of LdShake, which provides social network features, including sharing designs with different access rights, acting as a repository controlling the access to designs, and enabling the browsing of Learning Design by exploring the list of shared designs by tags or by community member's activity (Hernández-Leo et al. 2011). LdShake, and therefore ILDE, uses LdS as the term to refer to Learning Design solutions (LdSs) from a broad perspective, including different types of educational material and activities of diverse granularities that an educator can design (courses, activities, resources, etc.). In particular, it also includes several artefacts (from sketches to fully fledged solutions) that can be created in any of the phases along the Learning Design. From conceptualization to authoring and even to the implementation where a target technology-enhanced learning environment (typically based on a virtual learning environment) is automatically set up according to the pedagogical decisions reflected in the Learning Design. An LdS is composed of a body and a collection of open metadata and parameters. On the one hand, the body could enclose simple elements such as plain HTML documents or more complex entities in the formats supported by existing Learning Design authoring tools [e.g., IMS Learning Design in the case of Web Collage (Villasclaras et al. 2013)]. On the other hand, using open metadata and parameters, an educator can describe the resource he/she is creating, how resources are intended to be used, can add tags for supporting their search, or can configure the sharing options (i.e., giving access and editing rights) of the LdS.

ILDE integrates a number of existing tools for creating multiple types of Learning Design solutions covering the complete Learning Design life cycle (from conceptualization to authoring and to implementation), see Fig. 9.1. The life cycle begins with the conceptualization of the design where educators reflect about their educational context and objectives (e.g., characteristics of the learners, duration of the activity, special needs, expected learning outcomes, and resources available and needed). Figure 9.1 lists some of the ILDE conceptualization templates, and tools;

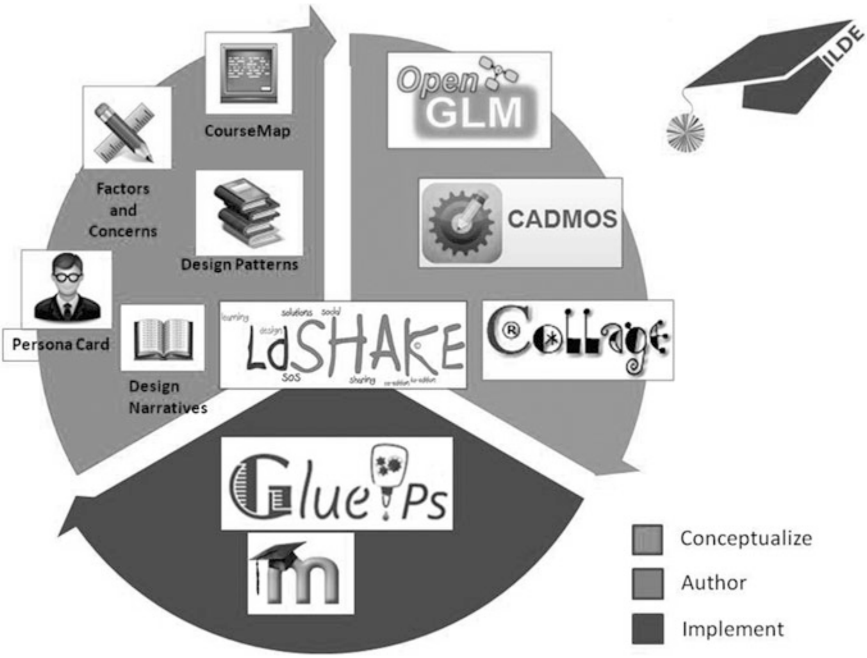

Fig. 9.1 ILDE and tools supporting the Learning Design life cycle

most of them derived from the Learning Design Studio (Mor and Mogilevsky 2013) and the OULDI project (Cross et al. 2012).

The reflections defined in the LdS from the conceptualization phase prepare the educators for the actual creation of the activities to be used with their students. In the authoring phase, educators enlist a flow of learning activities and associated resources that students are intended to follow. Such flow of activities is expected to generate the conditions for learning that the educator identified in the conceptualization phase. In the authoring phase, designs are not bound to a specific learning platform or groups of students. Authoring tools are educator-friendly, but they represent Learning Designs using computer-interpretable representations. In order to support different types of educators, such as expert Learning Designers, teachers who are familiar with didactic techniques but are not experts in Learning Design tooling, or even for those who are not familiar with pedagogy but show interest in innovative technology-supported teaching and learning methodologies to create sound Learning Designs, ILDE has a number of tools for supporting authoring phase. Two specific examples are Web Collage and OpenGLM. On the one hand, Web Collage provides several collaborative learning flow patterns as the basis for creating activities, where educators only have to fill templates particularizing the patterns to their cases (Villasclaras-Fernández et al. 2013). On the other hand, in OpenGLM, educators can program their activities by defining the visual design of the activity flow representing the activities with boxes, the flow with arrows, and editing each activity within the corresponding boxes (Derntl et al. 2011).

Furthermore, LdS from the authoring phase can be implemented in a VLE such as Moodle thanks to the Glue!-PS technology integrated in the platform. Glue!-PS is a software architecture and data model designed to deploy Learning Designs specified in different languages (e.g., the IMS-LD specification) into different existing VLE (Prieto et al. 2012). Through the implementation phase, the designs can be related with the necessary technological tools and students provided by the VLE. For example, an activity can be deployed in a Moodle course preparing the resources (such as forums) and creating the appropriate work teams, if needed, with the Moodle course participants.

However, and in spite of the support provided by all the tools integrated in the ILDE, the use of such tools could be difficult for educators without experience to define their own Learning Designs. Previous research shows the challenges around teachers designing educational resources from scratch (Griffiths and Blat 2005). Different literature contributions propose as a solution to face this problem supporting the design process through the reuse of existing material to create new ones (Harrer 2006; Hernández-Leo et al. 2007). In these regards, educators look for existing LdS in the platform that they may reuse before starting their LdS. Any time educators find an LdS that they find relevant to their context or subject, and they may duplicate it for taking ownership over it and refine/adapt them as necessary. Possible reuse scenarios are multiple. They include teams of teachers in which the experienced educator creates several LdSs to be used in a subject, and then, they are adapted and used in different environments with different students; educators reusing their designs from previous academic years in the following ones, etc.

9.2.2 A Model to Track Learning Design Versioning

In order to support the duplication-for-reuse process, we propose a model for the management and tracking of multiple versions of LdS, which is shown in Fig. 9.2. In the top-center of the model, there is the concept of «Learning Design Family», which is a set of LdS interconnected using the metaphor of a family hierarchy. On the one hand, we named a "parent" LdS as the original design created by teachers from scratch. On the other hand, any duplication or replica from either a parent LdS or another child originates a child or progeny. However, the distinction between a simple clone and a replica relies on whether there has been a process of refinement to suit individual needs (see «Cloned LdS» and «Refined LdS» in Fig. 9.2).

Any LdS is composed of both a body and an envelope. The LdS' body is created with a tool out of the myriad of tools integrated in ILDE to support in the phases of Learning Design life cycle: conceptualize (e.g., Persona Card), author (e.g., Web Collage), or implement (e.g., a deployment of Web Collage LdS into Moodle).

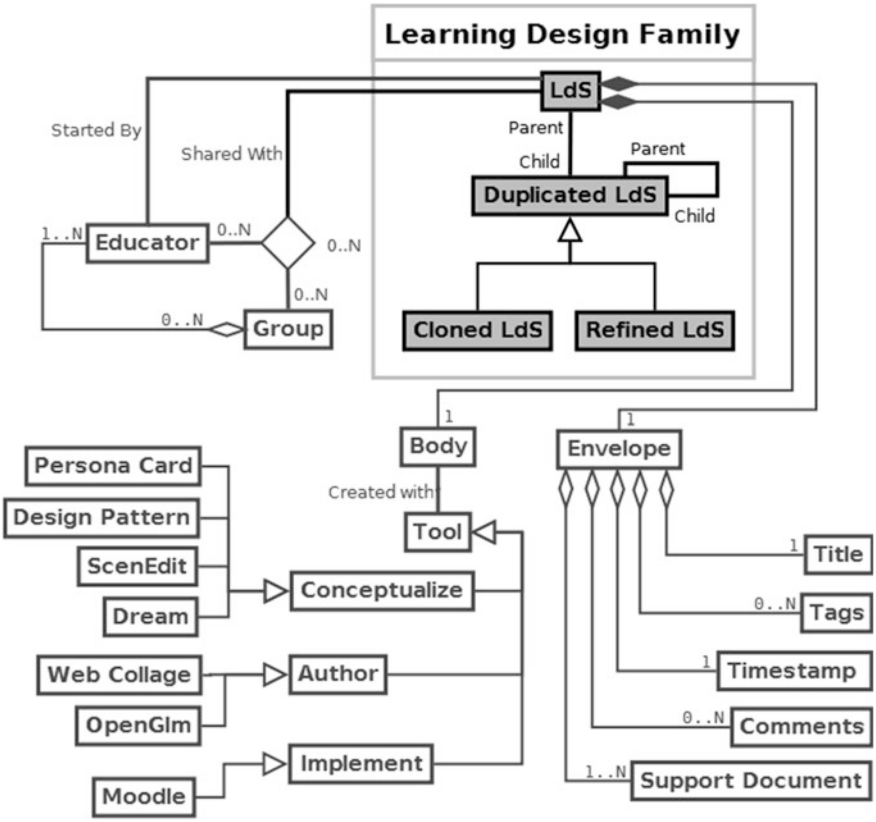

Fig. 9.2 The model for tracking Learning Designs' versioning

LdS' envelope may contain title, date when the resource has been created and each time it has been edited, a collection of tags of educators that categorize the resource, a support document where educators can specify any extra supplementary material related to the design (e.g., a guide on how to use the design properly, the resources needed to apply it, and indications about their evaluation), and the comments and extra information.

Additionally, every LdS is associated with an educator (initial author) that started the design and who may invite a set of co-authors (members of the platform community, a.k.a. LdShakers) to participate in the co-edition of the design. Every time an educator selects a tool from the ILDE menu, a new LdS is created and the author becomes automatically the person that started it. This LdS can be shared with other LdShakers or even with pre-defined groups comprising a preselection of them. So, each educator can define their own working teams for co-creating Learning Designs.

Keeping duplications in the form of Learning Design families enable the tracking of LdS' versioning for every single LdS in ILDE. Educators can navigate through the existing repository of LdS within the community and replicate the resources of their interest. However, before duplicating a particular LdS, an educator may be interested in exploring different versions of that particular LdS tracked by the model in ILDE. This is enabled by the "family-tree visualization" of Learning Design versioning.

9.2.3 *Family-Tree Visualization of Learning Design Versioning*

As teachers reuse designs along time, the number of LdS versions increases. To enable a comprehensive representation of the versioning for practitioners, a feature that supports visualization of different versions of the LdS and their interrelations is needed. In order to solve this, a visualization based on a "family-tree" metaphor is proposed (Chacón-Pérez et al. 2014). The feature shows graphically the initial LdS, all their duplications, and their relations in a user-friendly approach facilitating the navigation through LdS versions. Both the visualization and the model have been implemented in ILDE. In particular, the visualization of learning versioning is available from each LdS (in view mode, i.e., when the access to the LdS is not in the edit option). Close to the «View duplicates» option, users can duplicate the LdS selecting «Duplicate this LdS».

The visual design of the family-tree metaphor includes a box with LdS basic information as title, the picture of the educator (as configured in his or her LdShaker profile settings) who created the design (see Fig. 9.3a). Notice that the LdS that is used to open the family-tree visualization is the one in the area B from Fig. 9.3, while the other "relatives" of this LdS are colored different as seen in area A from Fig. 9.3. If the LdS has an "ancestor," it is automatically showed on top of the

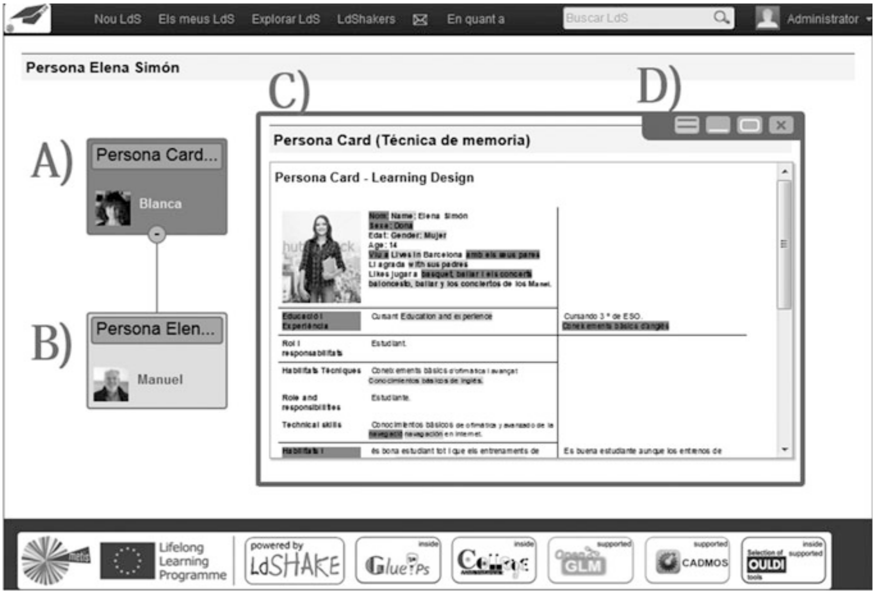

Fig. 9.3 An example of the visualization of the model for tracking Learning Designs' versions

actual LdS (Fig. 9.3a). There is a round button in every LdS which has been duplicated to expand or collapse their children, a «−» button for collapsing or «+» button for expanding (see Fig. 9.3a). Thanks to this option, practitioners are able to navigate through the tree without overloading the screen with LdS. Relationships are represented between LdSs using a black line.

Clicking on the name of each LdS opens a new window showing the LdS (view mode) (Fig. 9.3c). Furthermore, in this new window, educators can compare the modification that the replicating practitioner did to the original LdS. In order to activate this feature, practitioners can click on the compare button (Fig. 9.3d). When it is clicked, the added or modified text is highlighted in green, while deleted text is marked in red.

9.3 Examples of Learning Design Duplication and Versioning

The LdS' duplication and versioning features implemented in ILDE are being used in different educators' communities, in the context of the METIS project, in a MOOC organized by the HANDSON project, and at several design workshops framed in the learning layers' project. The following examples belong to contexts and illustrate diverse scenarios that benefit from these ILDE features: refinements of conceptualizations analyzing the target learners in adult education actions, duplications of authored designs to be implemented with different technologies with several groups of university students, and supporting ad hoc design templates.

9.3.1 Refining Versions of Predefined Persona Cards

La Verneda Adult Education school, run by the Agora association, has piloted ILDE in the context of the METIS project. The Association of Participants Agora is a nonprofit association of adults who do not pursue any academic degree and are characterized by their intrinsic motivation to learn. The main goal of the association is to promote the educational and social inclusion of its participants grounded on democratic participation (Sánchez-Aroca 1999). Agora/La Verneda offers a number of non-formal cultural and educational actions to the whole district of La Verneda in Barcelona (Spain) and is open to everybody, without any discrimination in order to promote equality. Most educators in this school are volunteers. It provides a daily educational setting for over 1500 participants and more than 100 volunteers. All the activities offered are free of charge and include language learning, basic literacy, information and communication technologies training groups, preparation for university access tests, preparation for driving tests, and dialogic literary circles among many other workshops. Volunteers share the educational materials, and when new educational activities are being planned, the process is open to all participants and volunteers to include all the different perspectives and possible contributions.

ILDE supports Agora's participants and volunteers in this process of planning and co-creation of educational activities for the school along the whole Learning Design life cycle. Of course, participants also use ILDE to share designs with others within their community or reuse other member's designs. Profiles of participants and volunteers are very varied. Some of them are experts on content topic (e.g., an introductory course to Microsoft Office), while others have a basic educational background, or are collaborators that facilitate sessions and workshops, and even learners with strong opinions on what they would like to learn. All of them participate in the Learning Design actions fostered by the school, but since their levels of expertise in education varies, it was decided by the school committee together with ILDE providers to define a design methodology that any Agora participant could easily follow when creating their own activities.

A team comprising of Agora experienced participants and Learning Design experts defined a workflow in ILDE aligned with Agora philosophy and practices to guide Learning Design within the school. This Agora's workflow includes a selection of ILDE tools that support the different phases of the Learning Design life cycle: a Persona Card (Nielsen 2013), a pattern design and design narrative for the conceptualizing phase; Web Collage for the authoring phase; and Moodle as the institutional VLE where the activity will be implemented. Out of the many tools integrated in ILDE, Agora participants were suggested to use these specific tools to reflect about, document, and co-create educational activities for the school.

To further facilitate Learning Design within school, it was decided to refine the proposed workflow by not using directly the original template of Persona Card but an elaboration of it in a way that it is very potentially suitable to all Learning Design projects in Agora/La Verneda. The refinement of the Persona Card was, first, a duplication of the original template translated into Catalan (mother tongue of most educators in the school). Then, the Catalan version of the Persona Card was used to create three pre-filled Persona Cards of typical Agora participants in their different roles (collaborator, learner, expert). To achieve this, the Catalan version of the card was duplicated three times and completed accordingly. Due to the fact that the three edited cards reflect the main profiles of participants, they can be reused in Learning Design projects within the school. These pre-filled cards were incorporated in the Agora workflow, and anytime the workflow is applied to create new Learning Designs the cards are duplicated so that the general descriptions of the Agora profiles are refined or adapted, if needed, in the context of the new design (e.g., immigrant learner, and elder learner). This procedure leads to a Persona Card's versioning family tree of Personas considered in Agora Learning Design conceptualization processes. One portion of section of the family tree originated is shown in Fig. 9.4.

Figure 9.4 shows the translated version of the Persona Card, at top of the tree. Then, in Level 1, there are duplications done by educators from the original version. Furthermore, there are the three duplications edited with data of the main profiles in the Agora's school as previously defined in this section. In Level 2, there are part of the versions that educators did by duplicating and modifying the edited Persona Cards incorporated in the workflow. Furthermore, in level three, there are duplications some educators did after navigating through the family tree of Persona Cards, selecting a refined Persona and further adapting it to their context. So, there are educators who adapted or refined versions of what other educators already refined.

Seven design projects have used the versioning feature in Agora/La Verneda: one about Spanish narrative, an introduction to Photoshop's layers, a chess course for beginners, and activity to learn about another cultures and cities such as Tegucigalpa capital of Honduras, a small course about Excel, the organization of a cooking course, and a course about photography. The designs of these activities were created

Fig. 9.4 Persona Card family-tree versions tracked

in teams. After completing the projects, the involved participants pointed that they found duplication and versioning as a very interesting and useful characteristic of ILDE. Some educators said that thanks to this feature they could adapt previous existing artifacts easily and could create new activities faster. Another educator argued this features could be very helpful for duplicating and adapting activities from one design group to another. Finally, another educator pointed that this feature allowed her to analyze how other educators refined existing resources.

9.3.2 Versioning Implementations

As already mentioned in Sect. 9.2, the implementation phase starts with the educator specifying with which learning platform and corresponding enrolled students he/she wants a particular Learning Design to be enacted. Then, educators can use implementation tools to carry out a particular configuration of groups of students that are expected to participate in the designed learning activities, as well as the learning tools (available in the target learning platform) those groups of students will have at their disposal. The implementation phase ends with the "deployment" of the implementation (i.e., the automatic setting up of the learning platform and associated tools to reflect the decisions made by the educator).

During METIS Learning Design workshops, two main cases for duplication of implementations were identified:

- In a training workshop for higher education teachers, one of the participating teachers wanted to enact the same Learning Design (part of a "Healthcare Education" undergraduate course in the Faculty of Nursing of the University of Valladolid, Spain) with two different sets of students (for a total of 128). Learning activities and tools, and even the social structure of students participating in those activities, were almost identical. The only difference was the actual population of groups. The educator created the implementation for one of the groups (except the actual population), duplicated it, and then he only carried out the edition of both populations (the only difference between the two implementations) for each implementation as a step prior to deployment.
- In a training workshop for adult educators, a teacher created a quite complex collaborative Learning Design using the Web Collage authoring tool integrated in the ILDE. The authored design was part of an introductory course on ICT tools within the program for adult education in the municipality of Valladolid (Spain). Web Collage was also used during the implementation phase to easily create non-trivial social structures of groups of students (14 were enrolled in the course). Once the social structures were created with Web Collage, the implementation could be deployed into the target learning platform using Glue!-PS. The drawback is that implementation edited with Glue!-PS cannot be edited again with Web Collage due to conversions carried out in the representations of the implementations within the ILDE. Therefore, eventual changes in the grouping

of students would need to be carried out with Glue!-PS (which can be a burdensome process in collaborative learning scenarios, since Glue!-PS does not support grouping features as powerful as those of Web Collage). The solution adopted by the teacher was to duplicate Web Collage implementations before editing them with Glue!-PS. Thus, if modifications in the grouping structure were required, the teacher would be allowed to roll back to the duplicated Web Collage implementation and do the changes (employing much less effort).

Both teachers underlined in the interviews carried out after they enacted their designs with actual students that during the design process, they highly appreciated the possibility of duplicating implementations. They both stated that the duplication feature saved them a lot of time/effort, especially taking into account the learning curve of implementation tools appeared to be significantly steep.

9.3.3 Supporting Ad Hoc Design Templates

Another effective design practice afforded by the versioning facility was the creation and the use of ad hoc templates within design communities. The ILDE included a set of templates for conceptualization (course map, course features, design narrative, design pattern, persona, factors and concerns, and heuristic evaluation). These were based on the representations developed by the OULDI project (Cross et al. 2012) and the Learning Design Studio (Mor and Mogilevsky 2013). However, in some cases, design communities needed additional templates for various reasons. The versioning feature proved useful in supporting such scenarios: Users could create a prototype LdS using the free-text editor and instruct other users to duplicate it. We present two examples to illustrate this use: the HANSON MOOC and the learning layers design workshops.

The HandsonICT project's aim was to aid teachers in the effective integration of ICT in their classroom practices, by guiding them in developing their Learning Design skills. One of the central instruments the project used to this effect was a series of three MOOCs. The latter two of the three used a "lightweight" version of the Learning Design Studio methodology, adapted from the Open Learning Design Studio (OLDS) MOOC (McAndrew 2013). This methodology introduces Learning Design by leading participants through a Learning Design project of their own initiative, situated in their context of work. Thus, participants have intrinsic motivation to engage with the concepts and methods introduced and can bind these to familiar situations. In order to kick-start this process, one of the first activities in this MOOC is the "Dreambazaar." In this activity, each participant was requested to share their dream techno-pedagogical innovation: a brief description of the context in which they work, a pedagogical challenge they wish to address in this context, and their initial ideas as to how to address it. Participants were then required to comment on each other's "dreams," as a way of fostering a sense of community and encouraging collaborative learning.

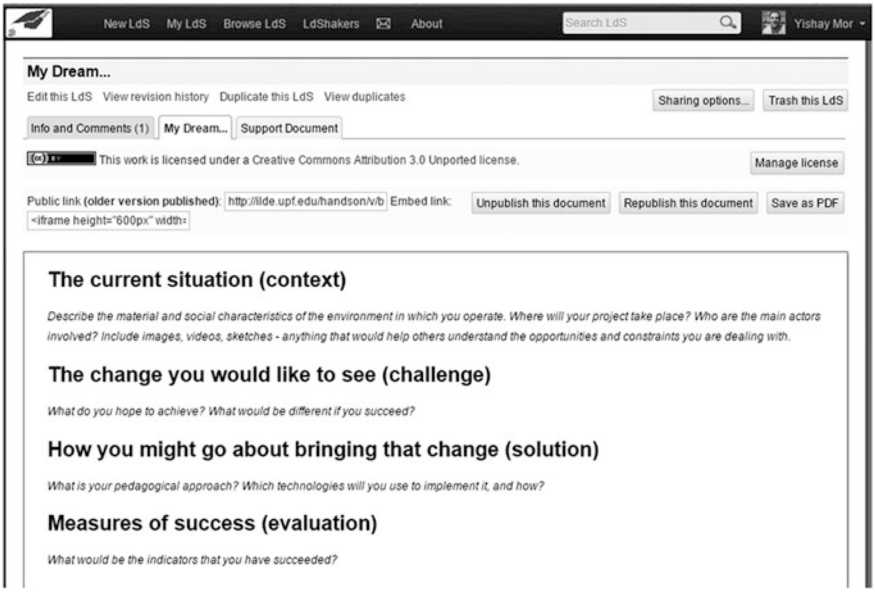

Fig. 9.5 HandsOnICT dream template

However, to streamline this activity, the MOOC team wanted to introduce a template for dream descriptions. Such a template was not part of the ILDE. Since it was unique to this initiative—it did not make sense to add a built-in template. Instead, the MOOC team created an LdS labeled "My dream…" with headings and prompts for filling in the various sections, and tagged it "dreambazaar" (Fig. 9.5).

Participants were instructed to open this LdS, click "duplicate this," and use the resulting document to create their own dream description (Fig. 9.6). Thus, the "My dream" LdS became an ad hoc template for the MOOC.

Fig. 9.6 DreamBazaar activity in the HandsOnICT MOOC

Indeed, participants found this activity straightforward and easy to follow and produced hundreds of “dream” LdSs. Apart from providing them a path into the mind-set of the MOOC, it also offered them a smooth introduction into the use of the ILDE platform. Since the original “My dream” LdS was tagged as “dreambazaar,” all the duplicates had the same tag—making them easy to find and comment on in the collaborative phase of the activity.

The second example of ad hoc templates is drawn from the learning layers’ project. This project develops tools and pedagogies to support informal learning in the workplace. As part of the healthcare strand of work, the project conducted two expert design workshops in early 2015. The aim of these workshops was to conceptualize designs for new informal learning practices and the tools to support them, which would be appropriate for the context of healthcare workers in the UK, and address their needs. The project decided to adopt the Participatory Patterns Workshop (PPW) methodology. However, considering the specific needs of the project, the team identified a need to extend this methodology to include explicit representations for capturing existing practices, describing user needs, and making links between theory and practice. To this end, the team created several ad hoc templates and then used them in their work. By contrast to the HandsOnICT MOOC, where the templates were provided to participants as a given, in this case the templates were negotiated between the members of the project team and modified in response to lessons learnt from their use. Thus, the ILDE allowed the learning layers team to engage in a multi-level process of co-design: On one hand, the team collaborated toward their immediate goal through co-editing representations of current practices, user needs, and proposed innovations to address the needs in the context of the practices. At a metalevel, the team continuously reflected on its own design practices and updated the templates to best serve these as they evolved.

9.4 Discussion

The ILDE community platform assists educators in the co-design of their own educational activities and resources. First, it provides educators with the necessary technological tools supporting the different phases of the Learning Design life cycle: from conceptualization to authoring and to implementation. Second, it enables the configuration of different design methodologies that may require different combinations of tooling (in the different phases) used along a workflow, which educators can follow when creating their resources. Third, the ILDE acts as a repository of designs and their potential multiple versions (created by the same educator or team of educators or created by other educator or team of educators). Versioning is conceptually managed by ILDE as described in the model presented in this chapter and visualized as a family attempting to facilitate tracking of versions when exploring, analyzing, and reusing similar designs.

The features such as versioning model and family-tree visualization implemented on ILDE have been used by educators from diverse communities; in particular, this chapter has elaborated three different scenarios that occur in four different context/communities. In the Agora/La Verneda adult school, seven design projects have used the versioning feature: one about Spanish narrative, an introduction to Photoshop's layers, a chess course for beginners, and activity to learn about another cultures and cities such as Tegucigalpa capital of Honduras, a small course about Excel, the organization of a cooking course, and a course about photography. For each of these scenarios, they reuse predefined Personas Cards already created in ILDE according to Agora context and did small refinements to completely reflect the Personas (representing Agora participants) that will be involved in the delivery of the designs (as learners and facilitators). In this sense, Agora members involved in the definition of these Learning Designs can take advantage of previous existent material, making their own more coherent (aligned with the institution) designs. In the case of Agora participants acting as educators, they found this feature useful for reusing previously defined Persona Cards for their upcoming courses. For new Agora volunteers, reusing the Persona Cards was also formative because they were able to reflect about the typical profile of individuals involved in the school and the kind of learners they have to address the activities they were designing. It is interesting to note that participants reusing Persona Cards felt more comfortable adopting and adapting material that other Agora members defined previously than starting from scratch. Designs belonging to larger families were also of a higher overall quality.

In addition to scenarios involving the duplication of conceptualization LdS (documents compliant with conceptualization templates), educators can also duplicate complex design solutions (diverse formats, e.g., IMS-LD) from the final phase of the Learning Design life cycle. For instance, duplication of implementations enables their multiple deliveries with diverse groups of students and duplications of authored designs created with Web Collage facilitate changes in social structures of collaborative learning activities that depend on particular implementation contexts.

The cases of the HandsOnICT MOOC and the learning layers' project illustrate a fortuitous side effect of the versioning mechanism. By making deliberate use of the LdS duplication functionality, these two projects could extend ILDE dynamically to meet their needs, by adding new templates to match their design practices. In the case of HandOnICT, the templates were predetermined at the time of the MOOC design and production and then used by hundreds of participants. In the case of the learning layers' project, they evolved in tandem with the project team's emerging design practices.

The family-tree visualization supports educators in exploring versions of LdS (conceptualization, authored, or implemented designs). Family trees can reach up to quite large sizes that challenge the visual representation of the trees and their navigation functions. The duplication and visualization features implemented in ILDE have satisfied the need of the explained examples. The family-tree visualization has been useful for educators when exploring what other teachers design and reflect about a potential adoption and adaptation to their cases. Yet, educators said that when there are too many branches in the tree, the LdS icons become too small hindering a proper exploration. Educators' feedback is currently being considered to improve the usability of the visualization.

9.5 Conclusion

This chapter has introduced a model for the management and tracking of multiple versions of Learning Design solutions of different types: from conceptualizations, to actual design of activities, and to their implementation in VLEs. This model has been implemented in ILDE, a community environment that integrates a number of design tools supporting the different phases of Learning Design life cycle. The implementation of the model together with a family-tree visualization approaches backup reutilization and related scenarios in the context of teacher communities. The chapter has described several of these scenarios framed in diverse educational communities and showed how the versioning mechanisms support refinements of conceptualizations, duplications of authored designs to be implemented with different technologies with different groups of students, and the use of ad hoc design templates. The scenarios show how the duplication and versioning mechanisms support cooperation between educators, can save time and effort, may lead to design richer activities (inspired by variations of previous related activities), and support institutions and projects in structuring their own design processes by creating and replicating ad hoc design templates. Additional scenarios include support to educational research, such as tracking versioning of Learning Designs can offer understanding about how educators design and reuse.

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Author Biographies

Jonathan Chacón-Pérez is a member of the Interactive Technologies Group (GTI) of Pompeu Fabra University (UPF) in Barcelona. He holds a computer science degree (2009), Master (2010), and has been awarded with arguably the highest competitive grant (Spanish Government) for carrying out his Ph.D. He has been collaborating with the GTI since 2007, conducting computer administration tasks to assist research project requirements. He also participated in the ICT IP European project TENCompetence, deploying and configuring the project infrastructure to support pilots. He is involved in the LdShake team (Learn3, EEE, METIS, IJIE projects). His research area is focused on educational technologies, with an emphasis on social and semantic-based approaches to support teachers in the Learning Design and sharing processes.

Davinia Hernández-Leo is associate professor in the Department of Information and Communications Technologies at Universitat Pompeu Fabra. Davinia is coordinator of the research in Educational Technologies of the Interactive Technologies Group (GTI) and is subdirector of Engineering School of the UPF and director of its Teaching Support unit. Davinia was previously (2003–2007) at the University of Valladolid, a visiting researcher at the OUNL in 2006 and Fulbright scholar at Virginia Tech in 2012.

Dr. Yishay Mor is a consultant in educational innovation and technology and the educational design scientist at PAU Education, Barcelona. His main areas of expertise are Learning Design, educational design research, and teacher professional development—which are combined in his work on Design Inquiry of Learning and the Learning Design Studio. In recent years, Dr. Mor has established himself as an expert on massive online open courses (MOOCs). He led the Open Learning Design Studio MOOC, acted as advisor to several other MOOCs, and guest edited a special issue of e-learning papers on “MOOCs and beyond.” At PAU Education, he designed and led the incubator program of the Open Education Challenge. Dr. Mor has published extensively, has participated in multiple EU and UK funded projects, and had founded the STELLAR network of excellence Learning Design Grid theme team. He is the co-editor of the book “Practical Design Patterns for Teaching and Learning with Technology” which offers a ground-breaking approach to bridging the gap between theory and practice in education. He has edited special issues of several journals, including Research in Learning Technology. He is editor in chief of e-learning Papers.

Juan I. Asensio-Pérez received the M.Sc. and Ph.D. degrees in telecommunications engineering from the University of Valladolid, Spain, in 1995 and 2000, respectively. He is currently an associate professor of telematics engineering at the University of Valladolid. His research interests within the field of technology-enhanced learning include the following: computer-supported collaborative learning (CSCL) scripting, the integration of external tools in virtual learning environments, the technological support for the orchestration of CSCL situations, the semantic annotation of learning tools in the Web of Data, and the application of augmented reality technologies for the support of CSCL situations cross multiple virtual and physical spaces.

Chapter 10
The Case for Multiple Representations in the Learning Design Life Cycle

Francesca Pozzi, Juan I. Asensio-Pérezc and Donatella Persico

Abstract This chapter draws a picture of the variety of representations that have been proposed to support the learning design life cycle. The intent is to show that such representations have different features and serve different purposes and that designers may find it useful to adopt one or the other according to their objectives and/or at different stages of their work. The argument is sustained throughout this chapter based on an example, concerning a learning activity, which is represented through several types of representations. The conclusion is that the quest for a single representation serving all purposes is vain, while the efforts of researchers should better be directed toward the aim of building tools that allow for interoperability of these representations and integration of the tools that make use of them, so to facilitate sharing and reuse of the half-fabricates of the learning design life cycle, as well as implementation of existing designs in different virtual learning environments (VLEs).

Keywords Learning design · Representations · Conceptualization · Authoring · Implementation · Learning design life cycle

F. Pozzi (✉) · D. Persico
Institute for Educational Technology (ITD)—National Research Council of Italy (CNR), Via de Marini, 6, 16149 Genoa, Italy
e-mail: pozzi@itd.cnr.it
URL: http://www.itd.cnr.it/personalescheda.php?Id=25&FlagSelected=en

D. Persico
e-mail: persico@itd.cnr.it
URL: http://www.itd.cnr.it/personalescheda.php?Id=24&FlagSelected=en

J.I. Asensio-Pérezc
Universidad de Valladolid, Plaza Santa Cruz, 8, 47002 Valladolid, Spain
e-mail: juaase@tel.uva.es
URL: http://www.gsic.uva.es/personal/juaase

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10.1 Introduction

The new frontiers opened by the massive use of technology are calling for radical changes in the educational sector, which is more and more characterized by problems in the search for innovative solutions based on the novel approaches, tools, and emerging pedagogies. This introduces a heightened degree of complexity in the critical process of designing and planning effective educational interventions; consequently, practitioners are nowadays called for reconsideration of their learning design (LD) practices, in a quest for more informed, methodologically sound and effective design methods (Conole 2012; Mor and Craft 2012; Earp and Pozzi 2006; Persico 2006).

The result has been an increased interest and a boost of research and innovation in the field of LD, which is characterized by extreme diversity and complexity, in terms of the technological and methodological solutions proposed (Prieto et al. 2013b; Persico et al. 2013). Among the most active debates in the LD research field is the discussion about how to represent a LD solution (i.e., the result of a LD activity); many proposals exist, ranging from visual to textual representations, and most of them are incorporated in one or more LD tools. On the one hand, such richness and variety can be seen as a positive sign as it witnesses the relevance of the topic; however, on the other hand, it can be regarded as evidence of a chaotic and yet immature sector, especially for non-specialist practitioners and novices. Several authors (Pozzi et al. 2015; Dalziel et al. 2013; Hernández-Leo et al. 2013) point to the need for order and integration of research results.

In order to contribute to this field and bring some order out of its chaos, this chapter makes use of a classification for existing LD representations (Pozzi et al. 2015). The classification encompasses four main dimensions (format, level of formalism, level of contextualization, and purpose) aiming to describe and compare the existing representations. This chapter, though, does not focus on the classification itself. This chapter goes a step beyond and uses the classification as an instrument to characterize how existing LD representations can scaffold the different phases of a "LD life cycle" (from the conceptualization at macro-level of a learning activity, down to the detailed planning of each task, to the setting up of the technological ecosystem that will support its delivery to students). This chapter claims that, being the phases of the life cycle characterized by different purposes (generating new ideas and designs, communicating them to others, delivering designs to learners, etc.), the use of multiple representations during the life cycle is not only quite natural and spontaneous, but even desirable. In fact, while there is no single representation that is 100 % complete and able to cover the needs of the whole life cycle, the use of different representations may help to express, at each phase, the information the learning designer deems as most appropriate.

In this light, we argue and illustrate by means of a representative example that the real need is not so much to find a "one size fits all representation," because different authors may have different preferences in different situations, but rather to integrate existing systems, to build bridges across different representations, in such a way to support the passage from one representation to another and the transition from one phase to the other of the design life cycle.

This chapter is organized as it follows: first, we describe what is a LD life cycle and provide a short overview of the literature to clarify the concept. Then, we take a look at the existing classifications of LD representations and draw the reader's attention on one of these classifications, which will be used in this chapter. After this, we make use of an example concerning a learning activity and use different representations to describe the activity in the various stages of the life cycle. Lastly, we discuss the representations in the Discussion section and draw final remarks in the Conclusions section.

10.2 The Learning Design Life Cycle

There is not a unique process for going from teachers' abstract LD ideas to their enactment with actual students (using or not the support of technological platforms). Different teachers may use different processes, depending on practices rooted on their previous experience, background, contextual restrictions, and community of practice (if any). The role of existing LD tools is to help teachers reflect on their LD decision, as well as to make them explicit (and thus potentially sharable and reusable), along the whole process of going from ideas to enactment. Explicit design decisions (in the form of "LD solutions") then need to be completed, particularized, and modified (using human or computer agents) so as to get closer and closer to the ultimate enactment (Muñoz-Cristóbal et al. 2012). That is why LD solutions are said to follow a "LD life cycle."

The research community on LD has proposed multiple models for describing the LD life cycle. They share many commonalities (being the terminology, in several cases, the main difference), but their variety underlines the fact that not a single life cycle fits all existing LD practices. Thus, for instance, the "7Cs for LD" model (Conole 2014) proposes four phases: vision, activities, synthesis, and implementation. Goodyear and Dimitriadis (2013) talk about configuration, orchestration, reflection, and redesign. Emin et al. (2009) include in their life cycle model the need for defining pedagogical intentions, integrating constraints, operationalization, and implementation. Or, in similar fashion, Weinberger et al. (2009) focus on specification, formalization, simulation, and deployment. Mor and Mogilevsky (2013) aim to capture the process of "Design Inquiry of Learning." According to these authors, such a process combines the iterative structure of educational design research with the principles of inquiry learning, thus giving birth to a cycle including defining a project, investigating the context in which it is situated and identifying appropriate techno-pedagogical theories, reviewing relevant cases and theories, conceptualizing a solution implementing a prototype of that solution, evaluating it, and reflecting on the whole process.

Acknowledging that there is a plethora of existing models for describing the LD life cycle, but also for the sake of avoiding terminology misleading, this chapter will use the LD life cycle model described in Asensio-Pérez et al. (2014) that is based on three phases: conceptualization, authoring, and implementation. The evaluation phase (also named as Reflection and Redesign, see above) is also necessary, but we do not regard it here as a "phase," since it should be carried out as an ongoing activity during the whole process, based on the peer feedback, small-scale experiments, or field tests (Persico 1997).

In the conceptualization phase, the designer starts the process by analyzing the context where she is supposed to deliver her intervention and sketches the intended learning objectives and the structure of the content domain, together with a first draft of the possible activities to be proposed. This phase can be carried out both individually or collaboratively, together with colleagues, and the approaches adopted should favor creativity and lateral thinking. Conceptualization can start from scratch or from existing "patterns" or good practices, which are analyzed to understand whether and to what extent they fit in with the learning context and needs. In the following, we will term the product of the conceptualization phase "macro-design."

Once the conceptualization phase is over and the macro-design is ready, the authoring phase takes place. In the authoring phase, the designer better defines the activity flow and provides detailed information for each activity, related, for example, to the technological tools needed, how the overall process will be orchestrated, and what learning resources should be made available to learners. This phase is an intermediate step toward implementation, and the approaches adopted provide guidance throughout the decision-making process. The output of this phase hosts this information, including contextualized details about the LD needed for the implementation phase, in a systematic and clear way, so that understanding and sharing between all the actors involved is facilitated. This is a very important half-fabricate of the LD life cycle, in that it is the basis for sharing and reuse among designers.

In the implementation phase, the authored design is completed with all the details needed for its deployment in a specific teaching context (e.g., assigning concrete students to the learning groups) using a particular technological learning platform for its enactment. Such technological learning platforms are typically based on learning management systems (LMS) or virtual learning environments (VLE). Therefore, the implementation phase often requires technical competences that the average teacher does not possess. This is why, among the tools that support LD, much attention has been focused on those that automate all or part of this phase by the LDs in LMSs or VLEs for student use. Of course, to do so, the representations needed must be formally defined, so that they are computer interpretable, and complete.[1] Since they include all the details needed for enactment in a given platform and a specific teaching context, they cannot be reused elsewhere.

[1]Actually, in most of the cases even authored LD solutions are based on computer-interpretable representations (see below for details). These solutions, though, are not linked to a particular technological platform nor teaching context, and thus, they can be reused in multiple platforms and contexts, as opposed to the implemented LD solutions, which are typically context-dependent.

10.3 Classifying Learning Design Representations

As already mentioned, a lot of representations exist aimed to describe the various LD solutions, which are the results of a LD activity (at any level of the life cycle). The need for order and/or integration in the field of LD representations has already been advocated in the literature (see, e.g., Dalziel et al. 2013); in order to meet such a need, many classifications have been proposed, mainly aimed to collocate each representation within the panorama and to support a better understanding of the potential of each individual representation as well as the relationships among different ones.

For example, Gibbons et al. (2008) identify 7 continuums along which it is possible to position the various design representations: complexity–simplicity; precision–non-precision; formality–informality; personalization–sharedness; implicitness–explicitness; standardization—non-standardization; computability–non-computability. Granularity and completeness have been proposed by Hernandez-Leo et al. (2007) to classify LD solutions, rather than representations. Agostinho (2009) and Conole (2010) are other two examples of existing works that provide an overview of the range of representations used to describe LDs, showing how they can be used to foreground different aspects of design development.

More recently, another classification has been proposed, which identifies a number of dimensions across which it is possible to place representations (Pozzi et al. 2015). This classification focuses on the following dimensions: format, level of formalism, level of contextualization, and purpose.

Taking into account all the aforementioned existing works, some of the authors of this chapter have recently synthesized an updated and unified classification (see Pozzi et al. 2015), which will be employed as the reference framework for the upcoming discussions. Thus, in the following, we briefly define the dimensions proposed by the adopted classification.

10.3.1 Format

Broadly speaking, formats fall into two main categories: textual representations, based on natural or artificial languages, and visual representations, relying on some kind of graphical notation (Conole 2012).

In particular, textual representations may be expressed rather freely in a natural language, through narratives, without constraints or imposed structure. Semi-structured narratives are also possible, i.e., narrative descriptions whose structure is provided, organized around items, so that the text answers specific prompts. Alternatively, textual representations can take the form of formal descriptions expressed in a computer-interpretable language, explicitly defined through a set of syntactic and semantic rules.

As to visual representations, these generally take the form of diagrams or graphs, which convey an overall view of the design or specific aspects thereof, such as the structure of the intervention, the learning objectives, the content to be addressed, and the roles of the people involved. Diagrams or graphs are a means to represent the main entities within a design and their mutual relationships; they include the likes of flowcharts, content maps, and swim lanes (Pozzi et al. 2015).

Another type of visual representations consists of charts, used to depict quantitative data about the intervention; examples are bar or pie charts representing features of the learning process, based on the suitable indicators, such as, for example, the expected degree of interactivity of a certain LD. These charts usually foster reflection on the design by focusing attention on the specific represented aspects (San Diego et al. 2008).

10.3.2 Level of Formalism

A representation's level of formalism regards the degree to which its use entails observation of fixed syntactic and semantic "rules": some representations have very strict rules and are therefore highly formalized, while others allow the designer much more freedom and—as a consequence—the meaning of the design will not be free of ambiguities. Among textual representations, for example, those that use natural language tend to be rather informal, while those that are based on the computer-interpretable languages are often well formalized.

10.3.3 Level of Contextualization

This dimension can be defined as the ability of one representation to bear details of how the design solution is implemented in different contexts, in such a way that the less specific the representation, the greater the scope for reusability.

Butturi and Stubbs (2008) distinguish between "sketch-oriented representations," that provide an outline, and representations that enable details to be specified. Of course, the fact that a representation allows the designer to specify all the contextual details is no guarantee that the designer will do it. In other words, a user may produce a generic LD even by using representations supporting high levels of contextualization, therefore underusing the representation potentialities. However, here we want to focus on the ability of the representation to express a high amount of details concerning the LD solution. Consequently, we will say that a representation features a high level of contextualization if it has such potential, regardless to the extent to which users take advantage of it.

10.3.4 Purpose

Generally speaking, "design languages can be used to generate designs and as a mechanism for interpreting and discussing them" (Conole 2012).

In a similar vein to the proposal made by Botturi and Stubbs (2008), who distinguish between "finalist communicative languages" and "representative languages," we contend that representations can be viewed in terms of purpose, as also Dimitriadis and Goodyear (2013) suggest. In some cases, there is greater emphasis on—and support for—the actual ideation process, thus allowing reflection and generation of ideas. In other cases, communicating design ideas through the sharing of design representations is the main aim; as Maina (2012) suggests "facilitating the sharing of pedagogical know-how supposes finding ways to make it explicit in a comprehensible manner, thus assuring communicability of the design generated" (p. 86). A third type of purpose is that of supporting automatic configuration of ready-to-use learning environments.

Ideally, we could distinguish between "representations aimed at personal use" (i.e., representations used when the designer is generating the design and/or is reflecting on it), "representations aimed at social use" (when the designer wants to communicate/share her ideas with her colleagues, such as co-designers or other perspective users) and "representations aimed at institutional use" (when the designer wants to deliver a course based on that design to learners). Even if the borders between these three categories are rather blurred, and representation forms are often blended to meet multiple purposes, some representations seem better suited—and more effective—for supporting one or the other.

10.4 Learning Design Representations and Learning Design Life Cycle: One Size Does not Fit All

The above description of the three phases of the LD life cycle supports the idea that each phase needs representations with specific features, and very seldom one representation used for one phase is also efficient to support the other phases.

It should be noted that each of these phases has a privileged relationship with the purposes mentioned in the section about representation: Conceptualization focuses on generation of ideas, authoring has a strong link with sharing and reusing effective design, and implementation usually entails the configuration of a learning environment (i.e., institutional use). However, this relationship between the three phases and the main purposes is not strictly one-to-one. For example, during the conceptualization phase it is very common for the designer to use representations that typically fall under the "personal use" purpose; however, the same representations could also be used with "social" purposes, especially when conceptualization entails reuse rather than ideation from scratch. This will be further exemplified in the following, where we will go through the three phases and show, through an example, how one learning activity can be represented at the various stages of the LD life cycle. This will allow us to discuss the various representations, focusing on their main characteristics in the light of the proposed dimensions.

The illustrative example employed throughout this section involves a higher education teacher that wants to design a learning situation, within her undergraduate course, aimed at: fostering the acquisition of competences related to the searching and selection of technical/scientific information in the Internet; the writing of technical reports; and work in groups. The learning topic of the example is purposely generic so as to illustrate how some design decisions could eventually be shared by teachers of different disciplines and teaching contexts (for a full description of this "real life" scenario refer to http://ilde.upf.edu/uva/v/dr3). In the following, this example is used to illustrate the type of design decision the teacher might make in the different phases of the life cycle, and how such decisions can (or cannot) be made explicit using different types of representations.

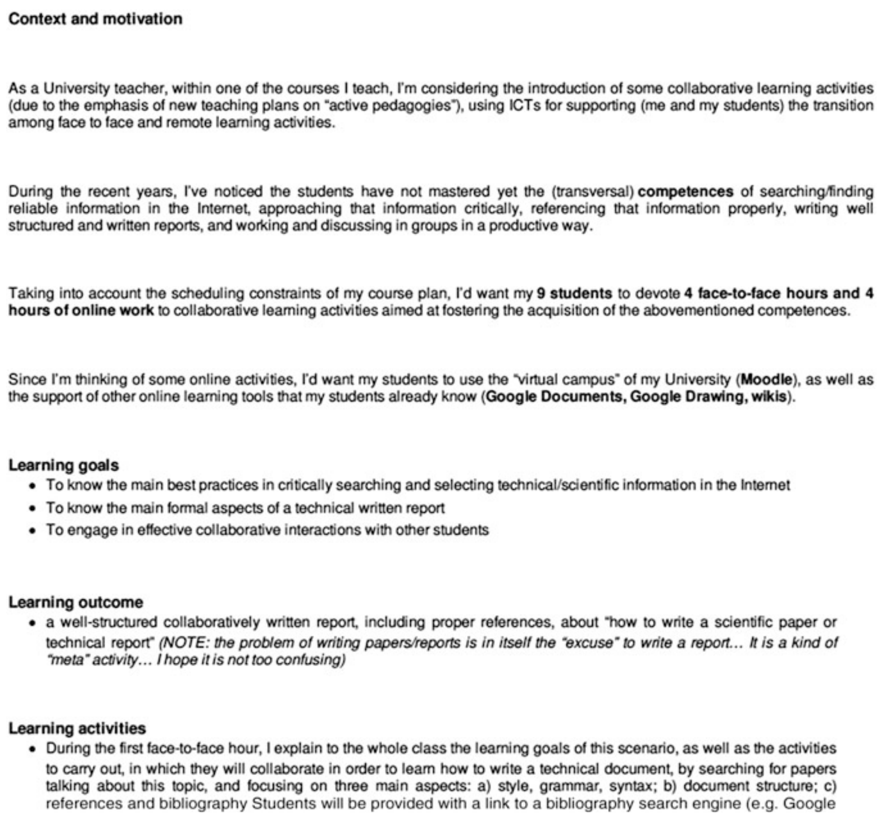
10.4.1 Representations for the Conceptualization Phase

The LD representations needed in this phase should have a maieutic function (Olimpo et al. 2010), i.e., they should facilitate reflection and generation of ideas and solutions. A strictly procedural approach and a rigorously formalized representation, in this phase, may turn out to be useless, and even hinder creativity. Furthermore, attention to contextual details can and should be delayed (to some extent), since what matters in this phase are the main ideas that will be better specified later.

As already mentioned, during the conceptualization phase designers may start up the design process from scratch or get inspiration from already existing good practices, or "patterns." In both cases, designers have to consider the variables at play, i.e., the context of the learning intervention, the participants, the goals, the existing constraints (in terms of available time and technology, etc.).

When they start from scratch, they formulate some first hypothesis about possible activities to be proposed, their schedule, the ICT tools that could be used (and how) and the way assessment could be carried out. One "traditional" way to reflect on all these elements is simply by describing them through a plain, free text; this originates a textual representation like the one shown in Fig. 10.1. In this representation, the designer has expressed the formative problem faced and the main constraints of her context, has defined the learning objectives, and has sketched a possible collaborative activity.

Looking at this representation through the lens of the aforementioned dimensions, we can see that it features a low degree of formalism, because no strict rules are followed. As to its level of contextualization, the presentation can be in principle very general (low degree of contextualization), or—as in this specific case—it might contain details (high degree of contextualization), but—given its low level of formalism—such a textual representation will never allow complete implementation



Context and motivation

As a University teacher, within one of the courses I teach, I'm considering the introduction of some collaborative learning activities (due to the emphasis of new teaching plans on "active pedagogies"), using ICTs for supporting (me and my students) the transition among face to face and remote learning activities.

During the recent years, I've noticed the students have not mastered yet the (transversal) **competences** of searching/finding reliable information in the Internet, approaching that information critically, referencing that information properly, writing well structured and written reports, and working and discussing in groups in a productive way.

Taking into account the scheduling constraints of my course plan, I'd want my **9 students** to devote **4 face-to-face hours and 4 hours of online work** to collaborative learning activities aimed at fostering the acquisition of the abovementioned competences.

Since I'm thinking of some online activities, I'd want my students to use the "virtual campus" of my University (**Moodle**), as well as the support of other online learning tools that my students already know (**Google Documents, Google Drawing, wikis**).

Learning goals

- To know the main best practices in critically searching and selecting technical/scientific information in the Internet
- To know the main formal aspects of a technical written report
- To engage in effective collaborative interactions with other students

Learning outcome

- a well-structured collaboratively written report, including proper references, about "how to write a scientific paper or technical report" *(NOTE: the problem of writing papers/reports is in itself the "excuse" to write a report… It is a kind of "meta" activity… I hope it is not too confusing)*

Learning activities

- During the first face-to-face hour, I explain to the whole class the learning goals of this scenario, as well as the activities to carry out, in which they will collaborate in order to learn how to write a technical document, by searching for papers talking about this topic, and focusing on three main aspects: a) style, grammar, syntax; b) document structure; c) references and bibliography Students will be provided with a link to a bibliography search engine (e.g. Google

Fig. 10.1 "Free" textual representation of a jigsaw activity. http://ilde.upf.edu/uva/pg/lds/view/4492/

(full life cycle). Usually, the purpose of this representation is to stimulate reflection and generation of new ideas (personal use), but it might also be adopted to support sharing with colleagues (social use).

Often, during the conceptualization phase, the designer needs to brainstorm and define concepts and constraints but, in line with the literature on LD and instructional design, she might also find very useful structuring them through maps, graphs, etc. Consequently, at this level of the macro-design definition, besides writing down a text like the one in Fig. 10.1, designers draw maps of the content domain or produce graphical representations of the ideas they are working on. For this reason, a number of tools intended to support LD provide for "double representations" for this phase. The Pedagogical Planner (Ott et al. 2014), for example, along with the description of some aspects through plain text (Fig. 10.2a), also allows the production of visual representations (Fig. 10.2b) through which the designer can map the content domain. In this case, the designer has defined the learning objectives in the same way as she did with the free text (Fig. 10.1) and

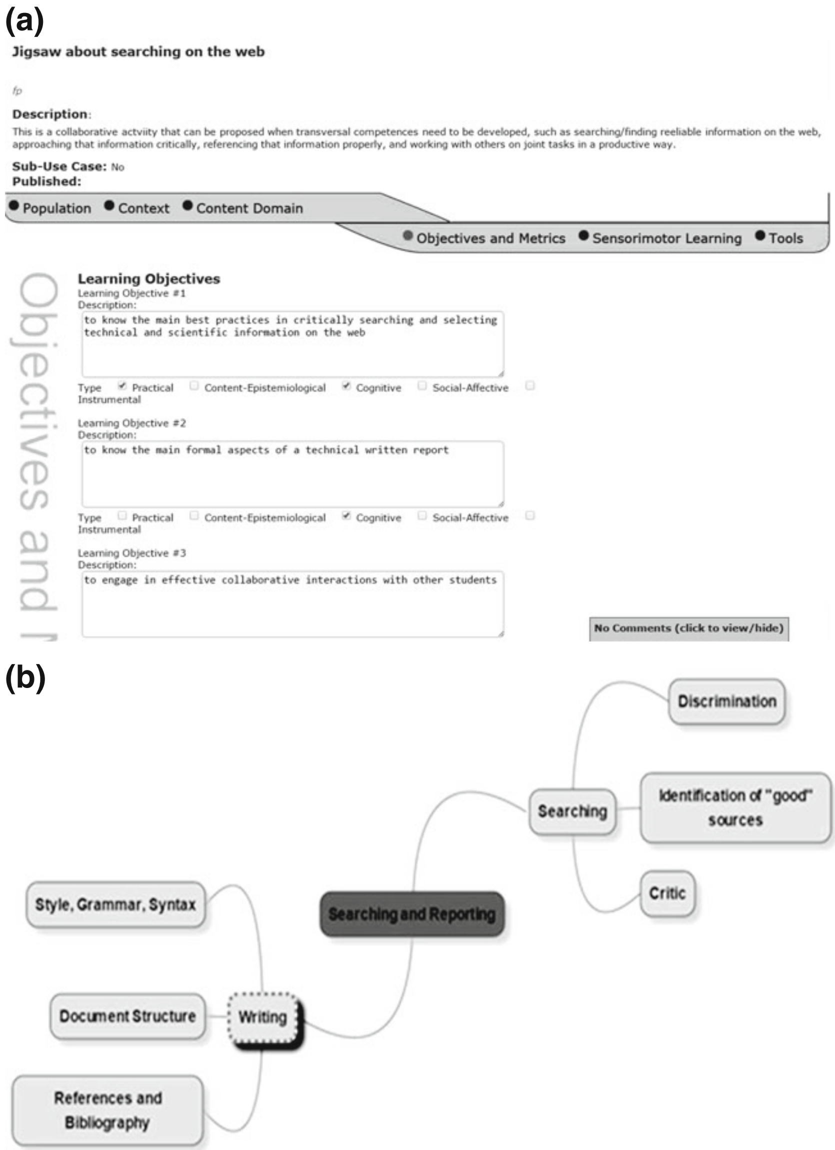


Fig. 10.2 Example of double representations in the Pedagogical Planner: conceptualization functions

analyzed the domain involved producing a representation of the content in form of a map. Such functionalities of the Pedagogical Planner can be ascribed to personal use and aimed to support reflection and generation of ideas, so to help the designer in taking decisions at the macro-design level.

Similar approaches are used by the other tools, such as the learner designer (Laurillard et al. 2011), which compound textual descriptions with graphical representations of some features of the design, to support reflection, evaluation, and generation of ideas.

When the designers get inspiration from already existing good practices, the conceptualization phase starts from "patterns," which are usually described in very abstract terms and with some level of formalism, in such a way that they are reusable in different contexts. It is the case of the pedagogical patterns (Bergin et al. 2012), which are textual representations, following a given structure, according to which it is possible to describe the pattern of an activity, that is, a generic procedure to be followed to carry out a certain type of activity and the conditions required to do so (see Fig. 10.3).

In this case, the original, "empty" pattern is very general (low level of contextualization); if the designer identifies a pattern suitable for her context, then she tries to localize the pattern into the concrete situation at hand. In our example, the designer has identified the jigsaw pattern as a possible design solution for her context.

Sometimes, patterns can be represented through visual representations (usually in graphical form), as in Fig. 10.4, which represents an "empty" jigsaw.

The difference between the two options (visual vs. textual patterns) lays in the immediacy of visual representation, while the textual one (at least potentially)

Name	Jigsaw
Problem	A complex problem whose resolution requires handling information that can be divided into disjoint sets and used for the resolution of independent sub-problems.
Context	Several small groups facing the study of a large amount of information for the resolution of the same problem.
Session's Agenda (flow of session's step)	1- Instructor gives a specific period of time for each participant in the group (jigsaw group) to study a particular sub-problem. 2- The participants in different groups that study the same problem meet in expert groups for exchanging ideas. 3- Finally, jigsaw group participants meet to solve the whole problem.

Fig. 10.3 The jigsaw pattern (textual representation). http://ses.library.usyd.edu.au/bitstream/2123/1943/1/thesis.pdf

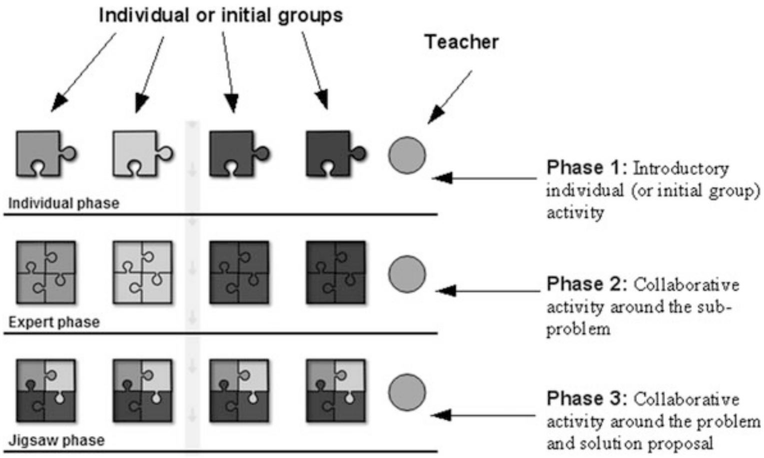


Fig. 10.4 The jigsaw pattern (visual representation). http://pandora.tel.uva.es/~wic/wic2Ldshake/patterns/en/jigsaw/

allows for a greater accuracy of information. The two representations share a medium level of formalism, as both of them follow some rules (the items of the patterns for the textual representation, and the use of a set of symbols with a specific meaning for the graphical representation), but these are not strictly defined.

These representations, and in particular the graphical one, are mostly used for sharing purposes, though they can also support reflection and generation of design ideas.

Several approaches and theoretical models exist, aimed to give a strong support to the designer in considering all the elements at play and their interconnections, i.e., to guide the decision-making process in LD (Persico et al. 2013). This is the case of the 4Ts approach (Pozzi and Persico 2013) and of the 4SPPices model (Pérez-Sanagustín et al. 2012), shown, respectively, in Figs. 10.5 and 10.6.

In particular, the 4Ts representation supports the design of CSCL (computer supported collaborative learning) activities, by focusing the designer's attention on four main elements (task, team, time, and technology) and the iterative decision-making process concerning them and their interactions. To continue with our example of the jigsaw, the 4Ts model helps the designer to consider the 4Ts of a jigsaw, and the way they are influenced by the contextual constraints, so to scaffold the "contextualization" process which will transform the jigsaw pattern into the "actual/localized" jigsaw activity.

Similarly, the 4SPPIces is a conceptual model (and related representation) conceived for providing practitioners (experts in education) and technicians (knowledgeable about technologies available) with a conversational framework to support and facilitate the design of computer supported collaborative blended learning (CSCBL) scripts (Pérez-Sanagustín et al. 2012). These representations are

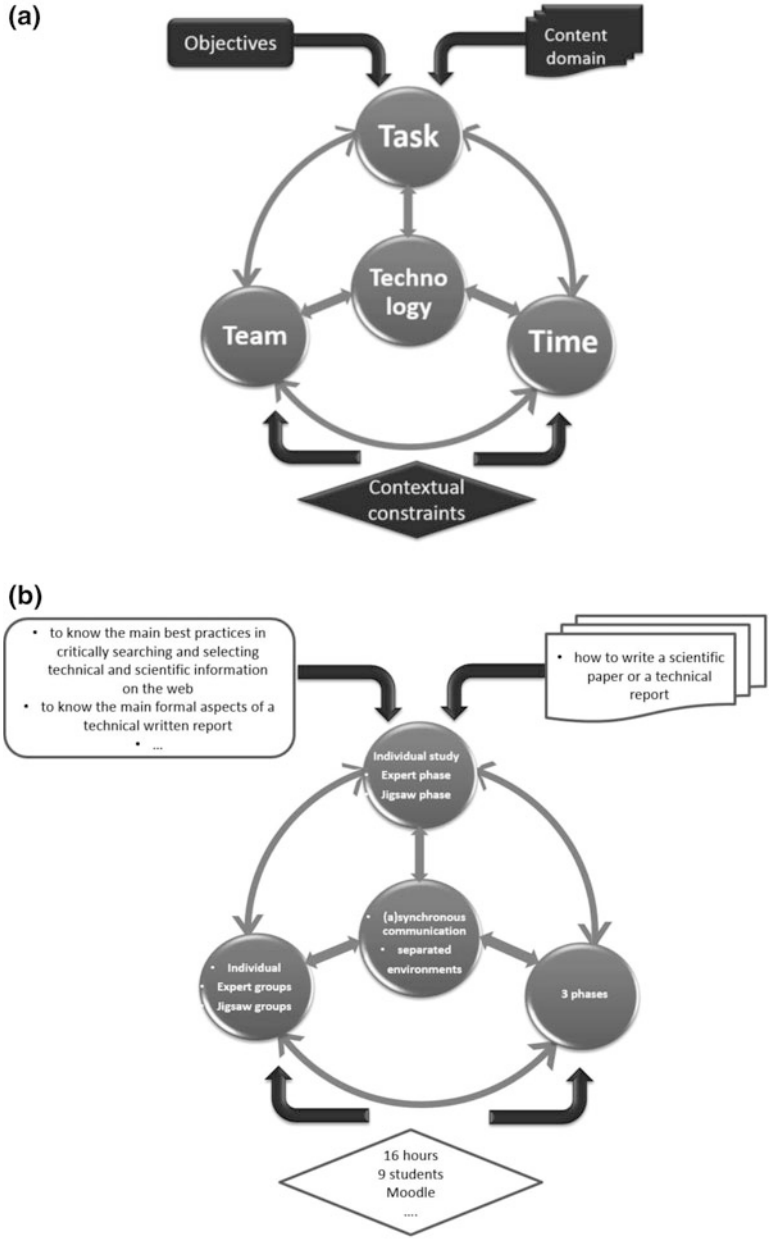


Fig. 10.5 **a** The 4Ts approach. **b** Application of the 4Ts approach to the design of a jigsaw

particularly useful to visualize the interconnections between the decisions to be taken by the designer, because they make it clear how a decision about timing, for example, influences relevant decisions about task, and in turn, about teams.

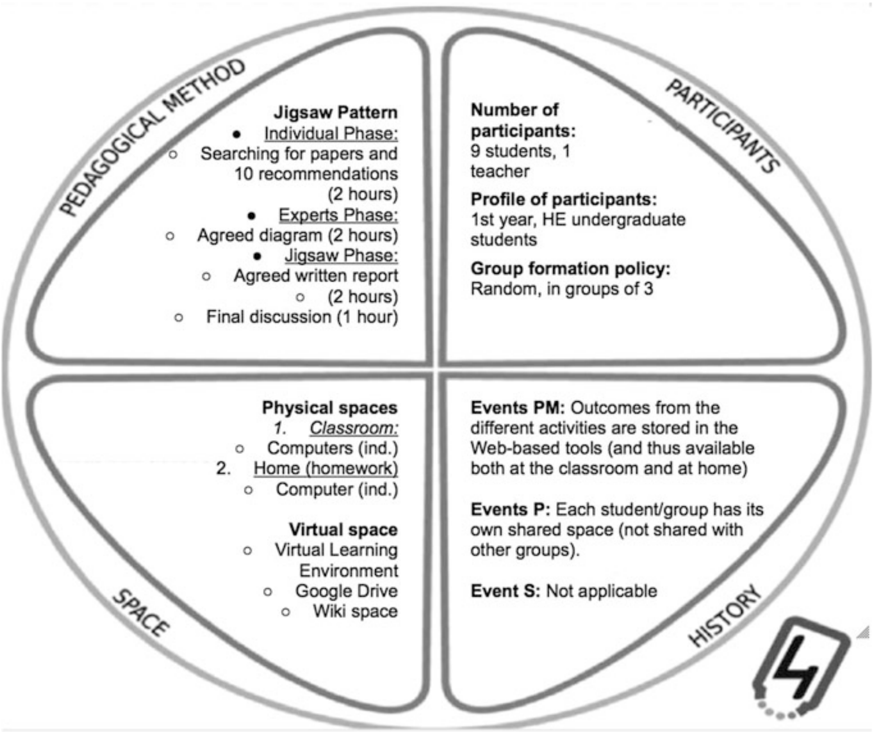


Fig. 10.6 The 4SPPIces approach

10.4.2 Representations for the Authoring Phase

Once the design has been conceptualized and needs to be transformed into a computationally interpretable design, the authoring phase comes into play.

This phase aims to complete the conceptualized design, by providing all the necessary information and resources to allow reuse by other designers and/or go for implementation. This may be a very complex and labor-intensive phase, including the development or identification of the learning resources and requiring the input of a lot of data concerning the set up of the learning activity. Given that the average teacher usually does not possess high technical skills, tools supporting authoring need to offer user-friendly and easy interfaces prompting the authors for the information and decisions needed.

In this phase, representations (usually visual ones) are used to guide the designer in specifying her design and compiling all the necessary fields. In WebCollage (Villasclaras-Fernández et al. 2013), for example, our designer could start from a jigsaw Collaborative Learning Flow Pattern (CFLP) (see Fig. 10.7) and further refine the conceptualized design, by adding detailed description of the activities,

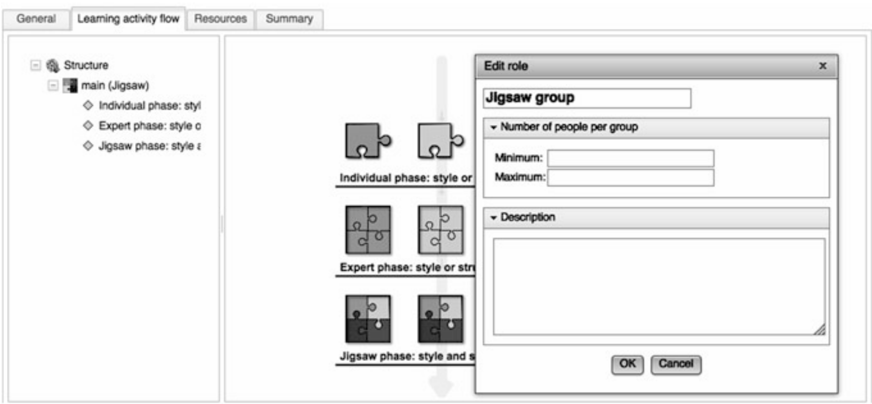


Fig. 10.7 Authoring phase in WebCollage

deciding their concrete sequence, detailing how many groups are expected to participate in each activity, etc. (see Fig. 10.8).

This generates other, more detailed, and more complex visual representations, able to convey detailed information. It is important to point out that during the authoring phase, designs are "decoupled" from the specific technological and teaching environment in which they are expected to be enacted. This way, designs created during the authoring phase can eventually be reused so as to be implemented (see next phase) in a different virtual learning environment or VLE (e.g., Moodle), with different groups of students, etc.

It should be noted that in WebCollage, as in some of the other tools examined so far, the diagrammatic representation is complemented with textual representations. For instance, the list of learning goals and the description of the activities are represented textually (using forms, tabs, etc.) (Fig. 10.9).

Similarly, the already-mentioned Pedagogical Planner, which also offers authoring functionalities, supports double representations, textual and visual: the former to describe each single activity and the latter to define the activity flow (Fig. 10.10).

Similar approaches are embodied in OpenGLM (De Liddo et al. 2011) and CADMOS (Katsamani and Retalis 2012).

The trend of several authoring tools, as well as of the conceptualization tools, to embed more than one representation indicates that the need is felt to use different representations, and specifically to compound the textual and the visual formats to allow for more expressiveness and completeness of information.

Unlike what happens in the conceptualization phase, the output of the authoring phase is the translation of all the data inputted by the designer into a computer-interpretable language (like, for example, IMS-LD or similar). This is usually transparent to the user and is a necessary step before the implementation phase. This computer-interpretable description of the output of the authoring phase is

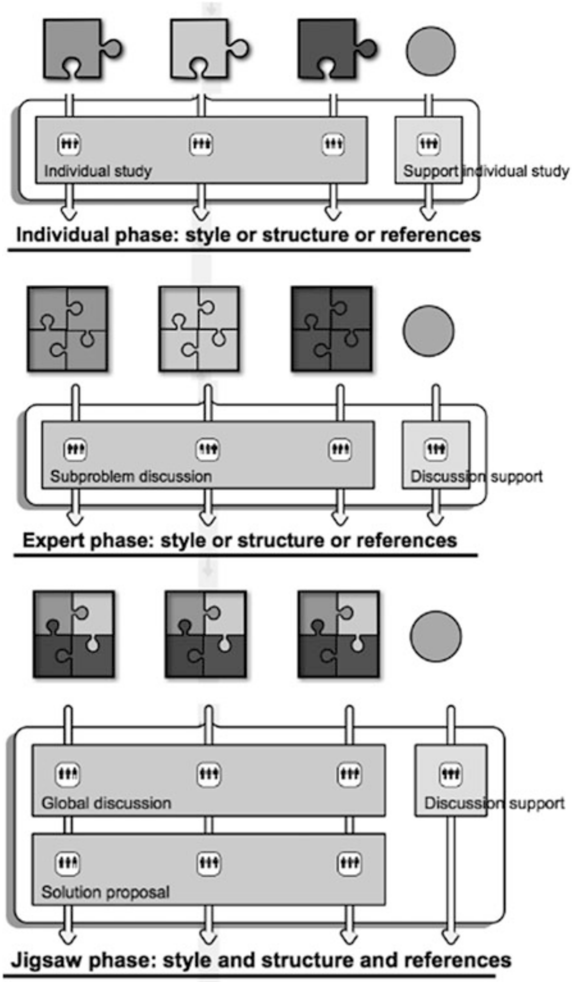


Fig. 10.8 Example of visual representation of WebCollage in the authoring phase

highly formal and can express different degrees of "contextualization," i.e., it can be very general (if it is used to represent an empty pattern, in our case a plain jigsaw), or very detailed, if it describes a "contextualized" pattern, in our case the localized jigsaw (Fig. 10.11).

10.4.3 Representations of the Implementation Phase

The implementation phase has to do with all of those design decisions concerning the details of the enacting technological platform (e.g., based on a VLE such as Moodle) by means of which the enactment of an authored design is intended to be

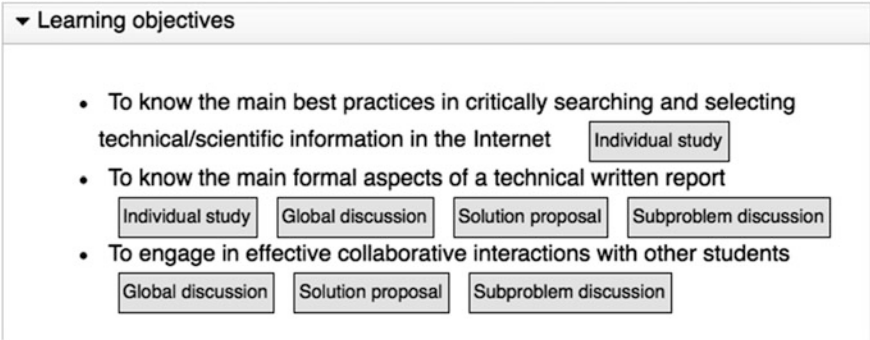


Fig. 10.9 Example of textual representation in WebCollage

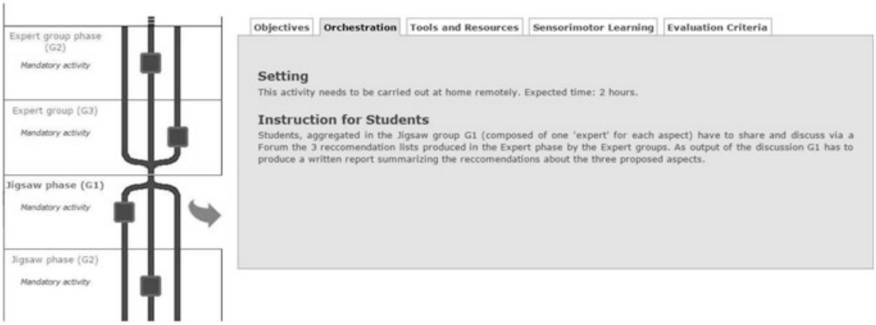


Fig. 10.10 Visual and textual representations in the authoring phase of the Pedagogical Planner

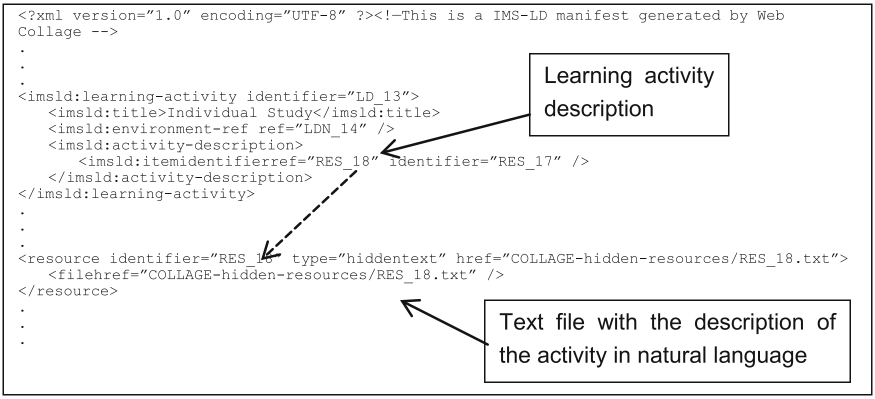


Fig. 10.11 Excerpts of MS-LD code describing our example

supported. Once the design decisions have been made (e.g., a Moodle forum is to be used for scaffolding the work of this or that specific group of students), the implementation phase finishes with the actual setting up of the technological platform that will be actually used by the students (a process known as "deployment," see Prieto et al. 2013b).

It is quite common that deployments are carried out manually by manipulating the target platform (e.g., editing a Moodle course) in a so-called bricolage approach (Berggren et al. 2005) that sometimes require technical expertise. When using this approach, the teachers (or instructional designers) need to understand the visual representations associated to the graphical user interface (GUI) of the target platform, so as to take design decisions at the implementation level (e.g., which Moodle tool should be used for each envisioned activity). For instance, Fig. 10.12 shows the representation of the sample scenario as a Moodle course. It is important to underline that these representations (and hence, the design decisions they contain) cannot be reused in different technological platforms.

However, when pedagogical ideas are made explicit using computer-interpretable representations, it is possible to automate the deployment process, thus reducing the implementation workload and avoiding the need for understanding technical details. Additionally, when using automatic deployment approaches, design decisions at the implementation phase are not made at the same time the target environment is being set up, but rather beforehand, using the features of the automatic deployment tool. This is the case of, e.g., GLUE!-PS (Prieto et al. 2013a) and LAMS (Dalziel 2003).

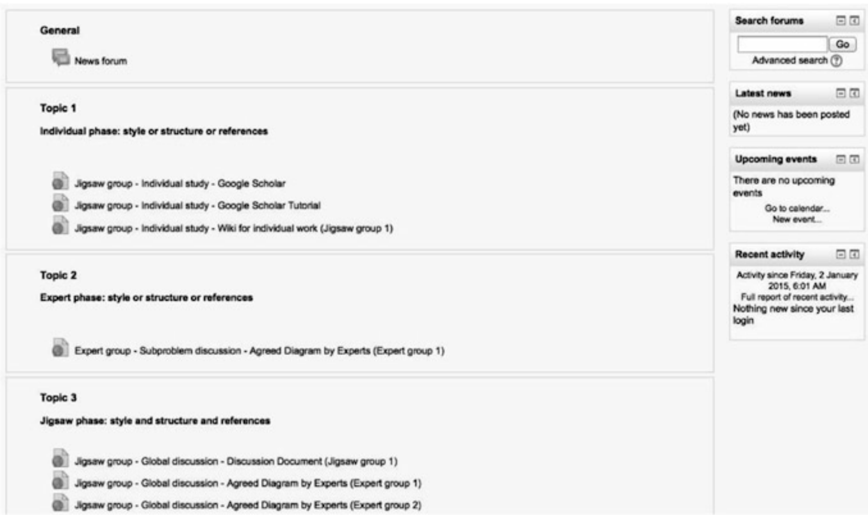


Fig. 10.12 Visual representation of an implementation in the Moodle virtual learning environment

When the implementation phase is carried out using automatic deployment tools such as GLUE!-PS or LAMS, two types of representations are usually employed: a visual representation intended to be manipulated by the teachers, and a computer-interpretable (textual) representation that will be used for automatically setting up the learning environment (i.e., for deployment). For instance, Fig. 10.13 shows a screenshot of the GLUE!-PS GUI, in which it can be appreciated how teachers can make decisions about: the number and/or composition of the groups of students actually enrolled in the targeted VLE; the specific "resources" (Web-learning materials, but also learning tools such as forums, document editors) that will be available for each activity, among those available in the targeted learning environment, etc.

As an example of computer-interpretable (textual) representation, the so-called GLUE!-PS lingua franca (LF) codifies all design decision taken by teachers at the implementation phase (when using the GLUE!-PS system). The GLUE!-PS LF includes elements for modeling "decontextualized" features of a LD (including notions such as activity, resource, or learning goal, which typically are defined during the authoring phase), as well as other elements for modeling "contextualized" features of the specific learning context (with notions such as group, participant, tool instance, or learning environment). Therefore, representations based on the GLUE!-PS LF (see, for example, in Fig. 10.14) are expected to be created by translating representations generated during the authoring phase (e.g., using IMS-LD representations), and then to be completed with design decisions made at the implementation phase by teachers (using the GLUE!-PS GUI). Once all the implementation details are worked out, the GLUE!-PS LF is ready to guide the (automatic) implementation process into the targeted learning environment.

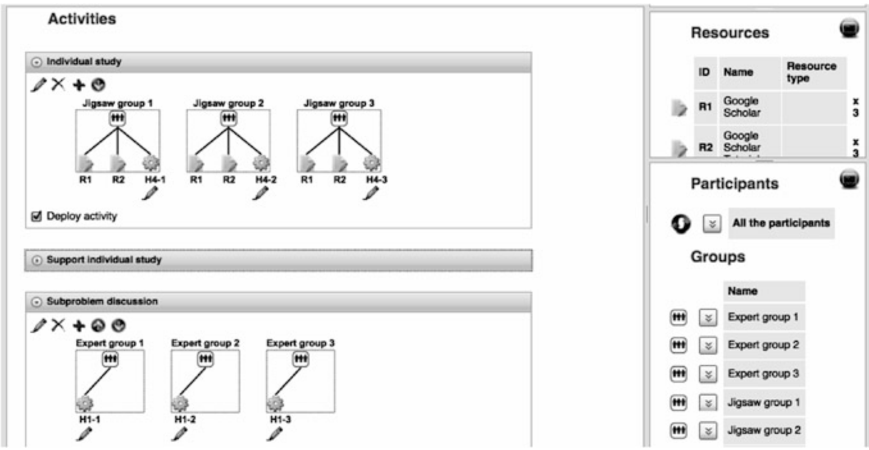


Fig. 10.13 Visual representation of an implementation in the GLUE!-PS graphical user interface (Prieto et al. 2013a)

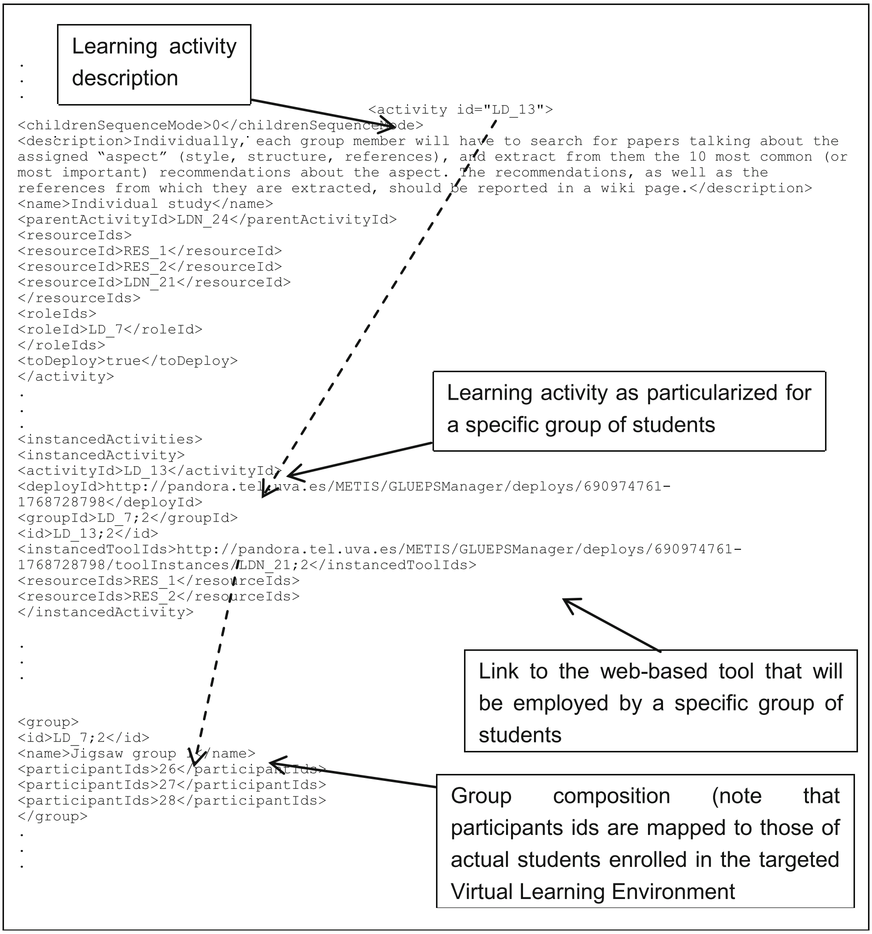


Fig. 10.14 An excerpt of the GLUE!-PS LF description of our example activity

In the case of GLUE!-PS, LDs can be deployed into different VLEs (Moodle, MediaWiki, etc.), unlike LAMS designs, which can only be deployed into the LAMS run-time environment.

10.5 Discussion

Starting from the overview sketched in the previous section, we can draw some final considerations.

First of all, it is clear that, if we look at the three phases of the design life cycle as a continuum (from conceptualization to authoring and then implementation) representations increase their degree of formalism, from informal representations typically used in the conceptualization phase to the highly formalized representations that are necessary to allow implementation.

The situation is different for the contextualization dimension: some of the representations used for the macro-design (output of the conceptualization) are able to express many details, but others express very general designs (the patterns) that will be later on contextualized and localized. Even in the authoring and the implementation phases the degree of contextualization may vary a lot.

The purpose dimension somehow mirrors the three design phases, but not completely: representations typically employed during the conceptualization phase are basically for personal use (sometimes also for social use); those employed during authoring are often oriented to social use, and representations typical of the implementation phase have got an institutional purpose.

Furthermore, it is clear that in all the phases (and for sure in the first two) there is a clear need to have a double format of representations, namely visual accompanied by textual representations.

From this overall picture, we can see that, on the one hand, there is not a widely acceptable way to represent ready-to-implement LDs, in spite of the efforts made in the last few years to define a unique computer-interpretable LD language (being IMS-LD the most remarkable one). The explosion in the number of available learning environments (each one based on its own, proprietary way of representing LD solutions) has created a “deployment gap” between the authoring and the implementation phases. Such a gap requires yet another set of intermediate representations as the one proposed by the GLUE!-PS LF.

On the other hand, the proliferation of tools oriented to conceptualization and authoring is justified by a need to allow various approaches during the early stages of the LD life cycle.

In other words, we are suggesting that trying to find the all-purpose representation would be pointless. What seems important, instead, is to make the integration of various representations possible, so to guarantee an easy and smooth way throughout the three phases and an interchange of by-products among different tools. This is the direction currently followed by the METIS project[2] and funded under the lifelong learning program, whose main aim is exactly to integrate into one single environment a number of existing tools and their associated representations of LDs. In the project, so far, most of the efforts have been devoted to build the bridge between a number of authoring tools and the Glue!-PS LF; for the future, it would be advisable also to work toward bridging the conceptualization tools as well. The downside of this integration approach of multiple tools and representations is the risk of increasing the cognitive load of teachers. A related risk has to do with the potential “loss” of design decisions taken in earlier phases of the life cycle when they cannot be represented by the tools employed in a subsequent phase (Muñoz-Cristóbal et al. 2012).

[2]http://www.metis-project.org.

10.6 Conclusions

This chapter acknowledges the existence of a rich literature and a variety of practices concerning the use of many different methods of representation in LD. These representations vary in format, degree of formalism, ability to incorporate contextual information, and to serve different purposes. Even the LD tools developed so far often integrate two or more types of representations and most of them try to support more than one phase of the LD process: conceptualization, authoring, and implementation. It clearly stands out that there is no one size fits all representation: personal preferences, technical competences, and aims of the representation determine the choice of the designers that may even be different at different stages of their work. So, the questions tackled in this chapter are as follows: Can we bring order out of this chaos? Is the quest for the perfect representation one of the main objectives of research in LD, or are there good reasons to preserve such a variety?

As for the first question, several authors (Agostinho 2009; Butturi and Stubbs 2008; Pozzi et al. 2015) have analyzed the features and potential of the different representations in use, proposing different ways to classify them according to such features. This line of work has led to a better understanding of the reasons why different designers may choose to use different representations and why even the same designers may adopt different representations at different stages of their work. Based on these results, it turns out that the quest for the perfect representation, which has been an implicit aim of a significant part of the research in LD, is perhaps a misleading objective. In fact, what would “perfect” mean in this context? A perfect representation should be easy to use and interpret, i.e., it should not require exceedingly high technical skills both to produce it and to understand it. At the same time, it should be complete enough to allow for the inclusion of all the information needed to understand, reuse, and implement a LD solution. However, to make reuse easier would entail omitting those details that have to do with the specific learning context at hand and are therefore needed for implementation. It should be formal, so that misunderstandings are virtually impossible and even computers could process it. However, a high degree of formalism can only be obtained by defining and following strict rules which might hinder creativity, unless such rules are so rich and flexible that they can be bent to represent virtually anything. But, in this case, could they be as easy to use as desirable?

In conclusion, it seems that some of the features that are highly desirable at one stage of the design, or in view of a specific purpose, almost contradict, or at least should be superseded by other features, whose importance have higher priority at other stages or in view of other purposes. This leads us to believe that it is not a coincidence that designers use different representations sometimes in an integrated manner (as they do with textual and graphical ones) and sometimes with different purposes. Neither is it a coincidence if they choose representations whose degree of formalism gradually increases, up to the point where implementation is almost natural and deployment automatically achievable. Based on this belief we conclude that, rather than looking for the perfect representation, researchers should aim for the development of tools that integrate and achieve interoperability between several representation formats, in order to help bridging the gaps between representations both within the same LD phase and among the different phases.

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Author Biographies

Francesca Pozzi is presently researcher at the Institute for Educational Technology (ITD) of the Italian National Research Council (CNR) and has got a Ph.D. in cultures, languages, and ICT (University of Genoa). Pozzi has participated in many national and international projects. Her main research interests include learning design: methods, tools and representations; computer supported collaborative learning (CSCL)—strategies and techniques to support collaboration in online learning processes; how to monitor and evaluate CSCL processes; models, methods, and tools for teacher training in the knowledge society; and technology-enhanced learning in cultural heritage education. She is author of several scientific publications of various kinds, including books, papers on journals, conference proceedings, concerning various aspects of educational technology.

Juan I. Asensio-Pérez received the MSc and Ph.D. degrees in telecommunications engineering from the University of Valladolid, Spain, in 1995 and 2000, respectively. He is currently an associate professor of telematics engineering at the University of Valladolid. His research interests within the field of technology-enhanced learning include learning design, the integration of external tools in virtual learning environments, the technological support for the orchestration of collaborative learning situations, the semantic annotation of learning tools in the Web of Data, and the application of augmented reality technologies for the support of learning situations across multiple virtual and physical spaces.

Donatella Persico is senior researcher at the Institute for Educational Technology (ITD) of the Italian National Research Council (CNR). Her major research interests include learning design, e-learning, self-regulated learning, and teacher training. She has been involved in several teacher training programs as a lecturer in educational technology. She is author of educational material and scientific publications of various kinds, including books, educational software, multimedia material, and research papers, concerning various aspects of educational technology. She is co-editor of the Italian Journal *TD Tecnologie Didattiche*, collaborates with international and national journals on educational technology, and has been in charge of several national and international projects.

Part III
Adaptive and Personalized Learning

Chapter 11
Measurement of Quality of a Course

Analysis to Analytics

Jérémie Seanosky, David Boulanger, Colin Pinnell, Jason Bell, Lino Forner, Michael Baddeley, Kinshuk and Vivekanandan Suresh Kumar

Abstract Traditionally, the quality of a course offering is measured based on learner feedback at the end of the offering. This chapter offers a method to measure the quality of a course offering—continually, formatively, and summatively—using factors such as the quality of resources used, learner motivation, learner capacity, learner competency growth, and instructor competence. These factors are represented in a Bayesian belief network (BBN) in a system called MI-IDEM. MI-IDEM receives streams of data corresponding to these factors as and when they become available, which leads to estimates of quality of the course offering based on individual factors as well as an overall quality of the offering. Continuous, formative, and summative course quality measurements are imperative to identify weaknesses in the learning process of students and to assist them when they need help.

J. Seanosky (✉) · D. Boulanger · C. Pinnell · J. Bell · Kinshuk · V.S. Kumar
Athabasca University, 1200, 10011-109 Street, Edmonton AB T5J 3S8, Canada
e-mail: jeremie@rsdv.ca

D. Boulanger
e-mail: david.boulanger@dbu.onmicrosoft.com

C. Pinnell
e-mail: slysavant@gmail.com

J. Bell
e-mail: maleficus1234@gmail.com

Kinshuk
e-mail: kinshuk@athabascau.ca

V.S. Kumar
e-mail: vive@athabascau.ca

L. Forner
Holland College, 140 Weymouth Street, Charlottetown, PEI C1E 1E6, Canada
e-mail: lforner@hollandcollege.com

M. Baddeley
CNRL Horizon, 2500, 855-2 Street SW, Calgary AB T2P 4J8, Canada
e-mail: Michael.Baddeley@cnrl.com

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This chapter professes the need for a comprehensive measurement of course quality and ensuing initiatives to personalize and adapt course offerings. It presents two case studies of this novel approach: first, measurement of the quality of a course offering in a blended online learning environment and second, measurement of the quality of training course offering in an industry environment.

Keywords Course quality assessment · Analysis versus analytics · Mixed-initiative instructional design evaluation model · Learning analytics · Blended online instruction · Continuous assessment

11.1 Introduction

The good quality of any online course is crucial to the proper learning process and success of the students enrolled in it. Without proper course quality measurements, it is difficult to accurately identify weaknesses in the learning process of the students in order to help them perform better, as a potential weakness can be caused by the poor quality of the course and not directly related to the student.

The course quality assessment process can be subjective and biased if the data for assessment come from a single source. To minimize the negative impact of such subjectivity, one can seek a combination of data sets originating from related yet independent sources. The underlying design of the course quality assessment framework goes beyond analyzing an isolated data set, but takes into account a series of unstructured and structured data directly and indirectly relating to students, instructors, and course materials.

This research proposes to analyze students' learning habits as a means to assess quality of the course offering, and to pinpoint any weakness in the design of the curriculum, explain the impact of this weakness on student's learning, and recommend corrective actions.

A system called Mixed-Initiative Instructional Design Evaluation Model (MI-IDEM) has been developed based on the course quality assessment framework. Analytics performed by MI-IDEM is based on factors such as the quality of resources used, learner motivation, learner capacity, learner competence growth, and instructor competence. Every factor is measured individually from one or more data streams. For example, the quality of resources can use the course exit surveys' data, the learner's motivation can be measured through sentimental analysis, learners can be clustered or profiled into capacity categories by analyzing their observed study habits as well as their course and assignment grades, students' competence growth can be measured as an abstraction of observation of skills over time, and the instructor competences can also be determined through course exit surveys as well as the general performance of students and personal reflections.

This course quality assessment framework employs Bayesian belief network (BBN) as the underlying representation and inference mechanism. This approach consists of using BBNs to probabilistically predict the quality of a course based on the aggregation of multiple data sets. This approach pushes forward the idea of adaptive and personalized course offerings based on real-time feedback from MI-IDEM. It is important to note that although this chapter showcases MI-IDEM in an entirely online environment, the same data method can be deployed in traditional classrooms as well as in blended courses.

11.2 Literature Review

This section is dedicated to evaluating current research in the area of course quality analytics, especially with respect to online courses. It also summarizes several research articles in course quality analytics, also referred to as instructional design assessment, and highlights recent trends and efforts in the domain.

Tervakari et al. (2013) report on the visualization of participation and activity of students as an indicator of course quality, in a TUT Circle. A TUT Circle is ‘a social media enhanced Web service for learning, networking, and communication.’ The study showed that adding well-designed visualization tools helped teachers improve learning–teaching strategies and also design better-quality online courses. Visualization helped students to monitor their own performance and activities in the course and accordingly adjust their learning processes or strategies.

Reumann et al. (2008) describe the benefits and methods for designing or redesigning courses to include ‘active learning’ methods and a student-centered instructional approach, as opposed to the classical course model where learning progress is assessed with the help of written tests and assignments at fixed points in the course schedule. This new course structure required only a few minor changes in the original structure of the course. New assessment methods were added to the course, such as minute papers, short tests, mini-projects, and a group project at the end of the semester. The overall idea was to allow teachers to closely monitor (at closer time intervals) the learning progress of each student throughout the course, thus enabling the teacher(s) to spontaneously come to the rescue of any student having learning challenges in a given course. This new model was applied to an actual university course. The results showed that before the changes to the course structure were applied, around 27 % of the class failed the course. After the new course structure was applied, the failure percentage dropped to 14 %. The new course methods resulted in more evenly distributed grades and enabled more students to achieve better results.

Hrmo et al. (2012) introduce methods or criteria for assessing the quality of textbooks in university courses, especially e-learning textbooks. A study was conducted comparing an e-learning textbook on Machine Production developed for 1st-year students of a post-secondary course with classical textbooks on the same subject. The comparison was done based on a list of properties desirable in any textbook. The textbook quality evaluation was conducted by means of a questionnaire. Overall, 22 teachers of technical vocational subjects participated in the survey, providing their own evaluation of the e-textbook on Machine Production. The text quality assessment used a scale of −2, −1, 0, 1, 2, with higher numbers indicating higher quality. The properties assessed by the teachers included content accuracy, exemplification, connection of theory with practice, simplicity, attractiveness, good organization and logical structure of the subject matter, student motivation, illustrations, recycling of the learnt matter, feedback, aesthetic aspect, and self-assessment. This research concluded that the e-learning material is better than the traditional textbook based on the evaluated properties.

Smolin and Butakov (2012) propose to analyze the quality of course syllabi using artificial intelligence (AI) techniques. Since syllabi are the backbone of a course, ensuring their quality is paramount. AI methods are applied to automate the syllabus evaluation process using characteristics such as validity, usability, and efficiency. This AI-based approach is compared against the classical human-based syllabus quality control methods. Rule-based systems are used to detect latent problems in the syllabus structure before it is implemented in a real course. To test these statistical and rule-based syllabus analysis methods, a prototype system called VIPES has been built. This program applies rules to assess the quality of the syllabus and present the syllabus as a mathematical graph. VIPES also visualizes the syllabus for the student and his/her achievements in relation to the syllabus. The student can choose an objective for next activities in VIPES, and the system will generate the appropriate learning path to achieve the outcome according to the syllabus.

Research reviewed so far tended to focus on ways to improve course quality based on the summative analysis of current courses. They used different methods of assessment to evaluate different areas of course quality. They focussed on analyzing one or more specific course aspects and then propose methods to improve the quality in those areas. In comparison, MI-IDEM's focus is the overall and continuous course quality analytics that also allows for partial course assessment and partial quality improvement methods.

MI-IDEM uses a combination of traditional course assessment methods in addition to methods that include specific aspects of any given course. The goal of MI-IDEM is to provide highly accurate, real-time, probabilistic information as to the quality of any given course using a BBN approach. This real-time feedback data serve to provide each student an adaptive, personalized learning experience based on the real-time course quality assessment information computed by MI-IDEM. MI-IDEM feeds on an extensible, continuous flow of course feedback data set coming from student feedback surveys, learning designers, learning activity sensors, forum postings, and course-oriented social media communications. The system provides a highly accurate probabilistic course quality figure which is then used to provide a personalized, adaptive learning experience to the student.

11.3 Contribution of LAMBDA to MI-IDEM

MI-IDEM is a system developed to assess the quality of any given course based on a combination of different learning and instruction-related data sets (El Kadi and Kumar 2010; Forner et al. 2013). MI-IDEM uses feedback such as course exit surveys filled in by students enrolled in the course, log data from LMSs, feedback from teachers in the course, performance data from students' assignments and tests, and student postings in online discussion forums to assess course quality based on pre-defined evaluation criteria.

Data from the feedback sets are fed into a database, which is then used to populate a course quality assessment BBN for the course under evaluation. For example, MI-IDEM currently uses a four-level grid to assess the course material based on student feedback. The four quality levels are 'strong,' 'satisfactory,' 'weak,' and 'unsatisfactory.' Each level has a value associated with it, which is the percentage of students who assessed the quality of the course material according to that particular level. Quality of course material/content is evaluated based on different sub-rubrics which are graded from student feedback. Each sub-rubric evaluation grid consists of five satisfaction levels. Those sub-rubrics are mapped onto the main evaluation rubric, course material quality, using conditional probability tables (CPTs). Finally, the rubric on course material quality, along with other rubrics and their sub-rubrics, is combined using CPTs to provide the final probabilistic course quality rating.

All the evaluation rubrics are presented as a BBN in a treelike structure. The core node depicts the overall course quality rating, which is determined by a combination of the assessments of the child nodes.

MI-IDEM can easily be considered a system 'at scale,' as the accuracy of a course quality rating depends on the amount of feedback retrieved from students, learning designers, learning applications, LMS log data, etc. The more the amount of feedback fed into the system, the more the expected accuracy of the course quality.

This chapter also highlights the integration of the LAMBDA system, a learning analytics platform (Boulanger et al. 2015; Seanosky et al. 2015; Kumar et al. 2014), with MI-IDEM to provide a novel feedback mechanism based on students' observed course work. LAMBDA is developed to assess the competency of students in their learning activities.

LAMBDA is a modular system consisting of several sub-systems for different learning areas. For instance, LAMBDA features, among others, a coding analytics sub-system (CODEX) where code-sensing plug-ins have been developed and deployed for different code IDEs such as NetBeans, Eclipse, IntelliJ, and Visual Studio. Other sub-systems are being developed for the domain of English writing, reading comprehension, mathematics problem solving, training in the oil industry, sentiment analysis, conversation analysis, healthcare analytics, and so on.

The purpose of the CODEX sensors is to capture any code-related activity in the programming integrated development environment (IDE) (e.g., UML design, source code, debugging activities, compiler warnings and errors, and keyboard and mouse events in the IDE) and to store this data in a database to be processed by LAMBDA's analytics processing engine.

LAMBDA provides a customizable competency analytics engine called SCALE that works across all domains. The SCALE processing engine retrieves the data collected by the learning activity sensors and identifies patterns of study habits using ontological rule-based techniques. The engine produces statistical results in addition to computed factors such as competence and confidence.

LAMBDA has the ability to continually track learning activities of students as they study in multiple learning environments, say within a learning management system (LMS) such as Moodle, within a social media tool such as FaceBook™, in the confines of the study desk at home, and in in-person brainstorming sessions with peers. It should be noted that students must consent to be tracked in such a manner and must consent to share their data with the others. In other words, LAMBDA continually captures data about learner performance in the setting of multiple study activities related to a course.

Considering the case of a programming course, LAMBDA's CODEX component captures every coding activity the student performs in the IDE. This involves tracking the amount of time spent on a given exercise, the source code progression over time, the number of errors in the code over time, the places where the errors occurred, the degree of persistence of errors, the proficiency level of the student in any given programming competence area, and the evidence captured from the student's code that testifies to the proficiency level assigned. These are examples of the types of data the LAMBDA sub-systems capture from the students' learning environment, in addition to tracking traditional data sets related to browsing patterns within a LMS, performance in informal assessments (e.g., pretest quizzes and chapter exercises), and formal assessments (assignments, midterms, and final exams). Some of the course quality-related questions that LAMBDA would be in a position to answer in the domain of programming are listed below:

- Is continuous and sparse analytics data appropriate and sufficient to estimate course quality?
- Does a relationship exist between time spent on an exercise and the quality of the exercise instructions?
- Does a correlation exist between a common misconception among students and course quality?
- Is there any relationship between persisting errors among students and the quality of instructional design?
- Is there any relationship between a classroom's average proficiency level for a specific competence and its corresponding learning materials?

MI-IDEM makes use of LAMBDA's continuous data sets on learners' activities to populate the underlying Bayesian network and estimate the overall course quality. MI-IDEM also uses data sets corresponding to traditional data (e.g., satisfaction questionnaire). In assessing the quality of a given course, MI-IDEM takes the available feedback data sets for the course and uses a Bayesian approach combined with rule-based methods to assign a probabilistic quality rating to the course. The accuracy of the rating depends on the number of feedback data sets available plus the amount of data available in each data set, which invariably depends on the number of students enrolled in the course who provide feedback directly (surveys) or indirectly (through LAMBDA).

MI-IDEM also employs specialized data sets that are not readily available, in general. For instance, SCRL (Zheng et al. 2014, 2015) is a tool developed for the purposes of explicitly engaging students in self-regulated and co-regulated learning activities in an online education environment. Figure 11.1 depicts an example of interaction with SCRL, where the student reviews proficiencies and initiates regulatory actions.

SCRL depends on the LAMBDA system for the data on students' competency and confidence assessments that will in turn be used to engage students in regulation-oriented activities. SCRL uses an initiative-based approach where students evaluate their proficiencies themselves and set about goals they want to work on to improve their proficiency in any specific competence area. Co-regulated features are also included, allowing students to assist other students to regulate on their learning competences. SCRL is designed to be a generic regulation tool, applicable in a wide range of domains.

SCRL provides an additional course-related feedback data set from students' interactions to MI-IDEM and introduces new factors to refine course quality assessment.

Fig. 11.1 Review of learner proficiency level in competence areas

MI-IDEM also utilizes data sets related to learner sentiments to assess quality of a course. Sentiment data are collected from Mechanical Moods (Kumar et al. 2014b), a tool that analyzes learner conversations to estimate learner sentiments on course-related subjects. Mechanical Moods captures course-related conversations from students in diverse social media tools, such as the Moodle discussion forums and SCRL chats, and analyzes the contents of these utterances to detect the swing in sentiments of students. In MI-IDEM, positive sentiments imply better course quality.

In all, MI-IDEM provides course designers, students, administrators, and instructors with information on the quality of a course offering. It offers evidences that support general or individual student discontent with a particular topic, based on sentiment analysis, and allows course designers counter-validate this information. It provides a view on competency growth as a function of measured quality of content and observed study activities. It collects feedback from students as well as instructors about the overall quality of the course offering. Continuous flow of data allows MI-IDEM to offer real-time course and learning design assessment and provides course designers and teachers with real-time information to continuously monitor the quality of their courses.

11.4 MI-IDEM's Enhanced Bayesian Network

MI-IDEM is a mixed-initiative method to evaluate the quality of instructional design through BBNs. Presently, the parameters contributing to the provision of the course quality metrics consist of knowledge expert feedback, student feedback, student interaction data, and student performance. These data sets are generated throughout the duration of a course, as and when they are available. Moreover, MI-IDEM can track the perception of the various course stakeholders as the course goes on and predict the level of appreciation of the student at the end. Hence, the predictive abilities of the current version of the MI-IDEM tool empower course designers to address issues in the instructional design of a course.

Traditionally, two types of evaluations exist to assess the quality of an instructional/learning design: formative and summative evaluations. The purpose of the formative evaluation is to 'determine the degree of mastery of a given learning task and to pinpoint the part of the task not mastered.' Bloom et al. (1971). El Kadi and Kumar (2010) indicate that 'summative evaluations tend to provide answers regarding the worth of the overall course, after the learning experience is fully observed.' The goal of this enhanced version of MI-IDEM consists of a blend of three types of evaluations—continuous, formative, and summative.

The LAMBDA system tracks student activities and performances at the continuous, formative, and summative levels. Continuous level of data capture implies that the learning processes that students undergo are constantly monitored to extract data about habits of learning, outcomes of learning, and issues in learning. Continuous data sets are not collected for the direct purposes of assessment.

Formative level means that students' learning data are captured at regular intervals throughout the course and at specific milestones (e.g., assignments, quizzes) in the course offering for the direct purposes of assessment. Summative-level data are captured at the end of the course offering through exams, surveys, etc. LAMBDA can track data at all three levels, which are combined in the MI-IDEM BBN to provide a more realistic, more probabilistically accurate, and real-time assessment of the quality of the instructional design of a course.

As reported by Forner et al. (2013), an experiment was conducted in the setting of a university-level Java course with data collected between July 2006 and December 2010 to assess the quality levels of the course with 777 students.

Performance-related data, student summative feedback data, and student interaction data were used in the study. Student course interaction data consist of the number of assignment submissions, forum posts, reading assignments completed, accesses to the LMS, and the number of exams completed in the allocated time as well as the average duration in every learning object. The student course performance was designed to describe quantitatively the performance of the student in the learning activities contributing directly to the overall grade of the course such as assignments, group discussion participation, exams, and journals. This is made possible by collecting fine-grained data directly from students' learning experiences within and outside of their LMS.

The version of MI-IDEM used in that experiment used the scale of excellent, very good, good, and poor. The probability that the course quality was excellent/very good was approximately 0.63, while the probability that it was good/poor was 0.37. The study showed the ability of MI-IDEM to monitor sway in the quality of the offering as and when data sets were made available. The study showed the feasibility of maintaining a robust course quality metrics in real time even with significant amounts of missing and/or sparse data. Research conducted in the setting of this experiment '*also demonstrated several approaches to improve the usability, performance, and accuracy of BBN-based systems for the assessment of online courses.*'

LAMBDA, as a competence management system, measures both proficiency levels and confidence levels of students in a wide range of learning activities, as a standardized means to measure quantitatively the effort and time spent on assignments, a specific learning activity, examination, etc.

LAMBDA is currently applied to one of the two Java courses in which MI-IDEM has been previously tested. LAMBDA tracks and analyzes coding experiences by sensing student's work and its associated metadata. A set of domain-specific parsers then scrutinizes the student's work as it occurs at real time and identifies evidence for the formation of a competence defined in a domain-specific ontology. LAMBDA offers a quantitative value for each competence identified in the learning domain at hand.

LAMBDA also assesses the confidence of a student in completing a learning activity. For every learning domain, a confidence model parameterizes LAMBDA for the assessment of confidence. For example, in the programming domain, some of the factors underlying the LAMBDA confidence model are total duration,

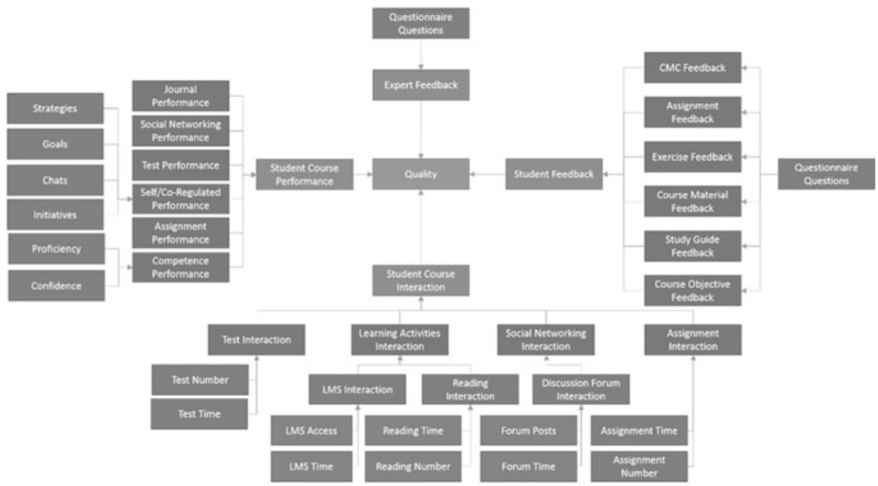

Fig. 11.2 Enhanced Bayesian network as proposed in the new version of MI-IDEM

number of builds, existence of errors, and persistency of errors in a given programming exercise. The overall student confidence is calculated from the average confidence values in all learning activities (see Fig. 11.2).

LAMBDA also tracks study habits of students in terms of time spent on a learning activity, number of attempts, or errors made in an activity, as well as the scope of training exercises in which students were engaged. Consequently, LAMBDA provides MI-IDEM with student course interaction data at a big data scale. It is important also to remember that the Bayesian network used by MI-IDEM to determine course quality requires aggregated data that are supplied by LAMBDA.

LAMBDA also computes and generates a new performance data set for MI-IDEM by backing any learning outcome with a set of proficiency values for the set of competences addressed in the course.

SCRL, discussed earlier, is a tool promoting and empowering students to self-/co-regulate their learning through a goal-oriented approach. By reporting to the students their whereabouts in the course competences, SCRL allows to address deficiencies or to strengthen proficiencies through mixed initiatives.

Initiatives can be triggered either by the teacher, student, or the software agent itself. An initiative involves the setting goals for a set of competences (one or more) by elaborating a strategy on how to reach those goals. For example, a student at the beginning of an introductory programming course in Java may be found to be 10 % competent in 'loop' statements. The student could then create an initiative to increase his/her competence in writing 'loops' in Java by selecting the 'while,' 'do,' and 'for' statements. The student can then choose his/her strategy among a predefined list of strategies specifying how he/she plans to reach his/her set goals (e.g., debugging errors in loops, seeking help from others, searching on the Web).

A trigger (numeric) value determines the threshold or next milestone the student wishes to reach in regard to the selected competences. This trigger may be bidirectional. If the proficiency value of a competence exceeds the targeted goal, the student will get notified to keep him/her updated about his/her progress and to encourage them to set new goals for those competences. Students can also be notified when their proficiency values fall below a certain threshold or if they get behind the class average.

Additionally, the SCRL tool will group students according to their profiles to promote discussion among peers having the same difficulty. The tool also allows students with proven competency to create and share initiatives.

SCRL data are continually collected and transmitted to MI-IDEM to add to the student course performance factors in the assessment of course quality. Traditional courses will guide students through well-defined sequences of activities (learning paths), potentially reducing the need for learning regulation. By comparison, there are also experimental course designs promoting the development of competences through a wide range of available resources from which students will form their own learning paths (or sequence of learning activities) to show that they have developed the right competences to successfully reach the target learning outcomes. SCRL helps to determine whether the creation of initiatives is related to the structure of the course and how students react or interact with that structure. In a few words, LAMBDA is a system that helps students with learning objectives through SCALE and with learning methodologies and process through SCRL.

By using continuous, formative, and summative evaluations, MI-IDEM targets the measurement of not only the overall course quality but also the quality of the course constituents. This is made possible by the fine-grained data provided by the tools integrated in the LAMBDA system (CODEX, SCALE, and SCRL). Thus, by analyzing the progress students make with respect to each competency; their successful completion of goals, the quality of messages exchanged; the quality of initiatives in each study activity, section, unit, or assignment in the course; and the feedback questionnaire for a specific constituent when situations at risk are detected, MI-IDEM builds a list of recommendations to improve or complement the instructional design of a course allowing course designers to intervene rapidly in case of inadequacy.

11.5 Emergency Procedure Quality Analysis Using LAMBDA

In May 2014, an experiment with an e-training tool called PeT (Procedure e-Training) was conducted in an oil and gas company in Canada to verify the operators' knowledge of one emergency procedure in a specific operating unit (Boulanger et al. 2014). In this context, an emergency procedure consists of a series of steps required to bring the whole system back to stability in the shortest time possible. For every step, operator(s) from one or more role(s) is/are required to take one or more actions to progress toward that stable state.

It is also important to note that some steps in the procedure are classified as critical, while others are not. Critical steps mean that operators during an emergency may have only a very short period of time to take the appropriate action and will not have the time to consult any resource for the achievement of those tasks. The consequences of exceeding the acceptable time threshold may be disastrous. These may include casualties and extensive material damage worth several hundreds of millions of dollars, if not more. The criteria to succeed with those steps are consequently significantly higher and require closer monitoring and quick intervention from the training and management staff to address any knowledge gap.

Due to the huge scope of potential disasters in case of failures, training and testing material quality control is needed to guarantee optimal learning and knowledge retention. The experiment aimed at capturing the knowledge traces of operators to identify gaps in emergency procedures. For greater accuracy, experienced operators were requested to fill in questionnaires to provide their feedback on precision (or quality) of the test question or the quality of the training materials related to knowledge gaps.

To test the operator's knowledge of the various roles involved in a step as well as the actions to take, a knowledge test was dispensed to 10 operators with diversified years of experience and roles. The knowledge test format consisted of a multiple-choice question for every step in the procedure (see Fig. 11.3). Every choice to a question was classified among the following categories: perfectly correct, incomplete but correct, partially correct, mostly incorrect, and totally incorrect.

In addition to collecting the final answers and the correctness of those final answers for every question, PeT also tracks the number of times an operator visits a question, the total duration that the question has been displayed to the operator, the operator's reaction time (that is the time he/she takes in providing his/her first answer), the total number of answers he/she selected (includes reselection), and the number of times the answer was switched (number of times the operator changes his/her mind over a question). A confidence model has been created based on these six metrics that make up the factors of this model.

Confidence takes into account both the knowledge (correctness of final answers) and the behavior of the operator. The purpose is to evaluate how the operator responds in an emergency situation since every element is critical in the outcome of that emergency. Presently, simple mathematical equations model confidence and describe how it decays as the operator exceeds acceptable thresholds. Those equations transform the raw data collected from the interaction of the user with the knowledge test to a ratio value between 0 and 1, inclusive. All those factors are then multiplied together to give an overall confidence value between 0 and 1, inclusive.

Confidence is calculated for every step in the procedure and for the overall procedure (average of all steps). Thus, operators may view their own confidence per emergency procedure as well as for every step (both critical and non-critical), and training managers can also view the average confidence of operators per emergency procedure and step to see which steps seem to be the most difficult for the trainees or which steps need some evaluation or improvement in case of poor quality in the instructions.

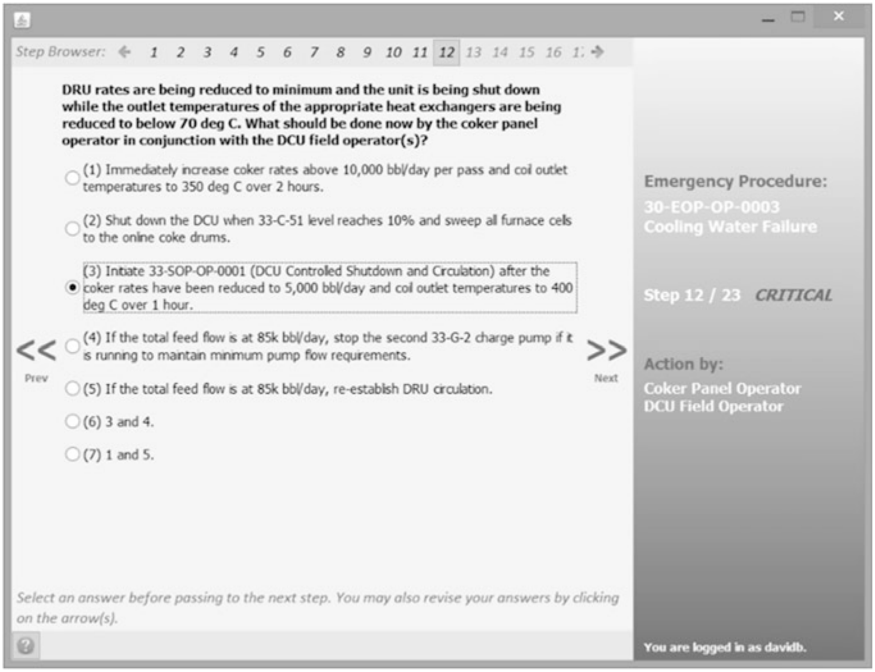

Fig. 11.3 PeT knowledge test

In Figs. 11.4, 11.5, and 11.6, the reader can view, for all operators in every step, the average and the standard deviation of the correctness level, reaction time, lingering time (total duration), number of visits, number of selections, and number

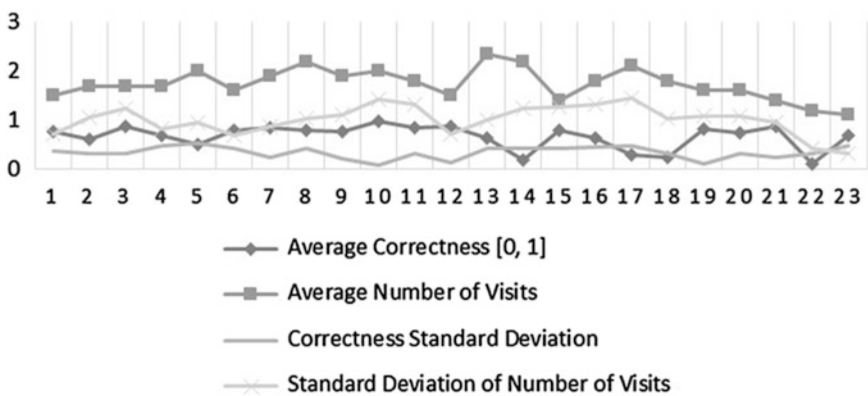

Fig. 11.4 Average and standard deviation of correctness level and number of visits per step

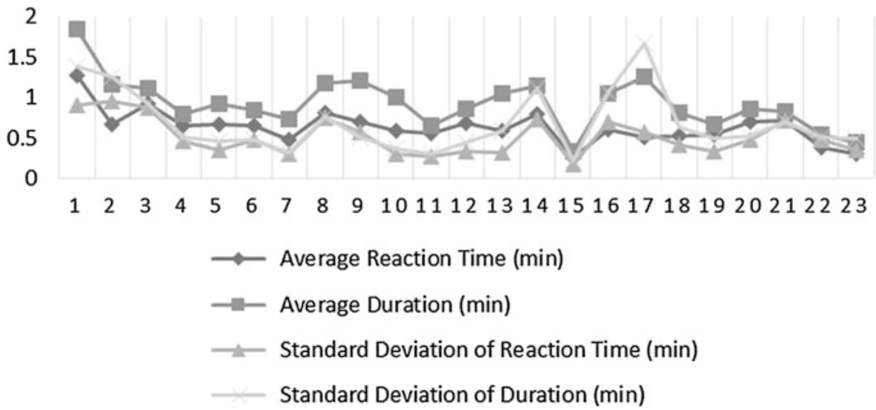

Fig. 11.5 Average and standard deviation of reaction time and lingering time per step

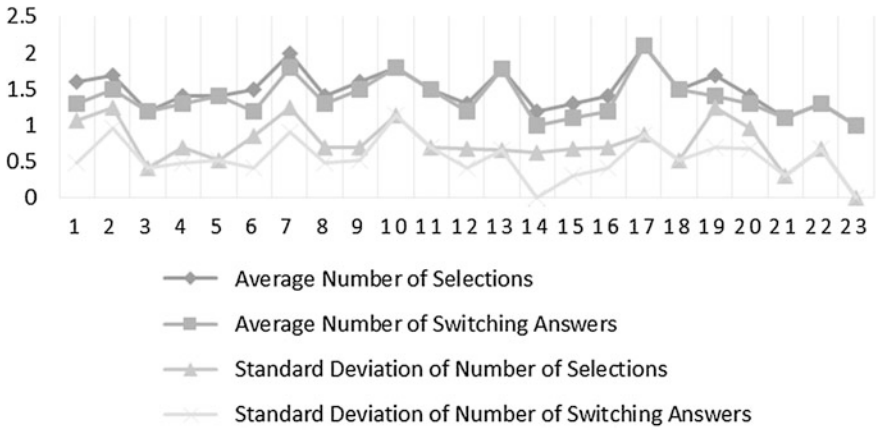

Fig. 11.6 Average and standard deviation of numbers of selections and switching answers per step

of switching answers. All these original data are then transformed in their corresponding confidence factor values.

Figure 11.7 shows the average confidence for all operators in every step. It can be seen that the overall confidence is also broken down into its confidence factors and how each factor influences the overall confidence. For example, it can be understood that the overall confidence is mostly influenced by the knowledge of operators and slightly by behavioral factors. Steps 14, 17–18, and 22 indicate very low confidence on average. This supposes either that operators in general have a knowledge gap in those steps or that the training/testing material is confusing and therefore of poor quality or both. A higher standard deviation may suggest a lack of knowledge is more likely while a lower standard deviation might suggest or at

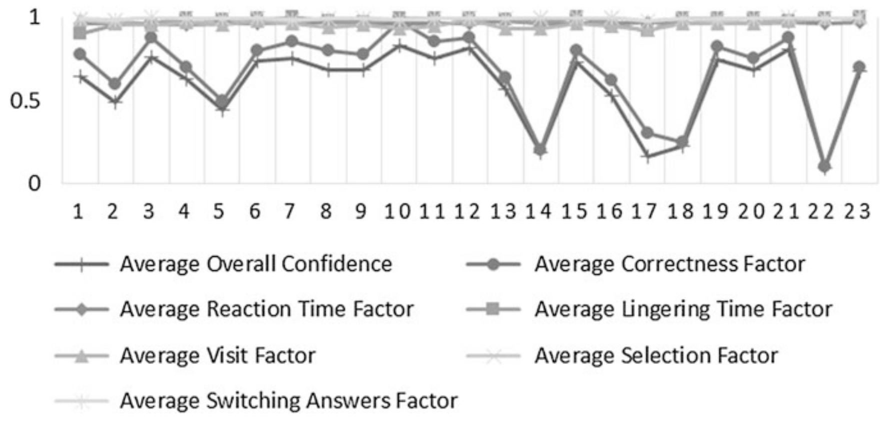

Fig. 11.7 Overall confidence and confidence factors per step

least recommend some revision or improvements of the training/testing materials. The quality of learning materials is determined by consensus, and a lower standard deviation is more likely to display that consensus.

One could also request feedback from experienced operators on steps for which the standard deviations are not particularly low. The combination of both human feedback and human performance is key in determining the level of quality of the training course.

As previously explained in this chapter, human feedback tends to be biased while performance data tend to correct that bias. If the feedback received from the questionnaires is rather good, then the questions are probably well designed and that highlights effectively the operators' knowledge gaps. This experiment concluded that the MI-IDEM approach of BBNs to handle uncertainty, missing data, split data, etc., to assess course quality is valid for training-based courses.

It is important to note that the results reported in this experiment are considered preliminary due to the limited number of study participants. Additional studies are being planned with a significant sample population.

11.6 Future Work and Conclusion

Continuous, formative, and summative mechanisms are essential for course quality assessment. Big data techniques are available to not only supply these data sets but also combine them in an optimal manner, thus shifting the focus of course quality from analysis to analytics.

This chapter showed an enhanced version of course quality analytics that employed data sets on performance improvement and regulation. The results indicated the possibility of increased accuracy of course quality measurements and quality measures at a more granular level with respect to individual learning objects, learning activities, individual proficiencies, and individual regulatory action.

The proposed approach is found to work satisfactorily in a higher education online course and in an industry training course.

In the future, MI-IDEM will look to use a standardized set of learning activities and foundational metrics from the IMS Caliper (http://www.imsglobal.org/caliper/) specifications, to represent, capture, and marshal learning experiences. The standardization of learning data will enable the standardization of a course quality metrics.

As a next step, we look to deploy MI-IDEM as part of a set of courses to determine its effectiveness and efficiency in continuously computing quality of these course offerings as they progress. We aim to compare the utility of MI-IDEM with respect to formative and summative evaluations of these courses.

In another future work, we aim to determine correlation between MI-IDEM's outcomes on quality, the performance of students at a given point in time in the course, and the quality of the learning design of individual course elements. Static learning design measures factors such as quality of objectives, instruction, teamwork/collaboration/communication, learning activities, assessments, and content. MI-IDEM can measure learning design of a course, dynamically.

Yet another future work involves the measurement of achievement of domain competences as well as meta-competences of learners, and their association with the quality of the learning design.

One other future work of MI-IDEM involves the development of a generic implementation of the system that can be applied across a large number of courses, both in-class courses and online courses.

MI-IDEM's real-time course quality assessment and feedback will offer notifications to teachers, course coordinators, and course designers as to the quality of the course offering at any desired time. Further, allowing students to have full access to their learning activity data as observed by MI-IDEM is another area of research in the area of open instructional design.

In case of adaptive course environments, MI-IDEM will not only assess course quality in real time, but will also be able to accommodate adaptations within the course contents.

MI-IDEM poses a number of open questions: What is the knowledge level of instructors/tutors about students' capacity to learn, level of motivation, and moods? What does scoring a B or 60 % in a particular assessment mean in terms of learning outcomes? Aided by MI-IDEM's learning analytics capabilities, how and when can an instructor/tutor predict and measure the success rate (or failure risk) of each student in a class? Does the profiling capability of MI-IDEM offer a competitive edge for students to showcase their unique talents?

In summary, course quality assessment is dependent on reliable sources of data sets from the students' learning environment. Learners need accurate, pedagogically valuable, and inspirational course material to be successful. Further, courses should offer a moderate and gradual learning curve. Course quality assessment is essential to evaluate weaknesses in the course contents. MI-IDEM and related systems come together to offer real-time course quality assessment and course content adaptation with a view to continuously improve the learning experiences of students.

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Author Biographies

Jérémie Seanosky is an undergraduate student and research assistant at Athabasca University. His areas of research interests include big data analytics, learning analytics sensors, failsafe data collection, retrieval, analysis, visualization, and automated assessment.

David Boulanger is a research assistant and undergraduate student at Athabasca University. His areas of research interests include big data collection, ontologies, analytics, and visualization of learning-oriented data.

Colin Pinnell is a research assistant and undergraduate student at Athabasca University. His areas of research interests include artificial intelligence techniques and their correlation to neuroanatomy, augmented reality and its application in human–machine interfaces, and pattern detection in big data.

Jason Bell is a research assistant and undergraduate student at Athabasca University. His areas of research interests include low-level data processing and kernel-level code, algorithms, graphics and visualization, and artificial intelligence techniques.

Lino Forner is an instructor in both the Computer Networking Technology and Electronics Engineering Technology programs at Holland College. He has a Bachelor's of Applied Science in Electrical Engineering from the University of Waterloo (Waterloo, Ontario, Canada). Recently, Lino completed a Master's of Science in Information Systems from Athabasca University.

Michael Baddeley holds the position of Manager, Project Standards, and Procedures at Canadian Natural Resources Limited (CNRL). His main area of focus and passion is leading and building organization, team, and individual capabilities for high performance. Most important skill exercised in his current leadership role is continuously adapting to change.

Dr. Kinshuk holds the NSERC/CNRL/Xerox/McGraw Hill Research Chair for Adaptivity and Personalization in Informatics. He is also full professor in the School of Computing and Information Systems and Associate Dean of the Faculty of Science and Technology, at Athabasca University, Canada. Areas of his research interests include learning analytics; learning technologies; mobile, ubiquitous, and location-aware learning systems; cognitive profiling; and interactive technologies.

Dr. Kumar is associate professor in the School of Computing and Information Systems and associate dean of the Faculty of Graduate Studies at Athabasca University. His area of research interests is in applications of causal modeling in big data learning analytics, artificial intelligence in education, collaborative learning, self-regulated learning, co-regulated learning, and mixed-initiative interactions using anthropomorphic pedagogical agents.

Chapter 12
Modeling Games for Adaptive and Personalized Learning

The A-GREM

Telmo Zarraonandía, Paloma Díaz and Ignacio Aedo

Abstract The potential of the adaptive games in the education is yet to be explored. This type of artifacts can increase the multiple benefits reported by the integration of digital games in educational processes, by adding up the advantages of delivering an experience tailored to the individual requirements of the learner. Unfortunately, the adoption of adaptive educational games in the practice is limited due to the difficulty of their implementation, which usually requires the application of techniques and skills related to several areas as pedagogy, game design, adaptive instructional systems, and artificial intelligence. Due to this difficulty, it is essential to carefully examine and evaluate the adaptation approach that best suits each educational process in order to ensure the efficacy of the personalization mechanism to implement. In this work, we present a conceptual model of adaptive educational games that supports this process of reflection and analysis required at the game design stage. The model supports the description of flexible game designs that can accommodate a wide range of adaptations and provides an abstraction layer over the technical details that allows its use by non-expert game designers like educators.

Keywords Adaptive educational games · Serious games · Adaptive instructional systems

T. Zarraonandía (✉) · P. Díaz · I. Aedo
Computer Science Department, Universidad Carlos III de Madrid, Avda. De la Universidad 20, 28911 Leganés, Spain
e-mail: tzarraon@inf.uc3m.es
URL: http://www.dei.inf.uc3m.es

P. Díaz
e-mail: pdp@inf.uc3m.es
URL: http://www.dei.inf.uc3m.es

I. Aedo
e-mail: aedo@ia.uc3m.es
URL: http://www.dei.inf.uc3m.es

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12.1 Introduction

Interest in making use of serious and educational games to support the educational process has grown exponentially in the last few years. While the term "educational game" puts the stress on the educational value of any kind of game, the term "serious games" is usually applied to put the focus on the value of simulation, authenticity, and realism to support immersive learning experiences (Wechselberger 2009). In this chapter, we will use the broader concept of educational game (EG henceforth) to refer to all kinds of games that might be used to support any kind of formal or informal learning process. The capability of games to provoke flow experiences, to promote socialization and creativity, and to be intrinsically motivating is some of the reasons that motivate the use of EG to support a variety of learning processes (Papert et al. 1998; Van Eck 2006; Ampatzoglou and Chatzigeorgiou 2007; Druckman 1995; Virvou et al. 2005). When EG takes the form of 3D worlds and simulations, the pedagogical value of the game is increased by providing a safe environment where learners can explore and interact with objects and other learners. Some of the main learning affordances of these immersive worlds include their capability to facilitate spatial knowledge development, to perform experiential learning tasks that would be impossible or dangerous in the real world, to increase intrinsic motivation and learner's engagement, or to recreate real situations where learning can be contextualized (Dalgarno and Lee 2010). In fact, EGs have proved to be particularly useful for education in specific domains such as medicine, science education, military training, or training on emergencies (Macedonia 2002; Remision 2014; UN/ISDR 2014).

However, designing useful EGs is a complex task since they are made up of many different components (such as scenarios, characters, rules, learning goals, and interaction modes) that require specialized knowledge on technical and graphical issues as well as on pedagogical strategies to make the game enjoyable yet educational. Furthermore, in the same way as with any other digital artifact, the design of the game should be informed by the profile, expectations, and characteristic of its users. As the preferences of the players might be varied, most commercial games address this issue by allowing them to adjust different parameters such as sounds, controls, or levels of difficulty. Taking the perspective of the game as an educational artifact, the problem becomes harder due to the increasing number of variables that have to be taken into account to support flexible learning processes that satisfy differences in learning styles, pre-existing knowledge, or social backgrounds among other user features. Adapting an EG might imply not only the capacity to modify specific characteristics of the game but also the whole philosophy of the game. Thus, the set of games offered to the learner, the interaction mode, the game rules, or even the game pace might depend on specific requirements of the users, both static (such as previous knowledge or the preferred learning style) and dynamic (such as a level of achievement of the educational goals). Adaptive EGs try to address these differences by dynamically adapting the game experience to accommodate the requirements of the players.

In this chapter, we present a conceptual model for describing adaptive EGs, called A-GREM (Adapting Game Rules and scEnario Model), whose main goal is to help designers identify the different components of an adaptive EG and how these components can be combined to support flexible educational approaches. The model provides then a number of components drawn from the literature and from existing games that can be used by EG designers to specify flexible designs that can easily be adjusted to the individual requirements of the players. The main benefit of such a conceptual model is that it compiles and makes it explicit knowledge from different sources in a simple and descriptive way, so designers have a view of the whole picture and how it can be applied to adapt the game to different requirements. The model here proposed is an extension of the Game Rules and scEnario Model (GREM) presented in (Zarraonandia et al. 2014), and it is drawn upon the combinational EG design method described in (Zarraonandia et al. 2012).

Both model and method are introduced in the second section of this chapter, after presenting some related work in the subject. In addition, an EG platform, that is able to interpret XML files containing EG descriptions specified in terms of elements of the model, and to automatically generate a 3D virtual environment in which the game can be played, is also briefly described. In the next section, the conceptual model for organizing the description of adaptations of EGs is presented. Next, and in order to assess the capacity of the model for supporting the description of a wide range of adaptations, different examples of adaptive EGs are reviewed and analyzed, outlining possible ways in which the adaptations they support could be described by the elements of the model. At the end of this chapter, some conclusions and ongoing works are presented.

12.2 Related Works

The adaptation of the instruction to the individual needs of the student is a key aspect of the success of any learning process (Corno and Snow 1986; Allison and Hammond 1990). Different learners have different goals, strategies, and even attitudes that might affect the learning process and for which specific support might help to avoid problems. Adaptive instructional systems aim to respond to those individual needs by delivering flexible learning environments that incorporate alternative strategies, educational content, or knowledge routes (Park and Lee 2003).

Intelligent tutoring systems (ITSs) and the adaptive educational hypermedia systems (AEHSs) constitute the most outstanding examples of adaptive instructional systems in technology-based learning environments. Although these two approaches differ in their pedagogical foundations and adaptation mechanisms, most of their implementations based their diagnosis and adaptation selection procedures on the use of different models including at least a student model, a knowledge domain model, and some kind of pedagogical model (Aroyo et al. 2006). The user model contains the different user profiles with all the attributes required to adapt the system. The domain model is usually a conceptual model of the system that includes both the contents to be delivered, and the information structure used to deploy them. Thus, in AEHS, this model can be split into a knowledge model, representing the concepts and abilities required in the domain, and the hypermedia model, defining the hyperstructure used to navigate through the knowledge space (Aroyo et al. 2006). Finally, the learning or pedagogical model provides a specification of different learning strategies and goals that can be linked to user and domain model components.

The necessity of supporting the description of individualized learning instruction has also been recognized by different standards and specifications intended to be used in e-learning. For example, the information model of the IMS Learning Design (IMS-LD) specification (IMS 2003) provides a core language for describing learning processes (Level A) and an additional set of elements for allowing the personalization of the instruction based on learner portfolios (Level B). This supports the design and implementation of e-learning systems that can recommend the most appropriate material to each individual learner (Santos et al. 2003). Although the adaptations supported by the Level B of the IMS-LD specification should be anticipated by the designer and included in the learning process at design time, some tools and extensions to the original model also allow the dynamic change of the process at runtime (Zarraonandia et al. 2006).

Adaptive EGs can also be considered as a subtype of computer-aided adaptive instructional systems. In this case, the adaptation process poses additional challenges as the experience delivered by the adaptation should be consistent and effective not only from a pedagogical perspective, but also from the viewpoint of the narrative and gameplay of the game. Furthermore, and in the same way as any other computer game, there are many components that can be tailored to the individual requirements of the learner, such as the game space, tasks, characters, rules, narratives, sounds, player mode, or difficulty level (Bakkes et al. 2012). Selecting and applying adaptations that encompass the modification of several of these components while maintaining the game coherence can be very complex. Consequently, most adaptive EGs focus on providing solutions to the adaptation of one single feature of the game. According to the state of the art, the characteristics most often adapted are the non-playing character (NPC) behaviors, the game narratives, and the gameplay mechanics, although there also exist some systems that are able to adapt the scenario and world of the game to some extent (Lopes and Bidarra 2011). In the case of the NPC behavior adaptations, and in a similar way as in commercial games, the diagnosis and selection of the modification to apply is frequently supported by AI techniques, such as case-based reasoning, reinforcement learning, or neural networks (Hocine and Gouaich 2011). With regard to the adaptation of the story, it is necessary to note that a recurrent approach in the design of EGs is to define them as collections of mini-games or "missions" (Bellotti et al. 2010; Carro et al. 2002) integrated as parts of the same story, where each one supports the training in a specific skill or type of knowledge. In these cases, the adaptation mechanism of the EGs is more similar to the one used in AEHSs, which can reorganize the sequence of the educational activities to present to the learner in order to adapt it to the current learner's needs. Regardless of the type of adaptation supported, and similar to AEHSs and ITSs, user models or portfolios are also required to define and gather the learner characteristics the system will be able to respond to.

The variety of features that can be adapted in an EG, and the diversity of information that might be necessary to consider for supporting their adequate modification, raise the necessity of models that organize in a clear and interrelated way all the elements involved in the adaptation definitions.

12.3 Modeling EGs

As a first step to identify the components that should be considered in adaptive and personalized GEs, we describe in this section an EG model and an incremental approach to use such model in the design of EG.

12.3.1 The Game Rules and scEnario Model (GREM)

The GREM (Game Rules and scEnario Model) (Zarraonandia et al. 2014) translates the features that are most often regarded in the literature as significant in producing engaging, fun, and EG experiences into a set of configurable elements and a basic vocabulary for each feature. The main goal is to offer EG designers, who might not be experts in all the fields involved in the design of the game (including gaming, education, and the domain of application of the game), a set of components that can be used to create their gaming experience whether from scratch or by reusing parts of existing EG designs.

The elements of the model are arranged in two different and independent sub-models (see Fig. 12.1): the game rules model and the scenario model.

- The *game rules* model describes the rules and norms of the game, that is, how the game should be played. From an educational perspective, the game rules will be used to implement the instructional strategy and to specify the sequence of tasks that the learners undertake.
- The *scenario* model defines the virtual environment in which the game will be played and the user interface to interact with the game. The game scenario will then include the representations of the concepts and the learning content the player interacts with during the game.

Designers will produce a game design by carrying out a match between the entities of one game rules description and one scenario description. This separation between game and scenario enables the possibility of playing the game in different scenarios (i.e., applying the same learning strategy with different contents) and to use the same scenario to play different games (i.e., to have different learning strategies to

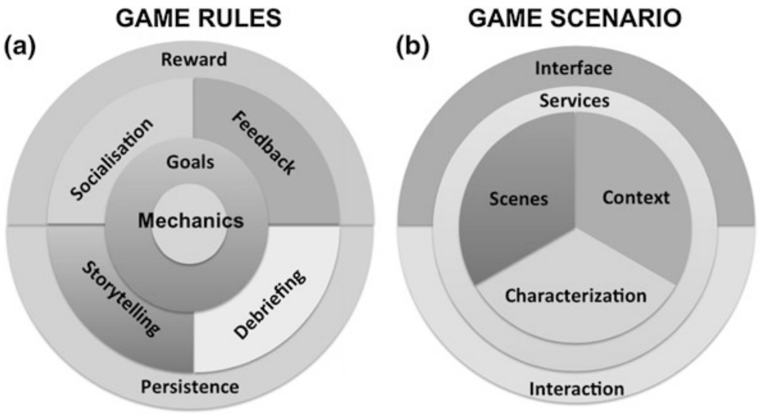

Fig. 12.1 GREM submodels: **a** game rules perspective and **b** game scenario perspective

approach the same knowledge). This approach is based on the separation model proposed in Díaz et al. (1998) aimed at easing the creation of variants of learning activities by splitting their main components and supporting the dynamic association of components to meet the needs of different learners or learning situations.

To facilitate reuse of the GREM elements, the two submodels are arranged in different layers as depicted in Fig. 12.1. The definitions of the elements of a specific layer are based on the definitions of the elements in the innermost layers, so that the specification of a submodel begins at the innermost layer.

Thus, to define the game rules, designers should start by describing the game mechanics and the goals players must achieve during the game (levels 1 and 2 in Fig. 12.1a). Once this basic logic of the game has been established, the designer can use the elements of the third layer to expand the game definition, for instance organizing the different goals into a sequence of episodes that the players will have to undertake following a specific order and that will conform to the story line of the game (storytelling in Fig. 12.1a). The elements of this layer also provide support for the definition of the social interaction (adding elements such as groups, roles, or synchronizing rules), to include debriefing activities (such as discussions, assessments, or essays) that might facilitate the connection of the lessons learned in the virtual world with their application in real life and to specify elements and feedback mechanisms for increasing immersion. Finally, the fourth layer makes it possible to add rewarding and persistence mechanisms frequently used in computer games, such as the accumulation of points, the opportunity to explore secret areas or allowing access to complementary games, and the possibility to customize the avatar, or to define save points, for instance.

With regard to the scenario model (Fig. 12.1b), the innermost layer allows defining the representations of the entities of the game that the designer wants to provide the possibility of interacting with and that can be organized into a set of interconnected scenes. Using the elements of this layer, it is also possible to define the characteristics and representations of the game characters and to describe other elements that can be useful to set the context of situations that will take place in the scenario. The following layer allows designers to specify a set of services that will increase the possibilities of the games that could be played in the scenario, supporting for instance different types of communication among the players. Finally, the last layer of the model allows designers to define, in an abstract way, the layout in which the representation elements and the services will be organized and presented to the player in each device and the type of interactions she or he will be able to perform through the corresponding input/output devices.

12.3.1.1 Designing Games by Combinations

As the complexity of computer games has grown exponentially over the last few decades, trying to describe an EG using a single set of rules and one scenario may result in a complicated set of rules and extensive scenario difficult to understand and analyse. On the other side, long and complex specifications might difficult to understand, maintain, and reuse the game. In order to reduce this complexity, we propose an incremental approach that deals with the design of a game as the combination of more simple game designs (Zarraonandia et al. 2012). For example, rather than using a single set of rules for describing the whole Mario Bros game, it is possible to describe it as a combination of three different games: a game in which the character should collect coins, a game in which the character should advance through the stage and reach a goal, and a game in which the character should avoid and eliminate enemies. During an ordinary stage of the game, the three sets of rules are active simultaneously, but during some special or bonus stages, it might be possible that only one or two of them are operational (i.e., the player only has to collect coins or to eliminate the "final stage boss").

Describing a game as a combination of more simple games would help not only to produce game designs easy to understand and analyze, but also to foster reusability, as it would make it easier to identify the pieces of design that can be reused in other games or that can be adapted to the specific needs of the learners. Furthermore, depending on the way the game designs are combined, the game experience offered to the player can differ. For example, Fig. 12.2 depicts graphically four different ways in which the set of rules of two different games can be combined. In general, combining several games' definitions at the *n*th level implies that all the elements of the *n*th level of all the games will have to be combined in order to produce a new single common-level definition. The elements of the innermost level of the games will remain unchanged, whereas the outermost levels will have to be redefined taking into account the new definition of the *n*th level. This way, combinations at the reward and persistence layers (see Fig. 12.2a) could be appropriate when the game corresponds to the mini-games genre; for instance, the game rules definition will remain independent to a large extent and might only share some of the scores, rewarding mechanism or the maintenance of a permanent record and other relevant information from previous sessions of the play. If the combination is carried out at the storytelling and debriefing layer (see Fig. 12.2b), the games jointly share the same story

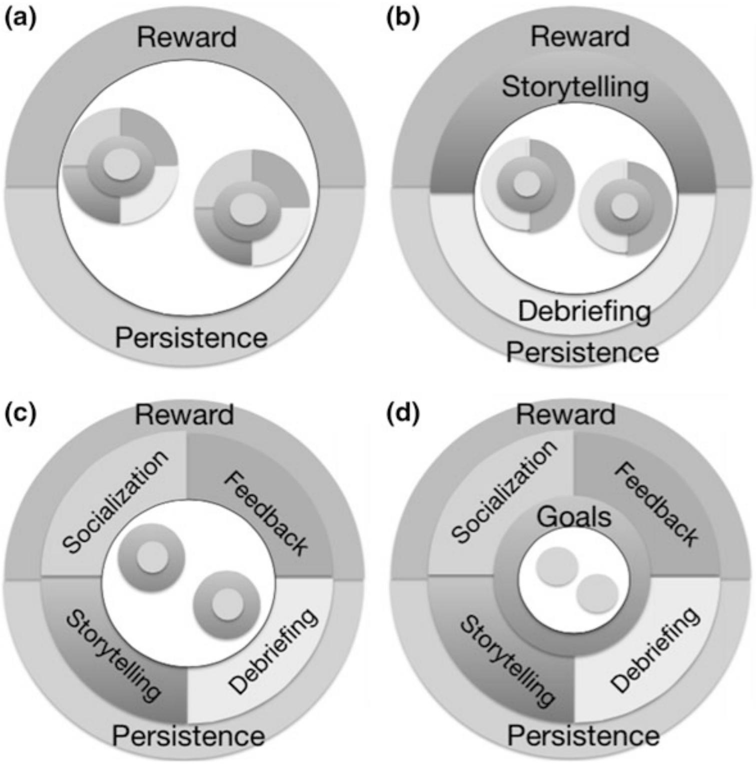

Fig. 12.2 Combining game rules at reward and persistence level (**a**), at storytelling and debriefing level (**b**), at socialization and feedback level (**c**), and at goals' level (**d**)

line so that the player plays different parts of each of the original games sequentially. This could be an appropriate approach for creating designs that implement the popular concept of "game missions." When designers combine games at a level lower than the story line, they can redefine the sequence of challenges and also the way these are defined (see Fig. 12.2c). This allows for offering the player the option of undertaking simultaneously certain goals that were originally included in different games. Finally, designers could redefine the goal level to provide learners with a new game experience which has been created taking as its start the original base mechanics of the two games (see Fig. 12.2d).

In addition, scenario definitions can also be combined at different levels in order to produce more complex scenario definitions. This way, given two scenarios, designers can merge their interaction and interface layers so that the final scenario definition will have a single interface and interaction layer definition that the player will use to interact with the scenes, characters, and entities of the two original scenarios, which would remain independent.

The set of rules as well as the scenarios defined by the combination approach can be used for any purpose as if it were a game with a single rule set definition or a single scenario definition. Therefore, it can be reused as a part of a new combination obtaining game design definitions, which nest with other game design definitions as a result.

12.3.1.2 The GRE Platform

With the aim of accelerating the implementation of an EG, and to minimize the technical assistance required during implementation, we developed the GRE platform (Game Rules and scEnario platform). The platform has been implemented using the Unity 3D engine (Unity Technologies 2014) and is able to interpret descriptions of EGs expressed in XML files and to generate 3D games based on them. These descriptions follow the schema of the GRE model, specifying an EG design in terms of components of the rules and scenario perspective.

To support the generation of a wide type of EGs, the GRE platform provides different types of implementations for several game components. For example, and with regard to the game interface, it provides different types of inventory windows, score sections, status bars, and a mini-map view. For supporting different types of game mechanics, the platform provides listeners based on entities' current positions, thresholds of attribute values, collisions, and the triggering of actions, among others. In the same way, it includes device component implementations for supporting the definition of games compatible with a keyboard, a mouse, and a Microsoft Kinect. The platform also connects with different repositories that can be populated with external resources so that EG designers can reuse them in their games. The gameplay is generated by matching the descriptions of these resources

Fig. 12.3 Screenshots of games generated using the GRE platform

and game components with the elements of the game designs and then configuring and activating the corresponding ones. Figure 12.3 depicts different screenshots of EGs generated using GREP.

12.4 A-GREM: A EG Adaptation Model

Establishing as its starting point the wish to accommodate the specific instructional needs of the learner, adaptive instructional systems distinguish three models of instructional adaptation: macro-adaptation models, aptitude by treatment interaction models, and micro-adaptation models (Park and Lee 2003). While macro-adaptation models can propose alternative instructional procedures to the learner, models based on aptitude by treatment interaction adjust the procedure to the learners' characteristics. Similarly, micro-adaptation models also take learner's needs into account during the instruction process and are mostly focused on adapting the amount of content to be presented and the presentation sequence of the content. The EG adaptation in (Göbel et al. 2009) uses the term "macro-adaptation" to refer to the adaptation of the sequence of scenes of a game, and the term "micro-adaptation" is applied when what is adapted are the elements of a scene.

Following these ideas, the adaptation model presented in this section will distinguish two broad types of adaptation. The first type of adaptation is used to adjust the definition of a given set of rules and a scenario to the requirements of a given gameplay and learner. Using these adaptations, it is possible to alter the sequence of predefined challenges in the game, to vary the level of difficulty through the modification of the game rules, or, for example, to select the character representation that best suits the player. Thus, these types of adaptation could be made to correspond to the micro-adaptation and the aptitude by adaptive instructional system treatment interaction models. For the sake of simplification, we refer to them as micro-adaptations of the game experience.

The second type of adaptation allows to activate and deactivate whole sets of game rules and scenarios combined in a macro-game design. This makes it possible to present the player with completely different game experiences, which implement different instructional strategies and make use of different representations of the learning concepts. Therefore, this adaptation approach for EGs could be considered as equivalent with the macro-adaptations of the adaptive instructional systems.

The following section describes the characteristics and benefits of the micro- and macro-adaption models.

12.4.1 Micro-adaptation Model

Figure 12.4 depicts the proposed model for describing micro-adaptations of EGs defined using the GREM that was described in the previous section. The model

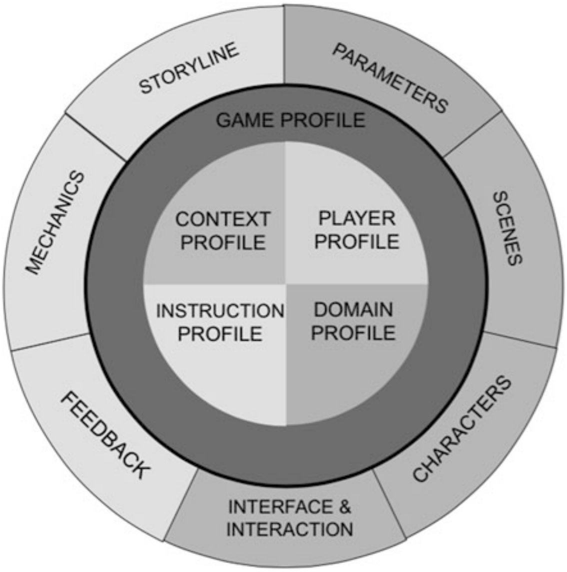

Fig. 12.4 Micro-adaptation model

organizes the information required to describe the adaptation in different layers: The first two layers are used to specify the conditions that trigger the adaptation, while the third one describes the changes to be applied in each case.

12.4.1.1 Initial Setting Layer

The innermost layer of the model provides the designers with the means to specify the information about the settings and circumstances of the gameplay that could be involved in personalization and adaptation processes. This information can be grouped in four different profiles:

- Player profile, which contains the group of attributes used to characterize the user both from the perspective of a player and from that of a learner. For example, the profile might include features such as age, control preferences, level of expertise, learning style, and previous background. In some cases, relations among features might be required; for example, some studies have shown evidence that there is a correlation between the pattern of behavior and the learning style (Graf and Kinshuk 2006) that might be represented in the player profile. The profile is usually conceived as individual with a view to support better personal experiences. For collaborative learning experiences, a group profile might also be required to adapt the experience to the group needs.
- Instruction profile, which describes the intended use of the experience from a pedagogical point of view. This might involve, for example, the inclusion of learning objectives, competences, and skills aimed at training in a given gameplay, or the instructional strategy to be applied.

- Context profile, which characterizes the available resources and the constraints that the setting of the gameplay might impose, for example, availability and quality of Internet access, type of interaction device, or the interaction styles supported. The context could be considered not only as a virtual context but also as a mixed context, depending on where the game is expected to be played and which conditions could be relevant for personalization and adaptation purposes. For example, if the EG is designed to be used in different platforms including mobile phones and tablets, the physical conditions of the environment (such as noise, light, and mobility) can influence the way the game is played. If a student is commuting by train for 1 h every morning, the system could automatically propose activities to perform, considering the constraints of that specific situation. Also, more advanced EGs could involve the integration of smart objects to develop ubiquitous learning environments, for which physical conditions will become a must.
- Knowledge domain profile, which includes the specific concepts if any that could be adapted. In a personalized or adaptive game, not only contents can be changed to fit the learners' needs, but also the story line, the game rules, or any other component of the game experience. Adaptation and personalization might not involve specific domain concepts if concepts are not explicitly deployed to the learners in the game but learned using inductive methods that rely on simulations or other activities. However, in other occasions, relevant concepts are explained in the game using any kind of media or resource. This model will contain all those concepts that are likely to be presented at some point, whether depending on the context, the instructional strategy, or the particular requirements of the learner. Each concept will then include the different facets or presentations it could have, so its representation can be adapted to fit the requirements of the learner, the context, or the instructional method.

12.4.1.2 Gameplay Profile Layer

The second layer of the model supports the adaptation of the experience to the learner during a gameplay. Given a definition of the game rules and scenario, the designer selects the events and information that has to be detected and retrieved during a gameplay. Then, this information is grouped in game profiles that can be linked to values of the profiles previously specified in the innermost layer. This allows the designer to define a game profile for young learners that specifies the retrieval of the number of goals achieved in a gameplay and a game profile for experienced players that also makes it necessary to keep a record of the time taken to complete each goal.

12.4.1.3 Adaptation Layer

The third layer of the model provides means to describe the changes and adjustments of the game experience that will be triggered by the values of the profiles for a given gameplay. Based on the type of change, the model distinguishes between three types of micro-adaptations: adaptation of the game parameters (green sector in Fig. 12.4), adaptation of the game rules (gray sectors in Fig. 12.4), and adaptation of the game scenario (lavender sectors in Fig. 12.4).

- Adaptation of the game parameters: For those games in which the design of the parameterization and personalization of some of its components are considered, it is possible to link sets of values for those parameters to the different profiles specified in the innermost levels of the model. For example, many games allow the user to personalize controls of the game, such as the background sound or the level of difficulty. Using this type of adaptation, it is possible to automatically select the most appropriate values for these features for any given player profile.
- Adaptation of the game rules: This type of adaptation allows the designer to modify and adjust the rules of the game to the specific requirements of a given gameplay. By tracking the progress of the player during the game, the rules can be adapted to support a better experience. For instance, if the player repeatedly fails in a given challenge, the game might provide the player with tips on how to succeed or temporarily adjust the game rules to reduce its difficulty, so as to prevent a learner's frustration that might end up in giving up the EG. In other cases, it could be appropriate to allow experienced players to skip some episodes or challenges in the story line, or to force them to repeat other ones in order to reinforce the learning of a given skill. In general, it would be possible to adapt any component of the game rules definition, although depending on the significance of the change it might be necessary to run some type of checking process to ensure that the consistency of the experience is not compromised, as in Peirce et al. (2008).
- Adaptation of the game scenario: Finally, it is also possible to define adaptations that adjust the scenario definition in order to make use of the graphical representations or the interaction mechanism that best suits the requirements of the current gameplay. For example, using this type of adaptation, it is possible to automatically select the avatar representation that best matches the player's profile. This can help to reinforce the identification of the player with the character, increasing his or her engagement and motivation by improving the sense of presence (Dalgarno and Lee 2010). In the same way, it is possible to adapt or make use of alternative representations of the concepts in the domain taught in order to respond to the current requirements of the gameplay. Finally, the definition of the interface and interaction components of the game could be altered to enable the use of the interaction device most suitable to the current context of use.

12.4.2 Macro-adaptation Model

When the game design is created using the incremental approach based on combinations of games described in the previous section, it is possible to define

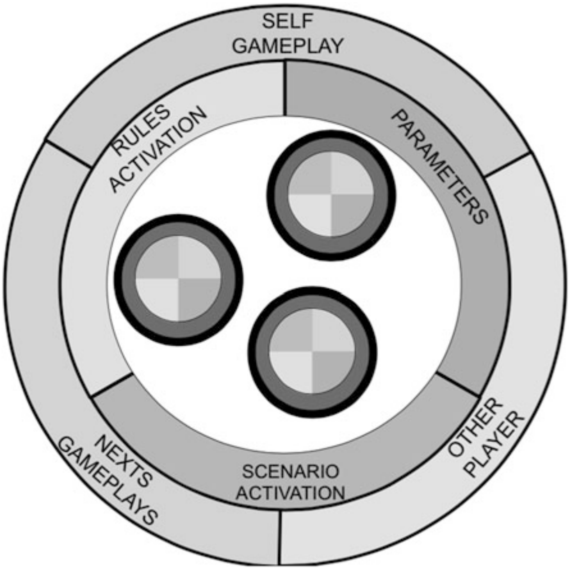

Fig. 12.5 Macro-adaptation model

adaptations that modify the game experience to a higher degree than the one supported when using micro-adaptations alone. The model for defining these types of macro-adaptations is depicted in Fig. 12.5. As shown in the picture, the model also follows the modular organization used for describing the micro-adaptations.

12.4.2.1 Gameplay Settings and Game Profile Layers

In the same way as with the micro-adaptations, the definition of the conditions that trigger macro-adaptations would be based on the current values of a set of profiles that capture the characteristics of the current context, learner, instructional approach and knowledge domain, as well as the progress of the player in the game. As in this case the design of the game has been produced by combining different games, it is possible to specify separate profiles for each of them. These profiles can be the same ones used for defining the specific micro-adaptations of each game combined, or might consider new aspects not relevant for those changes but important for establishing the conditions on the macro-modifications. For example, the gameplay profile of a given game might be extended to keep a record of the prices obtained by the player. Although at the micro-adaptation level, this information does not trigger any change, at the macro-adaptation, it could unblock the access to a bonus game.

12.4.2.2 Adaptation Layer

The adaptation layer of the macro-adaptation layer considers three basic types of modifications: activation/deactivation of game rules, activation/deactivation of game scenarios, and game parameterization. The first two adaptations are used to determine which of the game rules and scenarios combined are active at a given moment. Based on the type of combination carried out, these activations might result, for example in unblocking a game, modifying the story line, or proposing alternative scenarios to undertake a specific challenge. From a pedagogical perspective, when the combination includes more than one set of game rules, they could be used to deliver to the player the game whose mechanics best suit his/her learning style. Conversely, when the combination provides alternative scenario that matches for the same game rules, these adaptations could be used to select the one that would make the acquisition of the desired skills easiest for the current knowledge domain.

As with the micro-adaptations, it is also possible to define modifications to the parameters of the games at this level. As these adaptations can be triggered by conditions specified using the profiles of any of the games combined in this case, it is now possible to alter the parameters of one game as a result of the outcomes of another.

12.4.2.3 Target and Activation Layer

The outermost layer of the model allows the designer to elaborate adaptation mechanics that not only affect the current player, but also affect the subsequent gameplay of the same player or even other players. This way, given the same macro-adaptation definition, this layer allows the designer to define three possible targets of the changes:

- Self gameplay: By default, the modifications defined in the adaptation layer will be applied to the current gameplay when the condition that triggers the adaptation has been satisfied, i.e., the same player within the same game.
- Next gameplay: Using this type of activation, the modification is not applied to the same gameplay but to the next one of the same player. This allows the designer to define adaptations that take into account the results of previous gameplay and, as a result, increase the level of difficulty of the game as the player gains expertise or it may propose alternative challenges to avoid boredom and intensify curiosity.
- Other player gameplay: This activation allows the designer to interconnect the gameplay of different players so that the actions of one player in a gameplay might have an impact on the gameplay of another player. For example, this activation allows one to describe adaptations to specify that the more successful a player is in a play, the more difficult will be the next play of another player, or that the enemies that a player fails to kill in a game are the ones another player will have to defeat in his/her game.

12.5 Examples of Adaptive Games

To assess the validity of the design approach for adaptive EGs presented in this work, we review different existing adaptive games to analyze their adaptation capabilities and how these capabilities are represented in the model. In particular, we will describe four use cases: Darfur is Dying (Darfur is Dying 2014), Ecotoons 2 (Carro et al. 2002), ELEKTRA (Bellotti et al. 2010), and TiE (Bellotti et al. 2010). These EGs deal with different knowledge domains and provide different levels of adaptation and personalization, so they make up a reasonable collection of use cases to demonstrate the completeness of the model proposed here. For each specific EG, we will describe first the game and its adaptation capabilities, and then, we will discuss how these capabilities will translate into A-GREM entities. Table 12.1 at the end of this section summarizes the designs proposed for the games.

Table 12.1 Summary of the game designs and adaptations defined using A-GREM

Game	A-GREM design	
	Design	Adaptations
Darfur is Dying	*Rules* Combination at the story line of two games (episodes). The first one can be described as a combination of two games played simultaneously	*Macro-adaptation of game parameters* A parameter ("level of water") of one game is modified based on the results of the other game
	Scenario Each game is played in a different scene	
Ecotoons 2	*Rules* Different independent game rules combined at the reward layer	*Macro-adaptation* The games are selected and activated based on the learner profile and the results in other games
	Scenario Each game uses its own scenario. The non-interactive story is described by means of one additional scenario	
ELEKTRA	*Rules* Different game rules combined at the story line layer. One set of rules defines the main game story, and the other describe the tasks to accomplish	*Micro-adaptation of the rules* Adaptations of the feedback messages for each of the mini-games/missions included the story line
	Scenario All the games are played in the same scenario	
TiE project	*Rules* Several game rules combined at the story line layer. One game for defining the main game story and the other for the mini-games	*Micro-adaptation of game parameters* Adaptations of mini-game parameters are based on the learner profile
		Micro-adaptation of game parameters Adaptations of mini-game parameters are based on the results obtained in other mini-games
	Scenario One scenario where the main game is played in one window canvas and the other uses another canvas	*Macro-adaptations* Mini-games are selected and activated based on the learner profile and the results in other games

12.5.1 Darfur Is Dying

"Darfur is Dying" (2014) is an online serious game that aims to raise awareness of the humanitarian crisis in Darfur. In the game, the player takes the role of a Darfurian that tries to help the community in a refugee camp to survive. The game includes two different stages. The first one is a first person game in which a refugee searches for water in the desert while avoiding being captured by the militias. The second one portrays an aerial view of a refugee camp, including the hospital tent, the shelters, and the vegetable gardens. The current situation in the camp is represented by a set of counters that depict the level of health of the inhabitants, the water supply, and the food supply. The player must keep these meters in range by visiting the appropriate place in the camp in each case.

The "Darfur is Dying" cannot be considered a genuine adaptive game as it does not attempt to provide an experience adapted to the current player requirements. However, some of its rules can be described in terms of adaptations. For example, the amount of water available during the second game is adapted by referring back to the degree of success or failure in the first game and the character selected to accomplish the mission.

12.5.1.1 A-GREM Design

The rules of the game can be described as a combination of two games, one for the run to obtain water and another one for the camp management, each one played in its own scenario. The combination of the games is carried out at the story line level so that each game represents one of the episodes in the story. In addition, the first game could also be described as a combination of two classical games played simultaneously: a race in which the player should reach a goal and a survival game in which the player should avoid contact with the enemies.

In this case, the adaptation could be implemented as a macro-adaptation that modifies one of the parameters (water supply level) of the camp management game. The definition of the adaptation will only require a game profile for the "run for water" game, to capture the degree of success in reaching the goal and the type of character selected to accomplish the mission.

12.5.2 Ecotoons 2

Ecotoons 2 (Carro et al. 2002) is an adaptive EG to help students of 5–18 years of age improve mathematical reasoning. The development of the game was achieved by applying a methodology that uses similar techniques to those applied in the design of adaptive Web-based courses. In this case, the designer defines non-interactive stories for the different types of users considered, where each story organizes one or more sequences of activities to be accomplished, and each activity is linked to one or more specific games. Ecotoons 2 makes use of a game repository populated with ninety games that support the performance of different educational goals related to mathematical concepts and operations. The content and mechanics of the games are independent of the stories, and the game engine can select the most appropriate game for a given activity at runtime while also taking the goals of the games, the activities, and the user's characteristics into consideration.

The game engine allows the designer to introduce several dynamic adaptations based on the user's profile and behavior, such as the selection of the game presented for each activity, the modification of the order of the activities, the groups of activities, or even the displayed story line.

12.5.2.1 A-GREM Design

In this case, the game could be described as a combination of totally independent games with its own rules and scenarios, which might only share their contribution to the same total scores. The interrelation between games is kept to a minimum as they are not part of the same story and their activation will be triggered by the adaptation rules. As the story serves as a framework for the execution of the game, it does not include interactive elements. Therefore, it can be described by means of one single scenario containing fixed scenes that the adaptation engine selects and presents.

According to the game description, the adaptation engine is in charge of sequencing and selecting the appropriate games at each stage of the learning process. As the games themselves are not subject to any adaptation, the most appropriate way to define the adaptation design in this case would be to use macro-adaptations. To define the conditions that trigger the adaptations, it will be necessary to use elements from the first layer of the model (see Fig. 12.5), to obtain the specification of the learner profile, and from the second layer, to gather the results of the player in each of the games. The adaptation will activate the appropriate rules and scenarios based on that information and will also select the fixed scenes that represent the story that contextualizes the game action.

12.5.3 ELEKTRA

The ELEKTRA game (Peirce et al. 2008) is a 3D role-playing adventure game for teaching 13–15-year-old students the physics of optics. During the gameplay, the player needs to overcome different challenges related to that topic, which can take different forms, such as solving a puzzle, performing a task, or manipulating a device. All the challenges are presented and integrated as a part of a meaningful story.

The adaptation in the ELEKTRA game is supported by the Adaptive Learning In Games through Non-invasion (ALIGN) system. The system uses rule base and probabilistic methods to interpret the events in the game and to transform them into evidence about the learner, the adaptation, and the game state. This evidence is used to continually assess and select the most appropriate adaptation to apply from a repository of predefined ones throughout the gameplay. At present, the adaptations defined for the game provide motivational and hinting support, and meta-cognitive feedback. In both cases, the final feedback is delivered to the player as part of the speech of a NPC character.

12.5.3.1 A-GREM Design

The rules of the game can be described as a combination of one main game that sets up the story line and several mini-games that are activated as the players progress through it. Each of these mini-games uses its own game elements, rules, and feedback messages. However, both the main game and the mini-games are all represented using one single scenario that depicts the 3D game world. Some of the representations and graphical models in these scenes will only be used in some specific mini-games, but some others, such as the NPCs, could be used by all of them as a means to provide feedback to the player.

The adaptation mechanics of the game could be implemented by means of micro-adaptations of the feedback rules defined for each specific game. To specify the conditions that trigger the adaptations, it would be necessary to define independent game profiles for each mini-game as well as for the main game.

12.5.4 The TiE Project (Serious Virtual Worlds)

The TiE project is a treasure hunt game designed to promote knowledge of European cultural heritage (Bellotti et al. 2010). In the game, the player explores 3D reproductions of different cities in Europe, such as Prague, Genoa, or Strasbourg, undertaking different missions in each of them. During a mission, the player is required to find different places in the city and accomplish a series of tasks at each of them. These tasks are simple games played on a mobile phone-like interface window and are used to practice a specific cognitive skill. The game has been implemented using a flexible serious virtual world platform, which provides educators with a set of tools to select and parameterize tasks from a repository, to link them with places in the virtual world, and to define missions as sequences of tasks that the player should accomplish.

The game platform of the TiE project supports adaptations at two different levels. On the one hand, some of the task parameters, such as the skills level required, can be adapted to the player profile and his/her progress during the gameplay. On the other hand, the sequence of tasks presented to the player can be adapted to the difficulty level specified by the designer and the player's learning strategy. To support these types of adaptations, the platform makes use of three different models: user model, task model, and learning strategy model.

12.5.4.1 A-GREM Design

The rules of the game could be described as a combination of the rules of a treasure hunt game with the rules of several mini-games. These mini-games are selected and activated each time the player succeeds in finding a piece of "treasure" in the main game. The scenario for the game contains two types of scenes: scenes that represent the cities in the virtual world and scenes that support the plays of each mini-game. The definition of the scenario interface includes one canvas for displaying the action in the virtual world and a second one for displaying the scenes of the mini-games.

The implementation of the adaptations supported by the TiE project would require the use of both mini- and macro-adaptation models.

- Micro-adaptations for the modification of the mini-game (tasks) parameters: The adaptation of the parameters of the tasks to the player profile could be implemented by defining specific micro-adaptations for each of the mini-games of the parameterization type. The conditions that trigger these adaptations will only be based on the profiles of the first level of the model.
- Macro-adaptations for the modification of the mini-game (tasks) parameters: To adapt the parameters of the mini-games to the progress of the player in the main game, it will be necessary to make use of the macro-adaptation model. This way, the conditions that trigger the changes in the parameters could be specified using the information of the gameplay profiles of other mini-games or the game in the virtual world.
- Macro-adaptations for the activation of the mini-games: To modify the story line of the game and present the player with tasks that best suit the learning strategy and progress of the learner, it would be necessary to implement macro-adaptations that activate the game rules and scenario of the adequate mini-game.

12.6 Conclusions and Future Lines of Work

In this paper, we have proposed a conceptual model for adaptive EGs that identifies key concepts to be considered when trying to personalize the game to the learning and playing conditions. The design of adaptations for EGs entails a special difficulty. From the range of potential adaptations, game designers need to select the ones that best suit the type of personalization they aim to support. With that purpose, they have to carefully consider the interrelations existing among the desired changes and the rest of the components of the EG. They should also check the consistency of the resulting experience both from a pedagogical and from a ludic perspective. Although there already exist several adaptive game proposals, most of them are only concerned with some specific types of adaptations. The model proposed in this chapter organizes the game components and the elements of the adaptation definitions in a conceptual way aimed at facilitating the specification of flexible EG designs, which can accommodate a wide range of adaptations, both at a micro level and at a macro level. The main aim of the model is to provide support to the designers in the process of evaluating and studying different adaptation alternatives. As far as the model provides an abstract layer not related to the technical details, it can be especially useful for educators, whose knowledge of pedagogy and knowledge domain is required in the design process, but who do not normally exhibit a high level of expertise in game design. The model has proved itself capable of supporting the description of the designs of four different adaptive EGs, each of them implementing different types and adaptation capabilities.

Current work is being carried out in two directions. On the one hand, the model is being extended to support multidimensional representations of the concepts taught. These representations could be implemented both in virtual and in physical environments to allow exploring the benefits that different types of interaction modalities with the learning content could report. On the other hand, a set of authoring tools for the GRE platform presented in this chapter are currently under development. The tools will aid educators in the description of EG design files that the GRE platform can interpret, while hiding from the user the complexity of the XML code.

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Author Biographies

Telmo Zarraonandia holds a degree in computer science from the Universidad de Deusto and a PhD in computer science from Universidad Carlos III de Madrid where he is currently visiting professor. His research interests include technologies to support education and learning, video game design, mixed reality environments, and interactive systems. He has been visiting researcher at the Universidade Federal do Rio de Janeiro (UFRL) and at the Universitá degli Studi di Salerno (Italy). He has served as local cochair of the IEEE ICALT (2008) and associate chair of the technology subcommittee of the ACM DIS (2012). He has published several scientific papers in international journals and conferences related to the field of computer-supported education and interactive systems.

Paloma Díaz is full professor in the Department of Computer Science of University Carlos III de Madrid. She is the head of the LAB DEI research group (dei.inf.uc3m.es) focused on the design of interactive systems applied to different domains such as emergency and crisis management, e-learning, or cultural heritage. Her main research interests include interactive systems engineering, collaborative systems, visualization, and ubiquitous computing. Concerning the topics of this chapter, she has led projects on interactive and educational systems modeling and on the definition of conceptual frameworks for the codesign and production of serious games supporting children informal learning. She has been visiting scholar in the Information Science and Technology College of PSU, the MAGIC LAB of the University of British Columbia, and the ViSUS Institute of Stuttgart University.

Ignacio Aedo holds a degree and a PhD in computer science from Universidad Politécnica de Madrid. He is currently full professor at the Universidad Carlos III de Madrid (Escuela Politécnica Superior). His research interests include hypermedia, interactive systems in education, Web systems, electronic books, development methodologies, and information systems for emergency situations. In 1990, he started his research activity in the field of interactive systems on which he is still involved. He has been visiting researcher at CSCL department at IST Pennsylvania State University (2007–2008) and MAGIC of University of British Columbia (2011); chair of a groupVision Grant for Technologies for the Collaboration; cochair of IEEE ICALT 2008, 2009, 2010, and 2012; subdirector of Culture and Technology Institute; and deputy vice-chancellor for Faculty and Departments (UC3M).

Chapter 13
Personalized Learning for the Developing World

Issues, Constraints, and Opportunities

Imran A. Zualkernan

Abstract Personalized learning carries significant promise in improving the state of education in developing countries. However, much of the personalization technologies have evolved in the context of the developed world. In this chapter, an expanded definition of personalized learning for developing countries is presented. Capital and human resource constraints and information and communication technology (ICT) affordances in developing countries to support personalized learning are also discussed. Bronfenbrenner's Ecological Systems Theory is proposed to define a wider context for personalized learning for developing countries. In addition, McKinsey's staged maturity model is suggested as an analysis framework to explore various types of personalization opportunities in school systems of the developing world. The conclusion is that significant amount of work needs to be done to effectively implement personalized learning in the developing world due to unique human, capital, and ICT constraints. However, many new research opportunities to address these issues have also been identified.

Keywords Developing country · Personalized learning · Adaptive learning · Educational analytics · Educational data mining

13.1 Introduction

Using technology to improve quality and accountability for education in the developing world is a grand challenge (Kremer et al. 2013). This chapter is about issues, constraints, and opportunities in building personalized learning systems for developing countries. There is no unique definition of a developing country and

I.A. Zualkernan (✉)
American University of Sharjah, P.O. BOX 26666, Sharjah, UAE
e-mail: izualkernan@aus.edu

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different classification systems are being used to define what a developing country is (Nielsen 2011). For example, IMF considers below 75 % percentile countries in the HRD index as developing, while the World Bank uses the US$6000 GNI per capita in 1987-prices as the threshold to classify a country as a developing country. IMF does not use any specific development threshold to define a developing country. In addition, finer distinctions are also made in the development community between low-income and medium-income, and low human development and medium human development countries. For example, medium human development index countries include Maldives, Mongolia, Turkmenistan, Samoa, Palestine, Indonesia, Botswana, and Egypt. Similarly, low human development index countries include Nepal, Pakistan, Kenya, Swaziland, Angola, Myanmar, and Rwanda (Zambrano 2014). This chapter is mostly about developing, low-income and low human development countries.

Use of learning technologies in developing countries has recently been explored (Woolf et al. 2011). However, as Nye (2013b) observed, most research in the area of using information and communication technology (ICT) and adaptive systems for developing countries is based in WEIRD countries (Western, Educated, Industrialized, Rich, Democratic). In fact, Nye points out that 75 % of the data about adaptive systems had been collected in WEIRD countries. Therefore, there is a need to conduct a conscious analysis of the form learning personalization may take for the developing world.

The rest of this chapter is organized as follows: Personalization is defined next and the definition is expanded to include aspects relevant to developing countries. This is followed by a description of capital and human resource constraints of developing countries. ICT affordances of developing countries are described next. An expanded definition of personalization context is then provided followed by a staged model that mediates personalization strategies. Chapter ends with a discussion and a conclusion.

13.2 Defining Personalization

A number of technologies have been developed to personalize learning for an individual learner (Vandewaetere and Clarebout 2014). Even manual personalization of content to match students' interests seems to improve their engagement and performance (Bernacki and Walkington 2014). From a learning technologies perspective, personalized learning can be defined as adapting learning designs to account for individual differences or according to contexts and situations (Kinshuk and Nian-Shing Chen 2011).

Personalization for individual differences can further be classified in terms of traits or states of learners (Woolf 2010). Traits deal with aspects of a learner that do not change over time. Learning style (Feldman et al. 2014) is one trait that has been used extensively to personalize learning regimes (Mulwa et al. 2010). For example, Yang et al. (2013) have recently developed one such system that adapts based on students' learning styles. Cognitive abilities (e.g., processing memory loads) are also traits. For example, in English vocabulary learning, different learners have different short-term memory (STM) ability and therefore, different types of SMS's can be used for different types of learners (Chen et al. 2008). Many children in the developing countries have stunted growth due to lack of nutrition and other factors. Stunted growth is another learner trait. Therefore, personalizing learning based on learning and other disabilities is of special importance to the developing world. However, this is a newly emerging area of research in adaptive systems (Liu et al. 2013) and very little is known about how to apply these techniques for developing countries.

As opposed to traits, states are shorter term characteristics of learners. Emotive or affective states such as the learners being confident/anxious, frustrated, excited, and interested/bored are often used to adapt learning scenarios (Arroyo et al. 2014). For example, a learner who is bored during learning should receive different instruction than another one who is excited about what they are learning. Another largely unexplored area of learner's state is the physical parameters of the learner including heart rate and blood pressure. Finally, prior knowledge or what a learner knows is another parameter of their state. For example, commonly used programs such as Khan Academy (www.khanacademy.org) recommend different questions to the learner depending on what a learner knows. Similarly, Chen (2008) provides an example or personalization of learning paths by matching content difficulty with learners' abilities. Classical techniques such as item response theory (IRT) have also been used to account for learner's prior or current knowledge to adapt learning designs (Chen et al. 2005). Lin et al. (2013) describe a similar system to enhance learning paths of students related to creative thought.

As opposed to traits and states of the learner, contexts and situation define where the learner is when the learning takes place. Verbert et al. (2012) defined context of personalization to include location/time, physical conditions, computing, resources, user, activity, and social. If a learner is located in part of the city they need to learn about, learning targeted to the neighborhood can be delivered. For example, Hwang et al. (2010) describe a system where the adaptive learning system asks a student to go to a specific place to observe and identify particular plants. Similarly, learners may prefer different times for learning different types of materials (deep vs. shallow). Social context is another important determiner of personalization especially in social learning situation. For example, depending on which expert is currently available, the topic being taught may be changed automatically.

The individual differences and the learning context are not independent and can be combined for an overall personalization effect. For example, affective states can be combined with prior knowledge and context; a person who is already bored probably should not be taught materials they are not very good at first thing in the morning, for example. Indeed, systems using multiple dimensions for personalization have been proposed (Tseng et al. 2008).

One key aspect of context particularly relevant for developing countries is culture. This is an emerging area of research (Arroyo et al. 2013; Blanchard and Ogan 2010; John et al. 2014). For example, Finkelstein et al. (2013) found that third-grade students who were native speakers of African American Vernacular English (AAVE) showed the best science performance when the technology used features of AAVE consistently. Techniques for instructional design that take culture into account have also been proposed (Savard et al. 2014). Computer-based tutors from the developed world have also been adapted to work in different developing countries (Casas et al. 2014). Some studies such as Alcoholado et al. (2012) have successfully used adaptive multi-student systems in multiple countries such as India and Brazil successfully, but students from India behaved differently than the Brazilian children. However, no systematic cross-cultural analysis was been carried out to understand the cultural context as a personalization variable.

While personalization has been viewed in a narrower technological sense within the advanced learning technology community, wider frameworks for delivering personalized education have been explored for many years. For example, Breunlin et al. (2005) describe how "personalized" education can be brought to very large schools. According to Breunlin et al. (2005), personalization design within large schools consists of building teacher–student, student–student, and faculty–administration relationships, imposing discipline, building relationships within the community, and enhancing student attachment to school. Indeed, there is evidence emerging that this broader sense of personalization is associated with higher levels of academic achievement, improved school culture, and better student engagement (McClure et al. 2010). UNESCO (Izmesti 2012) considers this level of personalization as important for developing countries as well and believes that important components of this broader sense of personalization mean assessment for learning, effective teaching and learning, curriculum entitlement and choice, redesign of traditional classroom to support personalized learning and to extend learning beyond the classroom. Izmesti (2012) also states that ICT can help in personalization by presenting content in an engaging and attractive form, helping teachers record, and constantly monitor the progress of each student, allowing customized delivery of relevant education material to each individual learner, building virtual social communities among different educational institutions, teams of students or teachers, facilitating learning-to-learn skills and by using the latest innovations in ICTs (mobile tools, cloud solutions, etc.) to implement continuous learning processes in different learning contexts, and to provide on-demand support to students. Similarly, Wolf and Wolf (2010) envision personalized learning to include flexible, anytime/everywhere learning, an expanded view of teacher's role, project-based authentic learning, student-driven learning paths, and mastery-/competency-based learning. Policy enablers for this type of personalized learning are redefining use of time, performance-based/time-flexible assessments, equity in access to technology, funding models, incentivized completion, and P-20 continuum and non-grade banding systems. The P-20 and the non-grade banding systems create a highly integrated educational system from pre-school to higher education.

More generally, personalization can be applied to any service at the policy level (Cutler et al. 2007). When applied to learning, such a service must maintain the following aspects:

1. Provide learners and teachers with a “customer friendly interface”
2. Give learners and teachers more say in navigating their way through their learning process
3. Giving learners and teachers more direct say over how money is spent
4. Learners and teachers become co-producers and co-designers of learning
5. Self organization, with professionals creating platforms that allow people to devise learning solutions collaboratively.

In summary, this wider definition of personalization extends the view of a lone learner sitting in front of a computer that “adapts” learning path, to include relationships between the learners and its context to provide broad choices to the learner. However, such personalization needs to occur within the capital, human, and ICT constraints of developing countries. These are described next.

13.3 Capital Constraints

Much has been written about the infrastructure constraints of developing countries with respect to introduction of ICT in general, and e-Learning and automated tutors in particular (Woolf et al. 2011). One of the key constraints in developing countries is the amount of money being spent on education. About one-third (34 %) of the population of low-development countries lives on under Purchasing Power Parity (PPP) $1.25 per day as opposed to almost none (0.1 %) in very high-development countries (VHDC) (The World Bank 2014). In 2012, the low-development index countries spent on average 3.4 % of their GDP on public education while the high human development countries spent about 5.3 % of their GDPs on education (The World Bank 2014). However, in 2011, the PPP GDP/per capita of low-development countries was only $2830 while for VHDC was $40,397. Given that the overall population of very high human development countries is about the same as that of low-development countries, this means that VHDC spent about 14 times more money on their education in absolute terms as opposed to the low-development countries. This wide disparity in spending ability puts severe constraints on how much can be spent on ICT to support personalized leaning. For example, a typical public school system in Pakistan spends about $140 per student per year. Even if 10 % of this spending was reserved for ICT, the actual ICT spend it only $1.4 per student per year. For a typical class of 40 students, this amounts to $56 per year per class which the price of a low-end mobile device.

13.4 Human Resource Constraints

Human resource constraints in developing countries primarily manifest themselves at the level of children, teachers, and their parents. According to UNESCO (UNESCO 2013a), 41 % of children fewer than 5 in low-development countries have stunted growth as opposed to 4 % in very high-development index countries. Similarly, gross-enrollment in VHDC is 94 % as opposed to 54 % in low-development countries (UNESCO 2013a). The adult literacy rate is 58.4 % in low-development countries as opposed to 97.2 % in VHDC (UNESCO 2013a). The mean years of schooling of adults over 25 for low-development countries is 4.2 years as opposed to 11.7 years for VHDC. Consequently, teachers, parents, and community at large are less educated in low-development countries than their counterparts in very high-development countries.

Teachers in developing countries are much less trained than their counterparts in the developed world. For example, only 50–60 % of the primary school teachers are trained in countries such as Ghana, Solomon Islands, Belize, Sierra Leone, Serbia, and Ethiopia (The World Bank 2014). One out of every four teachers is not trained in the sub-Saharan Africa, while the percentage of trained teachers in least developed countries (UN-LDC) and heavily indebted poor countries (HIPC) is about 77 %. These numbers are also optimistic, because quality of trained teachers also varies widely. For example, 83 % of teachers are trained in a developing country such as Pakistan. However, a recent survey (ASER 2013) shows that 37 % of primary school teachers in Pakistan have 16 years of schooling, 34 % have 14 years of schooling, 17 % have 12 years, and 11 % have only ten years of schooling. Due to shortage of trained teachers, many developing countries have also resorted to creating a parallel cadre of undertrained, underpaid, often younger, inexperienced teachers and the ratio of such teachers is around 50 % in many African countries (Chudgar et al. 2014).

Not only are the teachers less educated and untrained in developing countries but the teacher–pupil ratios are also high. For example, at the primary level in 2012 the pupil ratio was 14.42 in the USA while the world average was about 24 (The World Bank 2014). Latin American and Caribbean countries and developing countries in middle and North Africa have a teacher–pupil ratio of about 20. The teacher–pupil ratio increases to 40 in sub-Saharan African countries. As Table 13.1 shows, in general, the richer countries have better student–pupil ratios that progressively get worse as countries become poorer.

Table 13.1 Primary school pupil student ratios

Country category	Teacher-pupil ratio
High income: OECD	14.47
High income: non-OECD	14.70
Middle income	24.21
Low and middle income	26.50
Lower middle income	29.61
Least developed countries: UN classification	39.53
Low income	41.73
Heavily indebted poor countries (HIPC)	41.43

Source The World Bank (2014)

Another problem which is relevant for developing countries is that teachers often teach in multi-grade classrooms. In such environments, multiple classes are being taught in the same physical space. For example, in Pakistan, 22 % of public schools were engaged in multi-grade teaching (UNESCO 2013a) while 48 % of class 2 teaching for governmental schools was multi-grade. Multi-grade teaching has unique pedagogical practices (UNESCO 2013b; Brown 2010; Miller 1989) that require special consideration from a personalization perspective. For example, peer-to-peer adaptive technologies (Walker et al. 2014) can be effective in such contexts. However, this area has received little attention from the personalization research community.

13.5 ICT Affordances

Countries have taken different policy approaches for developing their ICT affordance to support education (Kozma 2008). However, in most instances, operational characteristics of such policies include infrastructure development, teacher training, technical support, pedagogical and curricular change, and content development. ICT affordances are another key constraint on deployment and sustainability of personalized technologies in developing countries. The primary constraints are based on availability of reliable power, telecommunication, and Internet infrastructure which is often taken for granted in the developing countries. Nye (2014) identifies a host of barriers to introduction of personalized tutors in developing countries with respect to ICT affordances including student and teacher basic ICT skills, hardware availability, mobile device availability, Internet data costs, electricity, and unreliable Internet connections.

National policies have a great impact on providing access to affordable electricity in developing countries, and many have failed to formulate effective policies (Winkler et al. 2011). Table 13.2 shows the data that are available for certain regions of the world showing that higher income countries consume several order of magnitude more electricity than the developing countries. Data are, however, not available for many regions such as sub-Saharan Africa.

Not only is the electricity consumption in developing countries low, but large proportions of people in developing countries lack access to electricity. As Table 13.3 shows, only one-third populations of low-income countries have access to electricity. However, these numbers can be deceiving. For example, 68.6 % of Pakistan's population has access to electricity and yet the supply of electricity is highly erratic where electricity is typically not available for more than eight to twelve hours in a twenty-four-hour period. So even though electricity is available, it is not reliable. This means that schools cannot assume that electric power will available during the school time in a reliable manner. Consequently, more expensive options such as power generators are required to ensure reliable access to power. Finally, as Winkler et al. (2011) point out, access to electricity does not mean that it is available to the consumer as well because of lack of affordability.

Table 13.2 Electric power consumption (The World Bank 2014)

Country category	kWh per capita
Middle East and North Africa (developing only)	1696
Latin America and Caribbean (developing only)	1985
East Asia and Pacific (developing only)	2582
Middle East and North Africa (all income levels)	2705
Upper middle income	2932
European Union	6115
High income: non-OECD	7235
High income: OECD	9289
USA	13,246

Table 13.3 Access to electric power (% of population) (The World Bank 2014)

Country category	% Population
Heavily indebted poor countries (HIPC)	28
Low income	33
Least developed countries: UN classification	35
Fragile and conflict affected situations	43
Lower middle income	73
Low and middle income	78
Middle income	85
Upper middle income	98

While data on availability of electricity in schools in developing countries are generally sparse, Table 13.4 shows representative data from some developing countries. The table shows that despite the availability of electricity, very few schools have computer laboratories. For example, in Bangladesh only 1 % and in India 17 % of the primary schools have computer laboratories (UNESCO 2013c). The proportion of schools with computer laboratories goes up to 38 and 45 % for secondary schools in Bangladesh and India, respectively.

Table 13.5 shows the penetration of the ICT infrastructure for developing and the developed world. These ICT numbers show that at most one-third of the population of developing countries has access to the Internet. However,

Table 13.4 Availability of electricity in public schools (% schools) (The World Bank 2014)

Country	Primary schools (%)	Secondary schools (%)
Bangladesh	55	71
Bhutan	67	91
India	45	68
Maldives	100	100
Nepal	6	24
Sri Lanka	82	82

Table 13.5 ICT penetration (per 100 inhabitants) (ITU 2013)

Access type	Developed	Developing	World
Fixed-telephone subscriptions	41.2	10.9	16.2
Mobile-cellular subscriptions	119.2	87.6	93.1
Active mobile-broadband subscriptions	75.1	16.8	26.7
Fixed (wired)-broadband subscriptions	26.6	5.8	9.4
Households with a computer	75.5	27.6	40.7
Households with internet access at home	75.4	27.7	40.4
Individuals using the internet	75.7	29.9	37.9

mobile-cellular subscription seems to be quite high (87.6 per 100 inhabitants). However, these numbers also have to be carefully considered because many of the SIMS for mobile subscriptions are not active and in some sense, these numbers represent an upper limit at best.

One analysis suggests that One Laptop per Child (OPLC) program was not successful because it did not appropriately consider the curriculum and students' level of knowledge (Kremer et al. 2013). However, unavailability of one computing device per child remains a constraint in most developing countries and 1:1 ratio is untenable (James 2015). For example, at the primary school level, the learner to computer ratio is more than 500:1 in Nepal, 412:1 in Philippines, and 83:1 in Islamic Republic of Iran. Even combining data for primary and secondary schools, the student to computer ratios are 136:1 in Indonesia, 98:1 in Sri Lanka, 89:1 in India, and 79:1 in Bhutan (UNESCO 2013b).

In summary, the ICT affordance of developing countries is characterized by severe lack of electricity and lack of computers and computer laboratories. However, availability of mobile devices is growing rapidly. Access to reliable Internet still remains a luxury though.

13.6 Defining Personalization Context

If all children and teachers were the same and they lived in similar circumstances, then there would be little need for personalization. In the technology-enhanced learning community, the term context (Kinshuk and Nian-Shing Chen 2011; Verbert et al. 2012) carries a limited meaning when applied to developing countries. For effective personalization in developing countries, the concept of context of personalization has to be broadened. The development community is also very much aware of the nature of relevant context surrounding learning in developing countries (Berry et al. 2014). For example, Berry et al. (2014) describe contextual dimensions of learning in developing countries to consist of delivery systems, accountability, and teaching practice. In other words, delivery systems, accountability, and teaching practice would have to be personalized. Delivery systems consist of policy and planning, performance management, curriculum, and financing. Accountability, on the other hand, consists of quality assurance, data collection, and governance regimes. Finally, teaching practice includes teaching techniques, class time, language of instruction, and student–teacher ratio. Berry et al. (2014) also recognize that these dimensions are mediated by political economy, home environment, and school environment. Another way to think about contexts for personalization is within the various paradigms of application of AI in Education (AIED) in developing countries (Nye 2013a); within the classroom, around the school, and outside the school.

A more comprehensive model for formulating context of personalized learning is the Bronfenbrenner's Ecological Systems Theory (BEST) (Bronfenbrenner 1992). This theory stipulates that a child's development is affected by a host of systems operating at different levels. The various systems that have an impact on child's growth are shown in Fig. 13.1.

As Fig. 13.1 shows, *microsystem* layer is where a child interacts directly with its environment. These include relationships with peers, school, and family neighborhood. From a learning perspective, these are all the direct influences on the child that may include the school environment, her teacher, and learning materials.

The *mesosystem* layer provides connectivity between structures of the child's *microsystem*. For example, the relationship between a child and her parent, the relationship between the parent and the teacher, and the relationship of teacher to the community. The *exosystem* layer defines the larger social system in which the child does not function directly but this layer can have an impact on a child's

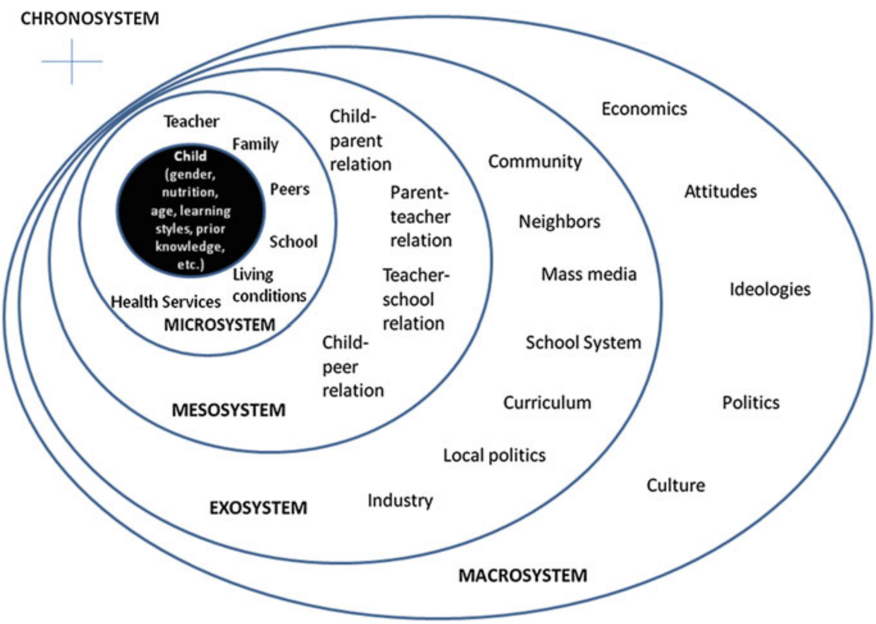

Fig. 13.1 Using systems to define contexts for personalized learning in developing countries

development and learning by interacting with some structure in the *microsystem*. For example, parent's work practices and schedules, and available learning resources and opportunities within a community may have an indirect impact on a child's learning. Even though the child is not directly involved at this level, but he/she must feel the positive or negative force when interacting with his/her own system.

The *macrosystem* is the outermost layer in a child's learning environment. This layer consists of cultural values, local customs, community attitudes, and laws. *Macrosystems* have an indirect and a cascading influence throughout the interactions of all other layers. For example, if the culture believes that a girl child should not be educated, then the community will provide little support for building of girls schools. This in turn puts more constraints on parents' ability to send their child to a nearby school. Therefore, the parent's ability to provide an education to their female children in effected in the *microsystem*.

Finally, the *chronosystem* is about time and how time relates to a child's environments. This system may include events such as timing of a parent's illness as well as internal developmental changes in a child. Children will learn differently at different ages especially during the early years.

BEST suggests that personalization of child's learning is not only focused on a child's internal parameters like learning styles and cognitive constraints, but also on the needs to be viewed in the surrounding contexts of the various encompassing layers. For example, two children whose parents have a different level of education (*microsystem*) will potentially require a very different type of learning design because of the lack or availability of parental support for their learning. Similarly, the level and competence of a teacher is another wider source of variability in the microsystem and techniques for a child's learning for an ill-trained teacher are not necessarily the same as those of a well-trained experienced teacher. For example, Chudgar et al. (2014) indicate that a wide variety of low-quality teachers are hired in developing countries to cut costs. Similarly, only 70 % of the teachers in developing countries with data are trained in national standards of teaching (UNESCO 2014). Teachers in different developing countries also may follow entirely different pedagogical approaches (Westbrook et al. 2013); different pedagogical approaches afford different types of personalization. While most developing countries may follow the traditional teacher-centric behaviorist approaches, certain regions do practice modern pedagogies like activity-based learning in Tamil Nadu (constructivism), thematic-based learning in Uganda (social-constructivism), or Escuela Nueva in Colombia (liberationist) (Westbrook et al. 2013).

A school's infrastructure is also a source of great variability. For example, even in developing countries, some schools are well-equipped and have generators that provide electricity as opposed to other schools that may not even have boundary walls. Very few schools in developing countries have libraries (ASER 2013). Clearly, the approaches optimal in one type of school do not necessarily translate into another school. One may consider using laptops and overhead projectors in one school while another may only afford the use of tablets or mobile phones that can be charged via solar panels. Similarly, living conditions and access to appropriate health services will have a direct impact on a child attendance and consequently the number of hours and frequency with which a child has been exposed to learning materials.

In summary, BEST provides an encompassing model for thinking about context of personalization and as one moves from one layer to another, different opportunities for personalization arise.

13.7 Capability Maturity Level

School systems in developing nations are at different levels of capability and consequently offer different affordances for personalization. ICT maturity is one aspect of capability. Peña-López et al. (2009) point out that the level of ICT maturity will dictate both policy and the nature of ICT-based interventions such as personalization. They define three broad ICT integration stages of e-readiness, e-intensity, and e-impact. In the e-readiness stage, ICT-trained teachers and ICT support staff, radio and television instruction, educational software, and email are important. The e-intensity stage consists of setting up distance education, virtual/open universities, virtual high schools, virtual laboratories and online simulations, and digital libraries. Finally, the e-impact stage enables self-learning through the Internet, Webcasting, podcasting, video conferencing, etc. From a personalization perspective, however, a more comprehensive staged model is required to incorporate a host of other factors in addition to ICT that have an impact on a school system's ability to implement ICT-based personalization interventions. McKinsey's staged intervention model (MSIM) is one such model (Mourshed et al. 2011).

Based on an analysis of why certain schools systems around the world keep getting better, MSIM is a school taxonomy that classifies school systems into the four capability levels. The levels are poor to fair, fair to good, good to great, and great to excellent.

School systems in the poor to fair category are characterized by low-skilled teachers and educational managers and need to exercise tight and centralized control over teaching and learning to minimize variation between classes and schools. These types of school systems, therefore, only admit certain types of personalization regimes both in terms of technology as well as business processes. For example, the curriculum is highly controlled and standardized and is not personalized. Poor to fair level of maturity schools have the primary theme of "achieving the basics of literacy and numeracy." This theme is tied to specific learning interventions. For example, the poor to fair theme suggests three interventions: training and scaffolding low-performing teachers, getting schools to a minimum quality level, and increasing student enrollment. Each intervention is implemented by certain activities. For example, training and scaffolding of low-performing teachers is done by providing scripted lessons, coaching on curriculum, incentives for high student performance, school visits by center, and increasing instructional time on the task. From a personalization perspective, each of these activities can be enabled through personalization technologies. For example, teachers need a lot of scaffolding and should receive personalized lesson plans for their class based on their students' performance.

On the other end of the MSIM maturity spectrum are schools that have highly skilled teachers and administrators and are called great to excellent. Themed as "improving through peers and innovation," these school systems use flexible guidelines for teaching and learning while providing local autonomy to teachers and educational managers to foster innovation. These schools practice collaborative practice, decentralize pedagogical rights of schools and teachers, and implement teacher rotation programs. A significant property of this stage is system-sponsored experimentation and innovation across schools by providing additional funding for innovation and by sharing innovation from the frontline for all schools. As opposed to the lower maturity schools systems, this type of school systems allows many more opportunities for personalization including an ability to personalize the curriculum to the level of each child and hence providing true autonomy of choice in pedagogical as well as administrative and governance aspects.

The theme for the intermediate second-stage schools called fair to good is "getting the foundation in place." The first task for such schools is to set up foundation of data collection for accountability. This is done by making school's performance transparent and by conducting structured school inspections. This type of data collection creates great opportunities for personalization at the school and school system levels. For example, data mining techniques can be used to tie teachers' time on task to correct for anomalies in curriculum coverage by providing each teacher with a customized curriculum. The second theme for this stage is building the financial and organizational foundations. This is done by optimization of schools and teacher volumes, by decentralizing financial and administrative rights, increasing funding, improving a funds allocation model, and through organization redesign. Finally, the pedagogical foundation is improved by focusing on the right type of school models and through initiating the right language of instruction. The personalization here is more about providing instruction in the local dialect or language.

Finally, the good to great maturity stage is themed by "shaping the professional" and is primarily concerned with increasing the professional competence of teachers and educational administrators. First activity is raising the caliber of entering teachers and principals by recruiting programs, pre-service training, and certification. Another activity is to raise the caliber of existing teachers and principals by in-service training programs, coaching on practice, career tracks, and teacher and community forums. Personalization for this type schools should, therefore, focus on teacher training. The third set of activities for such schools is to enhance school-based decision-making including self-evaluation and by setting up independent and specialized schools. The personalization for these activities is consequently less focused on pedagogy and more on the decision-making processes. For example, each school may employ different management strategies based on the quality and characteristics of their incoming teachers in a particular region.

In addition to stage-specific interventions, some learning interventions were observed to occur across the various capability stages and include revision of curriculum and standards, and using student data to guide better delivery. The key insight from this model is that school systems at various stages of development need to do different things in order to move up to the next stage and consequently will required different personalization regimes.

In summary, the MSIM clearly articulates that nature and type of personalization in schools systems is stage dependent. While many schools in developing countries are at earlier stages of maturity (e.g., lack of good teachers, resources, and processes), but even developing countries have individual school systems that are at higher levels of maturity. This is especially true for high-end private school systems. Consequently, even within a developing country, different school systems will focus on different aspect of personalization based on their MSIM stage.

13.8 Discussion and Conclusion

Learning in developing countries and ICT interventions like personalization happen in a richer context than most developing nations. This is partially due to higher variability. In addition, many of the assumptions under which personalization technologies evolved in the developed world simply do not hold in developing countries. For example, a significant amount of research in adaptive systems assumes 1:1 child–computer ratio where a child has access to a single computer. This is simply not true for most developing countries. There have been attempts to bypass such constraints. For example, MultiLearn+ splits a laptop display into quadrants that is shared by multiple children each with their own keyboard (Brunskill et al. 2010). Similarly, another approach is to provide a single mouse per child while the whole class shares a screen (Alcoholado et al. 2012). However, even these approaches fall apart when there is no reliable electricity or a laboratory in the school. Clearly, there is a need to move toward personalization strategies that are perhaps based on the concepts of one tablet or mobile phone per class or per teacher. Many developing countries now use solar panels to charge their mobile devices and hence availability of electricity is a non-issue for such devices.

A second message in this chapter is that given the constraints of learning in developing countries a much broader definition of personalization is required. This wider context includes business processes at various levels in addition to the typical pedagogical concerns. Within this wider context of personalization, use of data mining techniques becomes an important input into the personalization process. However, current research in this area is primarily focused on the traditional areas of student behavior modeling, student performance modeling, assessments, and student modeling (about 20 % each) (Peña-Ayala 2014). Systems providing student support and feedback, and curriculum, domain knowledge, sequencing, teacher support only account for one-fifth of the currently surveyed work (Peña-Ayala 2014). While in still in its infancy, measurement of learning is also taking increasing importance in developing countries (Wagner 2011). Large amounts of assessment data collected at the classroom, school, and national level will create important opportunities for personalization using educational analytics. This trend is also supported by the emergence of global standard to measure learning across nations (UNESCO 2013d).

In conclusion, personalization holds great promise for developing countries. However, the nature and form of personalization will have to change to cater to the human resource, capital, and ICT constraints of developing nations. In addition, more sophisticated models of contexts and application of learning are required for effective personalized learning interventions that go beyond pedagogical considerations.

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Author Biography

Dr. Imran Zualkernan holds a BS (high distinction) and a PhD from the University of Minnesota, Minneapolis. Dr. Zualkernan is specialized in application of learning technologies and educational analytics to improve education in developing countries. He has published over 125 papers in refereed workshops, conferences, and journals. He is an executive committee member of the Institute of Electrical and Electronic Engineering (IEEE)'s technical committee on Advanced Learning Technologies. He has held CXO positions in multiple technology start-up companies. He has worked as a consultant for World Bank, Asian Development Bank, GIZ, and DFID education projects related to improving primary education and schools. He is a member of the Phi Kappa Phi, Tau Beta Pi, and Golden Key National Honor Societies.

Chapter 14
Understanding Cognitive Profiles in Designing Personalized Learning Environments

Arif Altun

Abstract Understanding the learners' cognitive characteristics and designing the personalized learning environments accordingly is quite a challenging task. Although various models and frameworks have been proposed when designing adaptive environments, it is less understood how these cognitive characteristics are determined and how different personal characteristics change when exposed to various media and design choices. Therefore, this chapter first aims to introduce neuropsychological tests and their potential uses in determining cognitive profiles. Secondly, existing research will be reviewed to discuss how those individual cognitive characteristics yield different results while interacting with the content. Finally, some recommendations will be made for further research.

Keywords Neuropsychological tests · Cognitive profiles · Instructional design · Attention · Memory · Navigation · Personalized learning environments

14.1 Introduction

During the transition from hypermedia to multimedia, and then to the WWW, the way we present learning materials to learners has changed from a static "one design for all learners" paradigm to "multiple designs for one learner" approach (Altun 2012). Personalized learning removes time, location, and other constraints in teaching and tailors teaching for each learner's constantly changing needs and skills (Sampson et al. 2002). In another definition, personalization is described as adapting learning experience to different learners by analyzing knowledge, skills,

A. Altun (✉)
College of Education, Department of Computer Education and Instructional Technologies Beytepe, Hacettepe University, Ankara, Turkey
e-mail: altunar@hacettepe.edu.tr
URL: http://www.ontolab.hacettepe.edu.tr/en

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and learning preferences of individuals (Devedzic 2006). However, the issues of dropout and the dissatisfaction of learners are still among the main barriers researchers deal with (Karampiperis and Sampson 2005).

One of the solutions, as suggested by various researchers in the field, is to provide personalized learning experiences for individuals so that they could use the system on regular bases and benefit from the learning materials, both in mobile (e.g., Kinshuk et al. 2010) and in e-learning environments (Essalmi et al. 2010). In the past two decades, researchers adapted various profiling strategies in order to provide personalized learning environments for learners at various levels. Among those strategies are learners' cognitive and/or learning styles (i.e., Yang et al. 2013), learners' existing background knowledge (i.e., Tseng et al. 2008), and navigation and browsing behaviors (i.e., Altun and Kaya 2014). Researchers used learners' characteristics to develop an adaptive learning system by adjusting learning paths according to the characteristics of the content (such as difficulty levels and complexity nature of the material) and its mode of delivery (i.e., Li et al. 2013; Despotović-Zrakić et al. 2012). However, the interaction between the learner and the media from a cognitive characteristics point of view is less explored and it is generally assumed that learners equally benefit from the content when the delivery mode is manipulated.

Research has also demonstrated various benefits of using personalized systems over clustered approaches (i.e., Altun and Kaya 2014). For example, Papanikolaou et al. (2002) developed an adaptive learning system by taking students' knowledge levels as the main factor for adapting the learning content; moreover, Tseng et al. (2008) developed an adaptive learning system based on an object-oriented framework that composes personalized learning content by considering individuals' knowledge level and the difficulty level of the learning objects. When addressing the issues in adaptive and personalized learning environments, researchers are employing both existing and new methods of inquiry. In regular and constant monitoring of learners, learning analytics and data mining methods are being employed. Similarly, when determining cognitive and non-cognitive personal characteristics, the research in the field of cognitive psychology and mind, brain, and education research provide valuable input. Table 14.1 summarizes the general trends in addressing the issues as well as the domain of research.

Table 14.1 General trends in inquiry and practice into designing personalized learning environments

Issues and focus of research	Domain of inquiry
Regular and constant data monitoring and analysis tools	Learning analytics/data mining
Determining cognitive and non-cognitive personal characteristics accurately	Cognitive psychology/mind, brain, and education
Learners' interaction with designed medium and observations, i.e., learning outcomes	Instructional design
Tools to diagnose and/or guide learners with study or navigational paths	Ontology design and navigational paths

Although various models and frameworks have been proposed when designing adaptive environments, and various approaches were used in determining personal characteristics, it is less understood how these cognitive characteristics are determined and how different personal characteristics change when exposed to various media and design choices. Therefore, this chapter aims to introduce neuropsychological tests and their potential uses in determining cognitive profiles. Secondly, some examples from existing research are provided to describe how those cognitive characteristics play a role when interacting with the content. Finally, some recommendations are envisioned for further discussion.

14.2 Neuropsychological Tests and Cognitive Profiling

Neuropsychological tests are important evaluation tools that make it easier to put cognitive models into practice and assess cognitive processes. These tests can also be used to measure cognitive processes and complex information-processing events (Lezak 1995; Spreen and Strauss 1991) and have been used heavily in determining mental functions as well as potential dysfunctions in patients. Recently, these tests have also been transformed into computerized environments.

When using the neuropsychological tests, it is advised to have received proper training in order to administer these tests. Moreover, in addition to the availability of the computerized versions of neuropsychological tests, we also witness a wider range of applications with various names, such as brain training and attention training. Since these training-oriented applications are beyond the scope of this argument, the focus will be on discussing paper-and-pencil versus computerized versions of neuropsychological tests and their administration.

In a series of research, Aşkar et al. (2010, 2012) employed two computerized neuropsychological tests to see whether they would yield similar results with the paper-and-pencil version. The selected two tests were Line Orientation Test (LOT) and the Enhanced Cued Recall Test (ECRT). The paper version of the Line Orientation Test (see Fig. 14.1 for a sample screenshot) is developed for scaling of visual–spatial perception and orientation, and the recall test provides information regarding the source of memory problems. The Line Orientation Test could be used as a predictor of navigational problems, such as disorientation issues, whereas ECRT (see Fig. 14.2 for a sample screenshot) would yield valuable information regarding object location memory and transferring, which is known as the "transfer appropriate processing" approach. According to this approach, when the similarity between semantic and physical cues while coding and recalling step increases, then memory performances also increase (Fay et al. 2005). By using semantic cues, it would be easier to locate the source of memory problems, whether they are at the level of recording/storing or during recalling (for detailed information, see Aşkar et al. 2012).

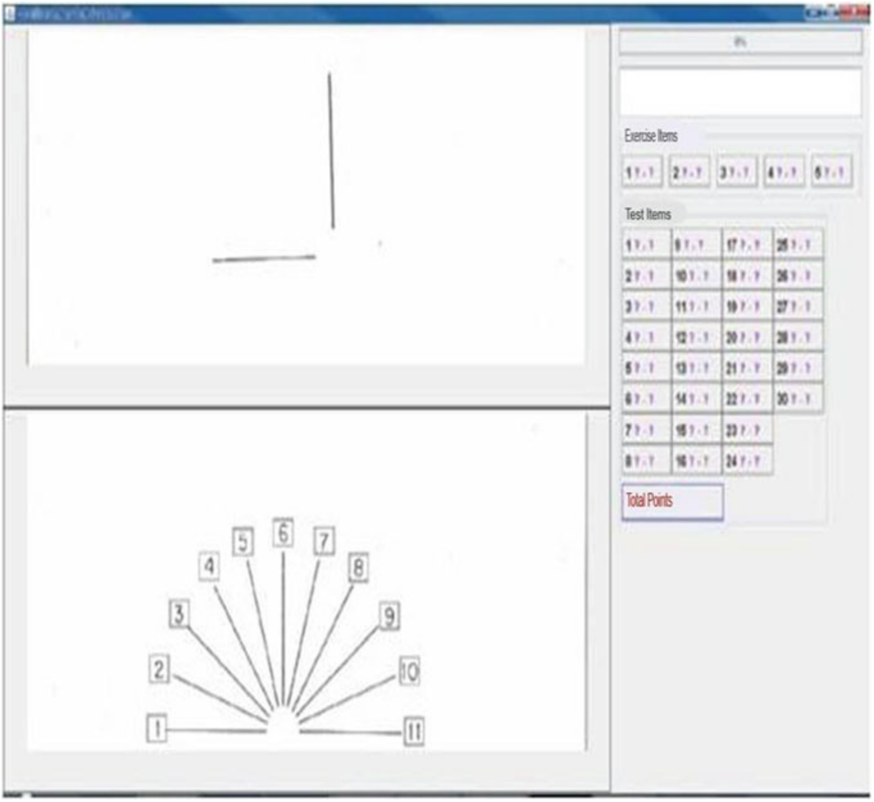

Fig. 14.1 A sample screenshot from LOT test. Reproduced with permission of publisher from Aşkar et al. (2012). © Psychological Reports 2012

Comparison analyses on 77 volunteer undergraduates showed that the Enhanced Cued Recall Test–computer-based scores did not correlate with Enhanced Cued Recall Test–paper-and-pencil results ($r = -0.09$; $p > 0.05$). The Line Orientation Test–computer-based scores did correlate significantly with Line Orientation Test–paper-and-pencil version ($r = 0.61$; $p < 0.05$). In both tests, paper-and-pencil scores were higher compared to computer-based tests. Total score difference between modalities is statistically significant for both tests: for Enhanced Cued Recall Test ($t(74) = 9.070$; $p < 0.05$) and for Line Orientation Test ($t(66) = 6.170$; $p < 0.05$). It took less time for participants to complete the computer-based tests compared to the paper-and-pencil tests: for Enhanced Cued Recall Test ($t(68) = 4.769$; $p < 0.05$) and for Line Orientation Test ($t(64) = 4.496$; $p < 0.05$).

These results indicate that persons' cognitive performances might be sensitive to the medium, especially when the task requires higher order performances as in the Line Orientation Test. In memory tasks, on the other hand, participants'

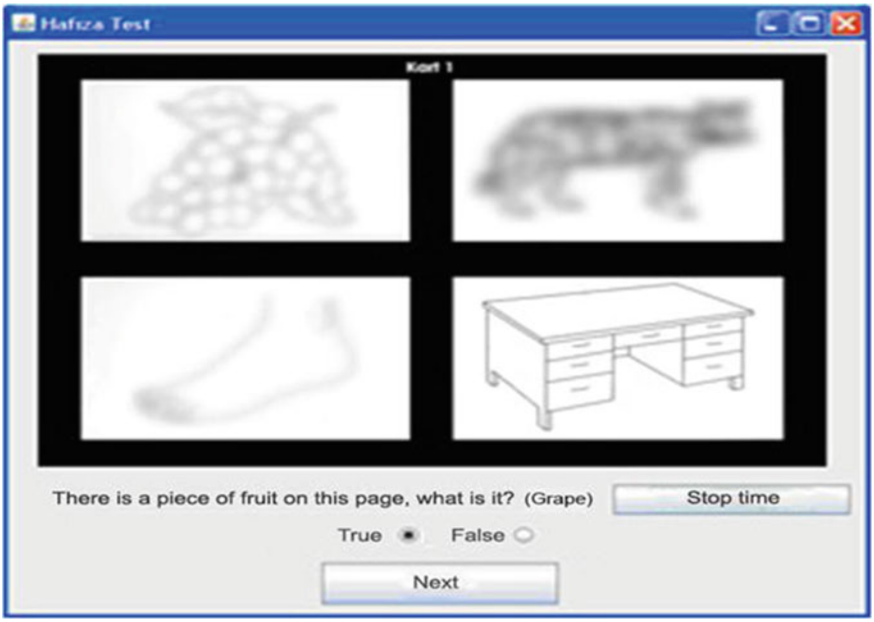

Fig. 14.2 A sample screenshot from ECRT. Reproduced with permission of publisher from Aşkar et al. (2012). © Psychological Reports 2012

performances on the computer-based test did show correlations with their performance on the paper-and-pencil test. Therefore, it would be highly possible that cognitive processing might be sensitive to the screen media, and more research is needed to explore other cognitive functions. In the following section, a review of research will be described to contextualize these findings and to provide instructional design guidelines for developing personalized learning environments.

14.3 What Would the Research Indicate for People with Different Cognitive Profiles?

One approach to understand cognitive differences is to observe how learners differ in terms of their attention spans and memory performances. Another approach would be to understand whether individuals with varying attention spans and memory capacities equally benefit with the provided navigational design patterns. In this section, learners' differences in attention span and memory capacities will be summarized and synthesized according to various design types in order to suggest a user profiling approach based on these cognitive functions.

14.3.1 Attention, Memory, and Design Differences

Memory and attention have been two of the most explored areas of research due to their multifaceted nature. There are various types of memory and attention. Learners might show differences in their memory performances and attention capacities. In this section, the focus will mainly be on research exploring the interrelated relationship between memory performances, attention types, and instructional design choices for personalized learning design.

Mutlu Bayraktar and Altun (2012) explored the effects of instructional designs created for different attention types on the recall performances of students with different short-term memory capacities. The attention design types included split and focused attention design types (see Fig. 14.3a and b). Memory capacity is crucial for storing, recalling, and remembering information. In addition, attention is the required process where the information is passed onto working memory. Therefore, the researchers divided learners according to their short-term memory performances into three groups by using a digit span test: low-, medium-, and high-memory groups. The findings showed that learners performed higher with focused attention design regardless of their levels of short-term memory capacity. The findings also imply that recall performances of students with low short-term memory capacities can be increased by taking the focused attention effect into consideration during multimedia design.

In an eye tracking study, Köseoğlu et al. (2013) explored whether learners with and without prior content experience would differ in their study behaviors and recall performances in two different design options: graphically animated design and in a verbal contextual cue design (see Fig. 14.4). A total of 39 undergraduates from the Biology Education Department studied a 3-minute animation showing the inter-neuron transfer of stimulus through synapses. In the graphically animated modality, the neural transmissions are animated with no verbal clues. In the verbal contextual cue design, on the other hand, the animation was accompanied by texts as verbal

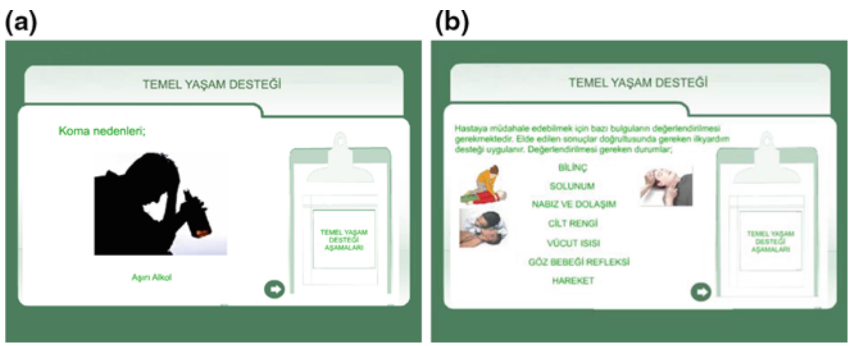

Fig. 14.3 **a** A sample screenshot from the focused attention design. **b** A sample screenshot from the split attention design

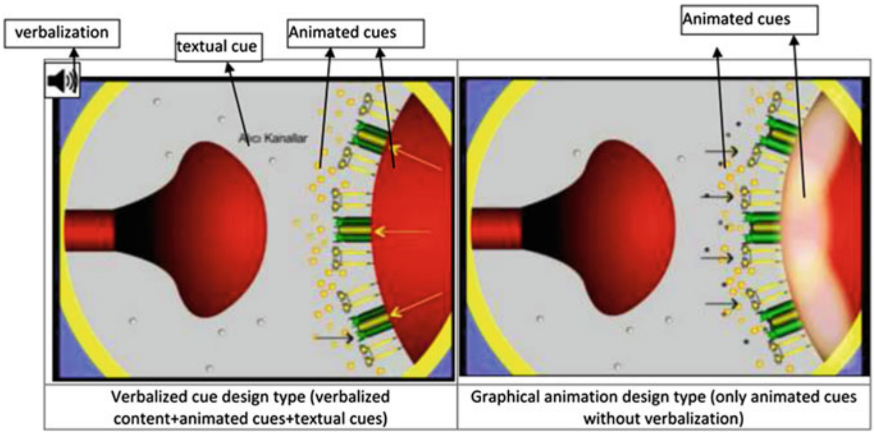

Fig. 14.4 Verbal and graphical contextual cues

cues as they were narrated. At the end of the study, results showed a significant within-subjects' treatment effect for design types (verbalized cue vs. graphical animation) in terms of eye movements, while between subjects, effects for comparison of prior experience groups were not found to be significant.

In another study, Ilgaz et al. (2014) explored how various attention types (dynamic and static cue types) used in e-learning environments affect university students' implicit memory performances with different sustained attention levels. The findings indicated that neither of the cues had a common effect on implicit memory performances of individuals with high or low sustained attention levels. In addition, the cues presented in two different forms, i.e., dynamic and static, have been found to be effective for participants' implicit memory performance when participants' sustained attention level is ruled out. In other words, those who experience attention problems would benefit more with static cueing design rather than with dynamic cueing in e-learning environments.

The findings in these studies indicate that cognitive differences at memory and attention levels could be important predictors of learners' achievement in e-learning environments. In addition, the findings imply various design principles to take into account when making instructional design choices. Depending on the performance results, certain cognitive differences would be minimized and/or eliminated when these steps are taken into account.

14.3.2 Navigation and Design Differences

Navigation in Web-based environments is one of the challenging tasks for hypertext readers. During reading, hypertext readers are reported to allocate their cognitive resources to meet the cognitive demands and often get disoriented while navigating through hyperlinks.

Cangöz and Altun (2012) investigated the effects of hypertext structure, presentation type, and instruction type on readers' implicit and explicit memory performances and their perceived disorientation. Implicit memory requires unintentional recall of earlier encounters, whereas explicit memory refers to recalling earlier encounters consciously and with certain intent (Graf and Schacter 1985; Schacter 1987). Automatic processes are known to require less attention with unconscious efforts, whereas controlled processes are conscious and require more cognitive effort and attention (Light et al. 2000). When measuring the implicit and explicit memory performances, a word stem completion (WSC) test is employed. This test consists of word fragments of which only the first three letters are provided (e.g., word stem: TAB, target word: TABLE). Once the task is completed, the learners are asked to complete them with the words that come to their mind, in the implicit instruction, whereas under the explicit instruction, they were asked to complete the words from the reading task they completed. The numbers of correct responses are computed as the dependent variable measure.

Cangöz and Altun (2012) reported that instruction-type and presentation-type main effects were found to be significant only on WSC scores (memory scores). There was no significant main effect of hypertext structure observed for either WSC or perceived disorientation scores. The interaction effect between hypertext structure and presentation type was significant only on perceived disorientation, yet no other interaction effects were significant. Furthermore, readers with low working memory were usually disadvantaged in hypertext (DeStefano and LeFevre 2007), and highly structural hypertext provides high coherence, which leads to better text-based recall than low coherent hypertext (Amadeieu et al. 2009). When designing personalized hypertext environments, it should be kept in mind that implicit memory would play a role in directing attention to the target more efficiently, whereas explicit memories can help in finding the target, which are based on implicit memories (Oulasvirta et al. 2005).

In another study, Mazman and Altun (2013) developed a computerized version of the Spatial Orientation Test (originally developed by Kozhevnikov and Hegarty 2001) and determined the norm values for Turkish undergraduate students. Spatial orientation is essential for several major functions in daily life, among which are way/direction finding, navigation in space, and route description (see De Beni et al. 2006 for detailed information), yet spatial orientation performance varies among individuals. Based on the result from this test, individual differences between low and high spatial orientation ability groups during performance on the Spatial Orientation Test were examined through eye movements. The findings indicated that there were significant differences in eye movements between different spatial orientation ability levels in terms of fixation duration and how high- and low-level spatial orientation level groups solved problems with different solution patterns.

Another cognitive characteristic is the object location memory (OLM), with which people can recall locations of and relationships between objects within a given environment. OLM span is known to vary among individuals (Silverman and Eals 1992; Kimura 1999; Kessels et al. 2006), across gender (i.e., Spiers et al. 2008), and that this type of memory has a significant effect on recalling spatial knowledge about objects during navigation as well as on overall navigation performance (i.e., Gallagher et al. 2006).

While making design decisions about personalized environments, to what extent would this cognitive characteristic be an important construct to take into account? In exploring this issue, Uz and Altun (2014) explored the effects of static and dynamic navigation environments on learners' spatial knowledge recall performances while considering OLM spans. In order to explore whether OLM spans (low versus high) would show differences in two different environments (2-D and 3-D environments), the researchers investigated learners' recall performances, while in the 3-D dynamic environment, individuals navigated through the smooth display of view changes (see, Fig. 14.5a); in the static environment, a 2-D representation of the 3-D real world, objects did not change with the movement of the observer (see, Fig. 14.5b). As participants finished the study task, they were given a spatial knowledge recall test.

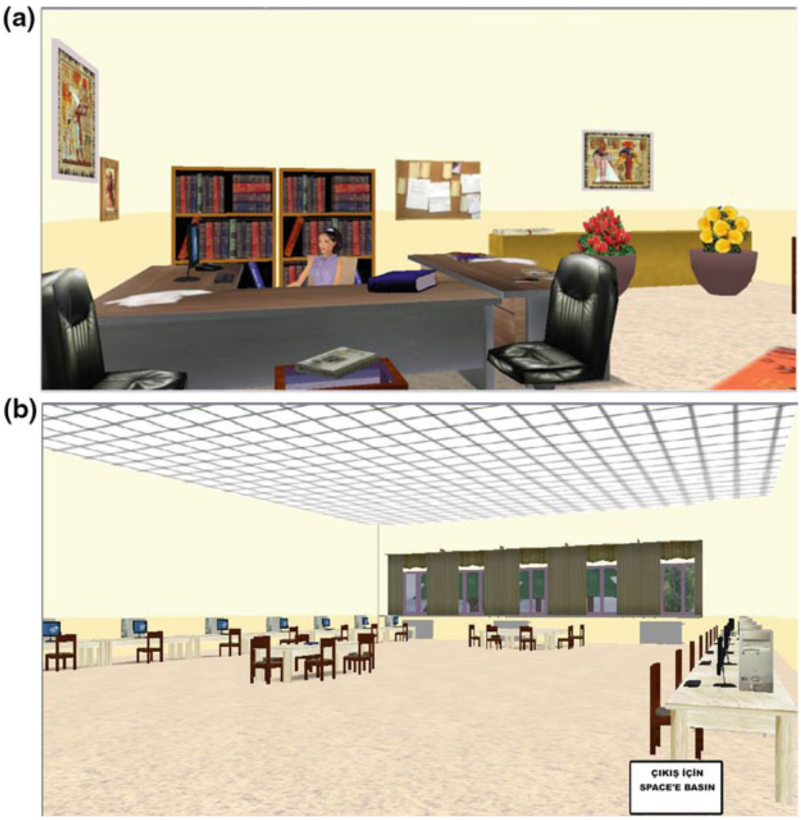

Fig. 14.5 **a** A sample screenshot from 3-D environment. **b** A sample screenshot from 2-D environment

Findings indicated that there was no significant difference between low OLM groups in their recall performances; however, high OLM span participants' recall performances in the static environment (2-D) were higher than those from the dynamic environment (3-D). Moreover, gender differences were also observed in terms of recalling spatial knowledge, with males earning the highest scores in the dynamic navigation environment. These findings clearly indicate that if high OLM span learners are exposed to a 3-D environment with no instructional guidance, they would be at a disadvantageous position in their recall performances, and similarly, so would females, who performed worse in 3-D environments.

14.4 Conclusion

This chapter intended to introduce neuropsychological tests in order to determine individual cognitive differences when developing user modeling for personalized learning environments. As suggested by Spector (2013), personalizing education, especially e-learning environments, is one of the grand challenges both for instructional designers and for system developers since it is well accepted that one method does not fit all.

As suggested by IMS (2001), three major structures (learning style, modality preference, and knowledge level) representing user model elements have established a starting point for designing personalized environments. With Henze et al. (2004), this base was elaborated to a quadruple: (1) the knowledge space (KS), (2) the user model (UM), (3) the observations (OBS), and (4) the adaptation model (AM) (as cited in Karampiperis and Sampson 2005, pp. 128–129). In Kaya and Altun (2011), the user model is proposed to include cognitive differences, embedded within CogSkillNet ontology.

It is clear that at the base of all models, understanding the learner and determining which characteristics are determinant in making learning experiences a success is vital. In this chapter, an attempt was made to draw attention to cognitive differences in memory types and attention spans in particular. Moreover, another aim was to emphasize the need for comprehensive instructional design research to explore how these cognitive characteristics benefit from different types of content and navigation designs. No doubt that much interdisciplinary research is needed to understand such interactions between learners and content from a dynamic student modeling perspective (see Graf and Kinshuk 2013). It should also be noted that applying neuropsychological tests in online environments is cumbersome, or even not quite possible for individual users. By using new methodological tools, predictive models could be developed in order to automate and update the learner models with the use of ontology.

Online courses, hence e-learning environments, require further considerations. Personalization can be a valuable tool to facilitate lifelong learning with just-in-time and on-the-job training, as well. Thus, it is important for educators to know their learners. Similarly, different frameworks and learner (and group) characteristics will drive the method of personalization that will be the most effective. Last but not least, it should also be kept in mind that cognitive characteristics are dynamic in nature and skill trajectories are always under construction (Yan and Fischer 2002).

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Author Biography

Dr. Arif Altun is a professor of computer education and instructional technologies at the College of Education at Hacettepe University, Ankara, Turkey. He holds a doctorate degree from the University of Cincinnati. He has been at the University of Eau Claire as a visiting scholar in 2011 and is currently a Fulbright Visiting Scholar at the Graduate School of Education at Harvard University. His main research interest lies at the crossroads of learning, instruction, and computers exploring the individual differences both from cognitive and from socio-cognitive paradigms.