Pedro Isaías · J. Michael Spector
Dirk Ifenthaler · Demetrios G. Sampson
Editors

E-Learning Systems, Environments and Approaches

Theory and Implementation

Springer

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Chapter 1
E-Learning Systems, Environments and Approaches: Theory and Implementation

Pedro Isaías, J. Michael Spector, Dirk Ifenthaler and Demetrios G. Sampson

1.1 E-Learning Systems, Environments and Approaches: Theory and Implementation—An Overview

Digital technologies and Information Systems (IS) are playing an increasing role in the planning, design and implementation of e-Learning systems and environments.

There is a great demand for technology-supported educational and training services that provide enhanced learning experiences. This includes access to technology and pedagogical services beyond those required for traditional face-to-face settings. There is a resulting emphasis on the reduction of the costs of implementing such systems in a variety of contexts associated with an increase in the number and diversity of e-Learning providers world-wide. Renowned academic institutions are joined by corporations, public sector organizations and small enterprises in offering e-Learning programs. These programs range from long-term academic degrees to short-term training courses. Education is becoming more widely available and adaptable to the structures of work routines and emerging social realities. While

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universities appreciate the technological advances that allow for technology-supported courses, industry is also grateful for the possibility of technology-supported training programs that address their particular business needs and swiftly respond to emergent new competencies.

E-Learning has been, since its early years, related to flexibility and options. While this dynamic nature has mainly been associated with time and space, it can be argued that currently it embraces other aspects such as personalized and adaptive learning experiences. Smart learning environments are making it possible to adopt teaching and assessment methods that, although theoretically well grounded, were not operationally possible in the past.

Technology's progress grants students the opportunity to pursue their learning objectives independently and proactively. Semantic-based services and ontological development are an initial means of improving authoring tools, enhancing information management and creating reusable learning objects. Social technologies continue to encourage and support Open Education Resources, content editing and sharing, especially in the form of learning communities. Moreover, an emphasis has been placed on the use of smart mobile technologies.

IS supporting e-learning implementations are demanded to respond to the challenges of its student-centered approach in an information overload age. Electronic learning environments have freed themselves from the expectation of mimicking the conventional in-person education. The widespread acceptance of e-learning as a valid and advantageous mode of education delivery has allowed a progressive realization of its full potential.

These developments have led to new research challenges that are discussed in this volume. This book is entitled *E-Learning Systems, Environments and Approaches: Theory and Implementation* and is comprised of four parts: (a) Exploratory Learning Technologies (Part I), (b) e-Learning Social Web Design (Part II), (c) Learner Communities through e-Learning Implementations (Part III), and (d) Collaborative and Student-Centered e-Learning Design (Part IV). The volume consists of twenty chapters, included expanded versions of highly rated papers presented at the CELDA (Cognition and Exploratory Learning in the Digital Age) 2013 Conference as well as several contributions from scholars from around the world with expertise in the topical areas covered herein.

Chapter 2, entitled *"Measuring problem solving skills in portal 2"* by Valerie J. Shute and Lubin Wang (Shute and Wang 2015), reports on a research project that investigated the use of video gameplay as a medium to support problem-solving skills in students. Participants played two games: a video game named Portal 2, and Lumosity (a Web-based platform that hosts more than 50 small-scale games). The authors reached the conclusion that Portal 2 can be used as a mean to measure and possibly support cognitive skills such as problem solving.

Chapter 3, entitled *"IPads in inclusive classrooms: ecologies of learning"* by Bente Meyer (Meyer 2015), reports on data gathered from a research project where iPads were used in a lower secondary school in Denmark. The research focuses on how the incorporation of iPads in teaching and learning can develop and maintain inclusive educational settings in a lower secondary school. The data presented in this chapter were collected from fieldwork in five classes of seventh graders (age 13–14), who were given iPads in the school year 2012–2013, including two special needs classes. The iPads became part of the dynamics of these classrooms, especially with regard to resource use. As a flexible technology, the iPads allowed learners to create their own systems of related resources or processes that are appropriate for their individual and variable learning needs.

Chapter 4, entitled *"Supporting the strengths and activity of children with autism spectrum disorders in a technology-enhanced learning environment"* by Virpi Vellonen, Eija Kärnä and Marjo Virnes (Vellonen et al. 2015), establishes four principles for a technology-enhanced learning environment with and for children with autism spectrum disorders (ASD). This chapter reports on how these principles were accomplished taking into consideration the children's actions in the technology-enhanced environment. The results show that the technology-enhanced learning environment offered many opportunities for making possible the appearance of potential skills, active participation, and the learning of children with ASD.

Chapter 5, entitled *"Learning with the simpleshow"* by Dirk Ifenthaler (Ifenthaler 2015), reflects on the notion that technological-enhanced learning environments are a great contribution to learning contexts, but sometimes the pedagogically aspects are left behind when developing this new learning environments. For that reason, it studied a new video format called Simpleshow that is capable of illustrating a theme, product, or problem in a maximum of five minutes. This first empirical study of the benefits of using Simpleshow shows that this new video format can be productively integrated into classroom teaching by promoting significant learning by activating the learners' previous knowledge.

Chapter 6, entitled *"Live, laugh and love to learn"* by Merja Meriläinen and Maarika Piispanen (Meriläinen and Piispanen 2015), establishes modern methods to develop teaching and learning. The purpose is to generate individual learning tools and to offer each child equal learning opportunities in the new learning environments of the twenty-first century. This research project emphasizes the questions of evaluation and assessment as tools to help each child find effective ways to achieve his/her learning goals. The classroom intervention was based on the Contextual Pedagogical Approach to Learning (CPAL) as a framework of teacher's twenty-first century civil skills pedagogical content knowledge.

Chapter 7, entitled *"The configuration process of a community of practice in the collective text editor"* by Cláudia Zank, Patricia Alejandra Behar and Alexandra Lorandi Macedo (Zank et al. 2015), reports on a community of practice in the Collective Text Editor (CTE). The CTE has the aim of promoting collaborative work mediated by a computer and to produce a space where the synchronous and asynchronous creation of collective texts among geographically dispersed users is encouraged. It is studied as a community of practice (CoP), which is composed of a teacher and five students of the Postgraduate Program in Education at the Federal University of Rio Grande do Sul in order to determine to what extent the CET can gather the needs, values, knowledge and information of the members of the CoP.

Chapter 8, entitled *"Using an ontological and Rule-based approach for contextual Semantic Annotations in online communities"* by Souâad Boudebza, Lamia

Berkani, Faiçal Azouaou and Omar Nouali (Boudebza et al. 2015), suggests and discusses a knowledge capitalization approach for knowledge reuse within a Community of Practice of E-learning (CoPE). For that end, the authors developed a prototype of knowledge capitalization system based on contextual semantic annotations, called CoPEAnnot. This prototype is a context-aware annotation system that has the purpose of leveraging knowledge in communities of practice of e-learning.

Chapter 9, entitled *"Recognizing and analyzing emotional expressions in movements"* by Vladimir L. Rozaliev and Yulia A. Orlova (Rozaliev and Orlova 2015), describes automated systems for the recognition and analysis of emotional reactions. This chapter presents a new approach to the automated identification of human emotions based on an analysis of body movements, gestures and poses. The authors developed a new approach to identify, classify and differentiate emotions, body movements. This approach is described with linguistic variables and a fuzzy hypergraph for temporal events, which are then transformed into a limited natural language expression.

Chapter 10, entitled *"Student-driven classroom technologies: transmedia navigation and tranformative communications"* by Leila A. Mills, Jenny S. Wakefield and Gerald A. Knezek (Mills et al. 2015) investigates middle school students' attitudes toward learning with technology. The authors recommend a design-based approach to formulate instruction that includes innovative classroom technology usage with computers and communications technologies.

Chapter 11, entitled *"ICT support for collaborative learning—A tale of two cities"* by Teresa Consiglio and Gerrit C. van der Veer (Consiglio and van der Veer 2015), focuses on experiences developed in teaching Service Design in a blended learning context. The authors present an electronic learning environment (ELE) that contains features appropriate for learners from different cultures. The ELE was used in a blended learning context on Service Design in universities in Italy and China. The ELE can be adapted to cultural contexts and the learners' needs. The authors concluded that a flexible ELE is possible for teaching in different educational cultures.

Chapter 12, entitled *"The investigation of Pre-service teachers' concerns about web 2.0 technologies in education"* by Yungwei Hao and Kathryn S. Lee (Hao and Lee 2015), identifies pre-service teachers' concerns regarding the integration of Web 2.0 technologies in teaching and learning environments. About 350 pre-service teachers participated in this research in a northern university of Taiwan. The authors reached the conclusion that preparing pre-service teachers with essential pedagogical skills and supporting the usage of technology as tools to improve their own learning skills will probably facilitate their adoption of Web 2.0 technologies in the classroom.

Chapter 13, entitled *"Teacher Training using Interactive Technologies: performance and assessment in second life and simschool"* by Julia Meritt, David Gibson, Rhonda Christensen and Gerald Knezek (Meritt et al. 2015), compares and discusses two different simulation environments—namely, Second Life and simSchool. Both simulation environments formed the basis of computer-mediated teacher preparation systems concerning implementation, operation, and assessment features. Findings were generally positive and impressive.

Chapter 14, entitled *"A study on improving Information Processing Abilities Based on PBL"* by Du Gyu Kim and Jaemu Lee (Kim and Lee 2015), investigated an instructional method for the development and improvement of information processing abilities in elementary school students in Korea. This study recommends a method for teaching information processing capacities based on a problem-based learning model. The research design involved comparing pre- and post-tests with twenty-three fifth grade elementary students over a period of eight months.

Chapter 15, entitled *"Constructivism vs Constructionism: Implications for Minecraft and classroom implementation"* by Catherine C. Schifter and Maria Cipollone (Schifter and Cipollone 2015), presents an exploratory case study centered on one instructor and the use of a videogame environment, called Minecraft (a learning tool videogame) in a high school English literature class. The authors propose that a complete implementation of tools like Minecraft will involve a shift in the way videogame technologies are perceived and used for learning purposes with the emphasis shifting from entertainment to learning.

Chapter 16, entitled *"Student-Centered, E-learning design in a university classroom"* by Melissa Roberts Becker, Pam Winn and Susan Erwin (Becker et al. 2015), reports on a group of faculty members who were concerned with the lack of student motivation and class preparation. These instructors redesigned courses placing the initial content acquisition responsibility on students. In this case, the process of redesigning occurred in a sophomore-level education course. Consequently, students were ready to engage collaboratively in student-centered learning activities and demonstrate workplace skills in real-world environments.

Chapter 17, entitled *"Some Psychometric and Design Implications of Game-Based Learning Analytics"* by David Gibson and Jody Clarke-Midura (Gibson and Clarke-Midura 2015), describes the context, methods and broad findings from the analysis of two game-based learning efforts. The authors present the analytics and data analysis from two virtual performance assessments (VPAs) developed by the Virtual Assessment Project at the Harvard Graduate School of Education. These VPAs assessed middle school students' aptitudes to design scientific investigations and design a causal explanation. The intention of this analysis was to explore patterns of action that possibly can relate to the performance of the user associated with the student's final statement.

Chapter 18, entitled *"Self-assessment and reflection in A 1st semester course for software engineering students"* by Jacob Nielsen, Gunver Majgaard and Erik Sørensen (Nielsen et al. 2015), explores how student self-assessment can be used as a tool and become beneficial for both lecturers and students. The authors used a simple self-assessment tool for pre- and post-testing in a first semester engineering course. In the pre-test, the students became conscious of the academic expectations in the course as they measure their own knowledge with regard to specific course terms. The students evaluated their knowledge on human-computer interaction based on their ability to understand and explain specific concepts.

Chapter 19, entitled *"Don't waste student work: using classroom assignments to contribute to online resources"* by Jim Davies (Davies 2015), presents and describes some types of assignments that not only educate students but also create durable online contributions for usage by other scholars and future students. Five assignments types are described: (a) paper summaries, (b) contributions to wikibooks,

(c) creation of Mnemonics for a wiki, (d) online flash cards, and (e) actual research. The teaching philosophy is primarily formative with emphasis on not misusing or wasting students' work and efforts.

Chapter 20, entitled *"The ancestor project: aboriginal computer education through storytelling"* by Marla Weston and Dianne Biin (Weston and Biin 2015), presents authors' findings from their project ANCESTOR, an aboriginal computer education program that uses digital storytelling as a way to encourage interest in technology for Aboriginal learners and to increase cultural literacy. Consequently, a curriculum was designed and first experienced with Aboriginal students at the LÁU, WELNEW Tribal School near Victoria, British Columbia, Canada. Based on the responses from teachers and students, the curriculum was updated and then tested with non-Aboriginal students. After additional improvements, the curriculum was distributed to Aboriginal learners tailoring the curriculum to local situations and requirements.

Chapter 21, entitled *"Perceived Affordances of a technology-enhanced Active learning classroom in promoting collaborative problem solving"* by Xun Ge, Yu Jin Yang, Lihui Liao and Erin G. Wolfe (Ge et al. 2015), explores both instructors' and students' perceptions of experiences with technologies in a technology-enhanced Active Learning Classroom (ALC). The main aim of this study was to examine the impact of an ALC on learning and instruction perspectives. The authors concluded that according to ecological theory, an ALC should and could improve learning and instruction; nevertheless, improvements still rely on the users' capacity to take appropriate and effective actions.

In summary, the contents of this volume provide a rich and deep exploration of how emerging technologies are transforming learning and instruction. Each of the chapters provides a theoretically and empirically grounded basis for the effort along with references to additional information relevant to the particular topic covered. We believe this volume will encourage further research and development likely to push forward movements to make effective use of new technologies in a wide variety of learning and training contexts.

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Part I
Exploratory Learning Technologies

Chapter 2
Measuring Problem Solving Skills in Portal 2

Valerie J. Shute and Lubin Wang

This chapter describes current research investigating the use of the video game Portal 2 (Valve Corporation) as a vehicle to assess and potentially support problem solving skills in students. Portal 2 is an example of a well-designed game in that it provides players with a very rich, interesting environment whereby players interact with complex problems, encounter adaptive challenges, receive ongoing feedback, and engage in meaningful learning (Gee 2003; Shute et al. 2011). As Van Eck (2007) has argued, playing games is an important part of the human experience, and serves as the basis for experiential learning. However, as we progress through life, playing-to-learn decreases, particularly in formal educational settings.

A main reason why this research on assessing and supporting problem solving skills is important is because in today's interconnected world, being able to solve complex problems is, and will continue to be, of great importance. However, students today are not receiving adequate practice solving such problems. Instead, they are exposed to problems that tend to be sterile and flat in classrooms and experimental settings (e.g., math word problems, Tower of Hanoi). We believe that schools need to move beyond the simple content-learning mindset and towards assessing and supporting important skills in the twenty-first century.

A survey conducted by the *Global Strategy Group* (a leading American research firm) has suggested that college graduates today are not prepared for their future careers (as cited in Minners 2012). Participants included 500 elite business decision makers selected by the researchers. Nearly half (49 %) of them agreed that having strong problem-solving skills is the most important skill set they are looking for in job applicants. But schools are falling short of supplying students with these skills. One problem is that learning and succeeding in a complex and dynamic world is not easily or optimally measured by traditional types of assessment (e.g., multiple-choice

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responses, self-report surveys). Instead, we need to re-think assessment, identifying skills relevant for the twenty-first century—such as complex problem solving—and then figuring out how best to assess students' acquisition of the skills. Valid assessments are key to providing effective support.

Our research was aimed at answering three questions:

1. Will students in either our experimental (Portal 2) or comparison condition (Lumosity) show significant improvement on their problem-solving skills after playing their assigned game for 8 h?
2. Will the Portal 2 group show equivalent gains on problem-solving skill compared to the Lumosity group?
3. Will the in-game measures of problem-solving skill (particular to each gaming condition) predict players' outcome measures?

The organization of our chapter is as follows. We begin with a brief review of the literature on problem-solving skill. Next, we discuss the advantages of using stealth assessment in games. This is followed by our study design and outcome measures. We then present the results from our study to answer our research questions, and conclude with ideas for future research in the area.

2.1 Literature Review

2.1.1 Problem-Solving Ability

Problem solving has been studied extensively by researchers for decades (e.g., Gagné 1959; Jonassen 2003; Newell and Shaw 1958). It is generally defined as "any goal-directed sequence of cognitive operations" (Anderson 1980, p. 257) and is regarded as one of the most important cognitive skills in any profession as well as in everyday life (Jonassen 2003). There are several characteristics of problem solving as identified by Mayer and Wittrock (1996): (a) it is a cognitive process; (b) it is goal directed; and (c) the complexity (and hence difficulty) of the problem depends on one's current knowledge and skills.

Can problem-solving skills be improved with practice? Polya (1945) has argued that problem solving is not an innate skill, but rather something that can be developed. Students are not born with problem-solving skills. Instead, these skills are cultivated when students have opportunities to solve problems. Researchers have long argued that a central point of education should be to teach people to become better problem solvers (Anderson 1980). And the development of problem-solving ability has often been regarded as a primary goal of the education process (Ruscio and Amabile 1999). But there is a gap between problems in formal education versus those that exist in real life. Jonassen (2000) noted that the problems students encounter in school are mostly well-defined, which contrasts with real-world problems that tend to be messy, with multiple solutions possible. Moreover, many problem-solving strategies that are taught in school entail a "cookbook" type of memorization, resulting in functional fixedness, which can obstruct students' ability to solve problems for which they have not been specifically trained. Additionally, this pedagogy can also stunt students' epistemological development, preventing them from developing their own knowledge-seeking skills (Jonassen et al. 2004). This is where good digital games (e.g., Portal 2) come in—which have a set of goals and complicated scenarios that require the player to generate new knowledge.

Recent research suggests that problem-solving skills involve two facets: rule identification and rule application (Schweizer et al. 2013; Westenberg et al. 2012). "Rules" in problem solving refer to the principles that govern the procedures, the conduct, or the actions in a problem-solving context. Rule identification is the ability to acquire knowledge of the problem-solving environment; and rule application is the ability to control the environment by applying that knowledge. In our current research, we did not directly collect data on students' rule identification skill as that typically involves paper-and-pencil tests or think-aloud protocols, which would disrupt students' gameplay. However, since rule application is the outward expression of one's rule identification, the measurement of rule application will reflect students' ability to identify rules.

Complex problems usually combine a mixture of basic rules and rules that require cognitive flexibility–the ability to adjust prior thoughts or beliefs and explore alternative strategies in response to changes in the environment (Miyake et al. 2000). Any given problem in Portal 2 requires the application of either basic rules or rules that require cognitive flexibility. Cognitive flexibility is the opposite of functional fixedness, defined as the difficulty that a person experiences when attempting to think about and use objects (or strategies) in unconventional ways (Duncker 1945). Such cognitive rigidity causes people to view a particular type of problem as having one specific kind of solution without allowing for alternative strategies and explanations (Anderson 1983).

Researchers (e.g., Gee 2007; Van Eck 2006) have argued that playing well-designed video games can promote problem-solving skills because of the requirement for constant interaction between the player and the game, usually in the context of solving many interesting and progressively more difficult problems. However, empirical research examining the effects of video games on problem-solving skills is still sparse. Our research intends to begin to fill this gap. Below is the internal structure of problem-solving skills that guided our research (Fig. 2.1).

2.1.2 Materials

Portal 2 is a popular linear, first-person puzzle-platform video game developed and published by Valve Corporation. The official age rating for the game is 12 or above but it is a fun brain teasing game that has wide appeal to players of all ages. Players take a first-person role in the game and explore and interact with the environment. The goal of Portal 2 is to get to an exit door by using a series

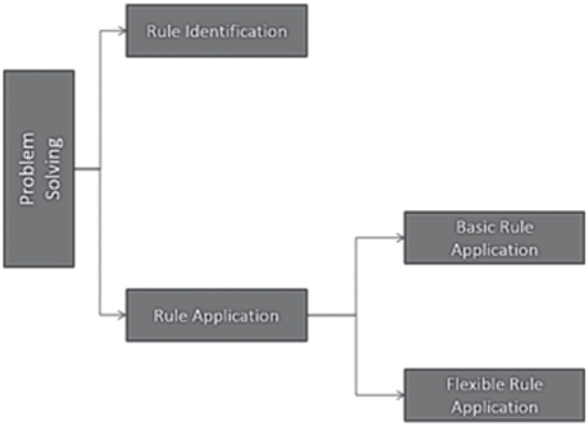

Fig. 2.1 Internal structure of problem solving skill

of tools. The primary game mechanic in Portal 2 is the portal gun, which is a device that can create inter-spatial portals between two flat planes. Puzzles must be solved by teleporting the player's character and various objects using the portal gun. To solve the progressively more difficult challenges, players must figure out how to locate, obtain, and then combine various objects effectively to open doors and navigate through the environment to get to the exit door. In addition to resources in the game that can help in the quest, there are also various dangers to avoid–such as turrets (which shoot deadly lasers), and acid pools. All of these game elements can help (or hinder) the player from reaching the exit.

The initial tutorial levels in Portal 2 guide the player through the general movement controls and illustrate how to interact with the environment. A player can withstand some amount of damage but will die after sustained injury. There is no penalty for falling onto a solid surface, but falling into a bottomless pit or a toxic pool will kill the player immediately.

Portal 2 provides a unique environment that can potentially promote problem-solving skills through providing players extensive practice figuring out solutions to complex problems on their own. In Portal 2, upper levels usually require skills or knowledge that players acquire from prior gameplay. This will push them to activate or examine their existing schemas. We believe that problem-solving skills learned in Portal 2 can be transferred beyond the immediate game environment. In 1989, Chi, Lewis, Reimann, and Glaser found out that successful students monitor their own learning process and generate explanations while studying. They could refine and expand the conditions in the examples given and apply the general knowledge learned from the examples toward problem solving in new contexts. Bransford and Stein (1984) also argued that people are able to apply information to a broad range of tasks if they learn with understanding.

Figure 2.2 illustrates how "flinging" works in Portal 2. That is, if a player jumps down to an entrance-portal (see arrow 1), he will be teleported through the inter-portal space and fly out of the exit-portal (arrow 2). The momentum he accumulates

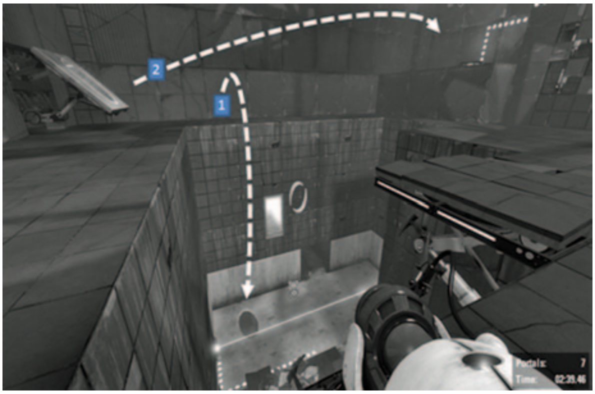

Fig. 2.2 Flinging in Portal 2

during the free fall will be conserved, and will provide sufficient energy to launch him over to the higher platform located across the plate where the exit-portal is placed. In another level, the player may have to use an in-game device called a "faith plate" which bounces objects (including players) upward upon contact to create momentum for the fling. Other tools that are available later in the game include redirection cubes, repulsion gel, propulsion gel, conversion gel, hard light bridges, funnels, and so on. Players need to learn the basic rules about each tool and then apply the tools as applicable. To succeed in later levels, a player will sometimes need to apply a tool in a different way from how it was learned. For instance, in early levels, players learn that the blue (repulsion) gel can be used to enable bouncing in the game. Later, the player needs to flexibly apply this rule by using the blue gel to smother turrets rather than using it for bouncing. This is important since the way in which students learn problem-solving strategies may influence their subsequent ability to understand and flexibly apply this information in the world.

We identified and used 62 levels in Portal 2 that elicit specific evidence related to problem solving skill. Basic and flexible rule application load on different levels with varying weights. For instance, a level may be easy on basic rule application, but difficult on flexible rule application. Below are examples of how the game elicits evidence for the two facets of rule application.

- Basic rule application: Basic rules in Portal 2 are rules directly instructed or that can be picked up easily. For example, players should be able to learn that the river is hazardous from the cueing picture on the floor near the river. Or, if a player fails to notice the picture and falls into the river, he will die and resurrect from the last automatic saving point. Afterwards, he should be aware of the rule. Other basic rules relate to avoiding laser beams, knocking over turrets to terminate them, and putting a cube on the weighted button to activate any device connected to it.
- *Flexible rule application*: Flexible rules in Portal 2 refer to rules that can only be inferred from the basic rules. For example, one basic rule is that the weighted button can be activated by the weight of a cube. A level following the one that instructs this basic rule requires players to realize that the body weight of the

player may be a replacement when a cube is not available. Other flexible rules in the game include the use of the hard light bridge to catch a falling cube or to hold it above a destination (e.g., a weighted button to be pressed) and release it after a sequence of actions are performed.

Lumosity, the game selected as the control condition, is a web-based platform that hosts more than 50 small-scale games. Advertisements for Lumosity note that the games were designed by neuroscientists to improve brain health and cognitive performance. The games were designed to appeal to a broad range of individuals, from kids to adults, although the website only allows persons over 13 years old to apply for an account. Most of the games focus on supporting the following skills: problem solving, cognitive flexibility, memory, attention, and processing speed. The challenge level of a game is usually decided by the presence and amount of distraction, the time limit, the salience or complexity of the pattern or rule to be recognized, and hence the amount of cognitive effort and skill required.

The Lumosity website also claims that their games provide personalized training to different users, and that 10 h of Lumosity training creates drastic improvements in problem solving, memory, attention, and mental flexibility. Choosing Lumosity as our control condition is thus a very conservative design decision.

Figure 2.3 presents how the "brain performance index" (BPI; the major indicator of players' overall performance) is calculated in the game. The BPI is the average score of speed, memory, attention, flexibility, and problem solving. Figure 2.4 is a sample game on Lumosity.com called "Word Bubbles Rising." It was designed to evaluate and enhance cognitive flexibility. Players are required to come up with as many words that contain the provided letter stems as possible.

2.1.3 Game-Based Stealth Assessment

Assessments can be deficient or invalid if the tasks or problems are not engaging, meaningful, or contextualized. This calls for more authentic and engaging assessments, which has motivated our recent research in relation to weaving assessments directly and invisibly within good games. In contrast, the amount of engagement in traditional (e.g., paper-and-pencil, multiple-choice) assessments is negligible. Another downside of traditional assessments (particularly those that are high stakes) is that they often invoke test anxiety, which can be a major source of construct-irrelevant variance. When these problems associated with traditional assessment—inauthentic and decontextualized items, and provoking anxiety—are removed (e.g., by using a game as the assessment vehicle), then the assessment should be more engaging. When assessment is seamlessly embedded within the gaming or learning environment that learners do not realize they are being assessed, we call it stealth assessment (Shute 2011). Additionally, if the assessment is designed properly, such as by using an evidence-centered design approach (Mislevy et al. 2003), then the validity argument is built directly into the assessment.

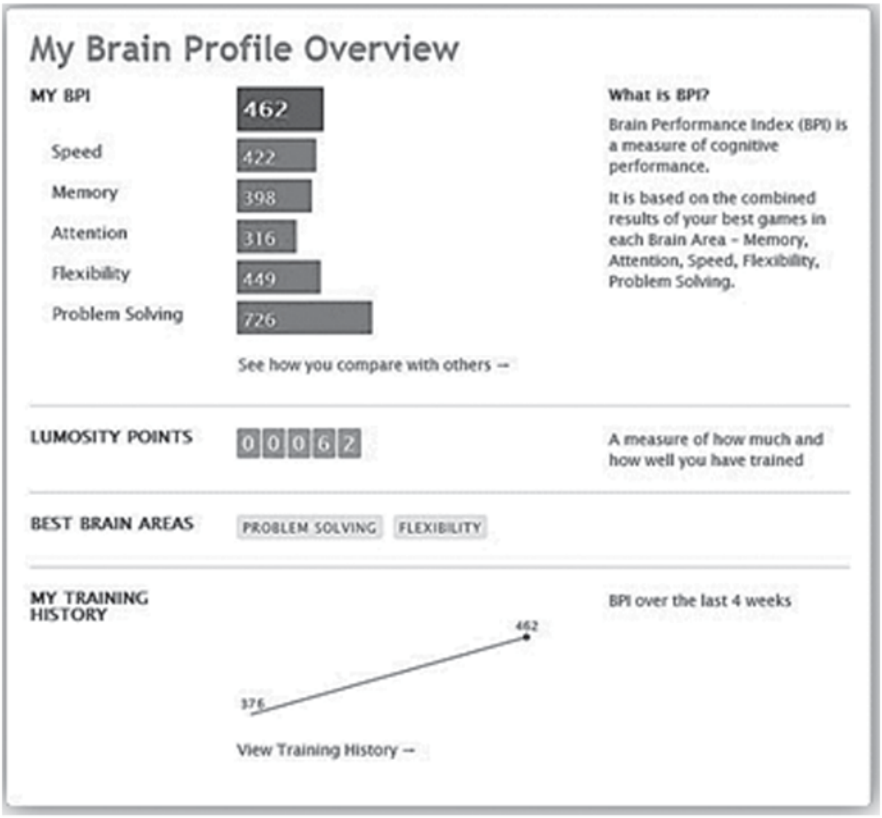

Fig. 2.3 Calculation of scores in Lumosity

Fig. 2.4 Sample game from Lumosity supporting cognitive flexibility

Using games as assessment vehicles has its own sets of issues. For instance, there are potential sources of error variance in video-game assessments such as a person's particular level of interest in the game. However, we believe this will not be a problem with Portal 2 given its broad appeal (e.g., over 3 million copies have been sold since it came out in 2012, according to GameFront). In short, we believe that Portal 2 can be used to effectively assess problem solving by virtue of having authentic, contextualized, and engaging tasks. That is, in Portal 2, if a player follows basic rules directly instructed or implied in the game such as avoiding harmful objects (e.g., turrets and acid river), or making use of the tools and other objects in the environment (e.g., refraction cubes and light bridges), this provides evidence that the player is competent at basic rule application. The players' competency levels will primarily be measured by the number of levels successfully completed over the course of 8 h of gameplay. Additional performance measures include the number of portals shot in the game, and the average time spent solving the levels (each negatively related to problem solving skill).

2.2 Method

2.2.1 Participants

Participants for our study were solicited with flyers posted throughout a university located in northern Florida. Potential participants were screened using an online video game questionnaire. A total of 218 students ages 18—22 applied to participate, and 159 were approved to participate. Among the approved population: 77 completed the study, 54 never signed up for scheduling, 1 signed up but never showed up, and 27 dropped out of the study due to various reasons (e.g., sickness or lack of time or interest). Approval was not given if a person indicated (a) susceptibility to motion sickness, (b) had played through Portal 2 before, or (c) self-reported as a frequent video game player (i.e., playing every day). Among the 77 college students who completed the study, 42 of them were randomly assigned to the Portal 2 condition and 35 were randomly assigned to Lumosity condition. About 43 % of them were male students and 57 % were females. Students were compensated with a $ 100 gift card for full participation (i.e., 8 h of gameplay and 2 h of pretests and posttests—our external measures).

2.2.2 Procedures

Consent forms were obtained from all participants before the study and then participants were randomly assigned to either the experimental group that played Portal 2, or the control group that played Lumosity. The participants were asked to come to a laboratory in the university across four sessions spanning 1–2 weeks for a total of

10 h. At the beginning of the first session, they were required to complete the online pretests (50–60 min). After they finished, they started to play their assigned game. The first three sessions lasted 3 h each. The fourth session lasted about 50–60 min where students completed the posttests. Students played their assigned game for about 8 h in total. They were provided with a pair of Sony headphones to wear during gameplay. Talking about their respective games was not permitted. One or two graduate students served as proctors in the study, per session. Proctors were instructed to only provide technical assistance to the students and to remind them to focus on the task if they appear to disengage.

2.2.3 Assessment in Portal 2

Log files that record students' performance during gameplay were extracted by enabling the developer console of the game. Students' problem-solving performance can be assessed by information in the log files. For this study, we focused on three main performance measures: overall number of levels completed, number of portals shot, and average time per level–where the last two were reverse keyed. Students' performance on these in-game measures were used to predict performance on the external measures of problem solving.

2.2.4 External Outcome Measures

The stealth assessment of students' problem-solving skills were validated against external measures of problem solving. Two sub-facets of rule application (i.e., basic rule application and cognitive flexibility) were measured. Basic rule application was measured by *Raven's Standard Progressive Matrices* (1941). The test requires participants to infer the pattern of the missing piece from the given pattern(s). Although the test is widely used as an intelligence test (e.g., Prince et al. 1996; Rushton and Jensen 2005), as Raven (2000) pointed out, Raven's Progressive Matrices focus on two components of general cognitive ability–eductive and reproductive ability. Eductive ability involves making meaning out of confusion and generating high-level schema to handle complexity. Reproductive ability is the ability to recall and reproduce information. In Portal 2, for example, players are instructed that the laser beam is deadly. If the player knows this rule, she should realize that the turret is also harmful since it emits a laser beam. We selected 12 items from the Raven's Progressive Matrices test for the pretest and 12 matched (by difficulty) items for the posttest. Each item had a time limit of 4 min before the system moved to the next item.

Cognitive flexibility was measured by two tests: insight problems and the remote association test. *Insight problems* are intended to yield an "Aha" moment for problem solvers when the solution occurs after a short or long moment of confusion (Chu and MacGregor 2011). Insight problems require individuals to shift their

Table 2.1 Descriptive statistics for Portal 2 ($n=42$) and Lumosity ($n=35$)

Measures	Portal 2		Lumosity	
	M	*SD*	*M*	*SD*
Raven's pretest	8.39	2.29	8.24	2.31
Raven's posttest	8.51	2.33	7.65	2.60
Insight pretest	1.30	0.97	1.40	1.09
Insight posttest	1.36	0.91	0.96	0.99
RAT pretest	2.59	1.40	2.65	1.28
RAT posttest	2.83	1.34	2.56	1.33
Pretest (standardized average)	−0.01	0.71	0.13	0.77
Posttest (standardized average)	0.15	0.61	−0.18	0.67

perspective and look at obscure features of the available resources or to think of different ways to make use of an object. We selected three insight problems for the pretest and three for the posttest. For instance: *You need to throw a ping-pong ball so that it will travel a short distance, come to a dead stop and then reverse itself. You are not allowed to bounce it off any surface or tie anything to it. How do you throw the ball?* The answer is to throw the ping-pong ball straight up. The question is not particularly hard, but it requires problem solvers to break from routine thinking and think beyond the immediate context. The posttest was an alternative form of the pretest. The time limit per item was 5 minutes.

The Remote Association test was originally developed by Mednick (1962) to test creative thought without any demand on prior knowledge. Each item consists of three words and problem solvers are required to find the solution word associated with all words that appear to be unrelated. The fourth word can be associated with each of the three words in multiple forms, such as synonymy, formation of a compound word, or semantic association (Chermahini et al. 2012). For example, the answer to the triad night/wrist/stop is "watch." Schooler and Melcher (1995) reported that problem solvers' success on this test correlates with their success on classic insight problems. We selected five items for the pretest and five for the posttest. The time limit for each item was five minutes.

2.3 Results

Table 2.1 displays the descriptive statistics for the external measures of problem-solving skill (based on raw scores per test—one item equals one point) for both groups.

Hypothesis 1 Players in both conditions will show improved pretest-to-posttest gains relative to the problem solving test scores. To test hypothesis 1, we computed paired t-tests, separately by condition, across the three tests (pretest and posttest data). For both the Portal 2 and the Lumosity conditions, there were no significant

Table 2.2 Posttest partial correlations to Portal 2 and Lumosity performance controlling for respective pretest scores

Measures	Portal 2			Lumosity	
	Levels completed	Portals shot	Avg level time	Problem solving	Flexibility
Raven's	0.03	−0.02	0.05	0.05	0.22
Insight	0.35*	−0.40*	−0.35*	−0.08	0.25
RAT	0.14	−0.15	−0.19	0.14	−0.01

For "levels completed," more is better; for "portals" and "level time," less is better
*$p<0.05$

differences among any of the three pretest-posttest pairs. Note, however, that for the Portal 2 condition, the three posttest scores are all higher than the pretest scores, while for the Lumosity condition, the posttests are all lower than the respective pretests.

Hypothesis 2 Students in the Portal 2 group will show comparable (or better) problem solving improvement compared to the Lumosity group. To test this hypothesis, we standardized the individual pretest and posttest scores and computed an average pretest and posttest problem solving score, per condition. Next, we computed an ANCOVA with the average posttest score as the dependent variable, by condition, controlling for pretest score. We found a significant difference in the outcome favoring the Portal 2 group: $F(1, 71)=5.49$; $p=0.02$; Cohen's $d=0.59$. To further test the hypothesis, we computed three ANCOVA tests (with corresponding pretests as covariates) to examine the effects of the two gaming conditions on the three specific tests of problem solving skill. The ANCOVA tests did not show any significant differences by condition for RAT or Raven's Progressive Matrices, but the insight posttest scores were significantly higher for the Portal 2 group compared with Lumosity group at the one-tailed level: $F(1, 66)=3.76$, $p<0.05$.

Hypothesis 3 Players' performance during gameplay will predict their posttest scores. To test this hypothesis, we correlated the performance measures associated with each condition with individual posttest scores, holding the associated pretests constant. Players' performance during gameplay was represented by three variables for the *Portal 2* group: number of levels completed (more is better), average number of portal shots in each level (less is better), and average time per level (less is better). For players in the Lumosity condition, their performance was reported in the game as "problem solving" and "flexibility" scores (other variables reported by Lumosity include memory, attention, speed, and average "brain power index"). As presented in Table 2.2, all three Portal 2 in-game measures significantly correlated with the insight posttest after controlling for pretest score. Neither of the Lumosity in-game measures correlated with players' posttest scores on any of the three external problem solving tests.

Although it was not one of the main research questions, we were curious about how much subjects in each condition enjoyed their games. We examined students' responses to a self-report question administered after 8 h of gameplay. The question was, "I enjoyed playing…" then either "Portal 2" or "Lumosity" was presented, depending on assigned condition. Students rated their enjoyment on a 1 (strongly disagree) to 5 (strongly agree) Likert scale. Those in the *Portal 2* group reported much higher enjoyment compared with those assigned to the *Lumosity* group. For *Portal 2* participants, enjoyment $M=4.32$; $SD=0.93$, while for the Lumosity participants, $M=3.50$; $SD=1.05$. The difference between the two groups' enjoyment is significant, with a strong advantage for the *Portal 2* group: $F(1, 73)=12.69$; $p<0.001$. Cohen's $d=0.83$, which is a large effect size.

2.4 Discussion

Lumosity is a commercial, online suite of games that has been expressly designed by a group of neuroscientists to enhance a number of cognitive skills including problem solving and flexibility. Thus using Lumosity as our control condition was a very conservative decision, and any findings showing a Portal 2 advantage would be more powerful than using either a no-treatment control or a casual game.

When examining the results related to hypothesis 1 (i.e., pre- to posttest gains on each of the individual problem solving tests, separately by condition), we found that neither group significantly improved on any of the three external tests. The Portal 2 group, however, did show increases from pretest to posttest while the Lumosity group did not (see Table 2.1). One reason for the finding may be that students suffered from fatigue. They were asked to come to the lab four times within two weeks and they needed to stay for 3 h in three of the four sessions. Moreover, since we also investigated other skills (i.e., spatial ability and conscientiousness) in the same study, we had a large number of test items that took participants about an hour on average to finish, which may have negatively influenced participants' performance on the posttests.

Our second hypothesis examined how the participants in Portal 2 fared relative to those in Lumosity in terms of their overall and specific problem solving test scores. The composite problem solving posttest score for those playing Portal 2 (holding composite pretest score constant) was significantly higher than the posttest scores of Lumosity participants. Looking at the individual test data, we see that this was likely a function of differential performance on the insight problems test. That is, while Portal 2 players showed an increase from pretest to posttest, Lumosity players showed a decrease from pretest to posttest. This may be because Portal 2 required players to exercise insight during the solution of various problems while Lumosity did not, or at least not to the same extent.

Finally, our third hypothesis related to in-game measures of problem-solving in the Portal 2 condition. Two of the three in-game measures were significantly correlated with the insight problems. We were not surprised with this finding because Portal 2 is a video game that depends heavily on players' ability to shift their perspectives and use rules in uncommon ways, which aligns with the nature of the external test. However, we only had 3 insight problems in each form, which might be inadequate to detect any real differences in the participants. Another issue with insight problems is that some participants may have seen some of the items before. Finally, other researchers have pointed out that the skills used to solve one insight problem may not be transferrable to other insight problems. Thus to complement the insight test, we additionally used the remote association test. But one downside of this test is that it appears to require adequate language skills (specifically vocabulary) to succeed. We did not survey whether subjects were native English speakers, but the proctors did report that between 25 and 40 % had accents. Thus language skills may have confounded the results.

Overall, we believe that Portal 2 has the potential to serve as a highly engaging way to measure and possibly support cognitive skills such as problem solving. A next step of this research will be to explicitly test the transferability of the gained problem-solving skills to real life situations. Given that Lumosity is a game specifically designed to improve problem-solving skills, we expected that it would support players' growth across the 8 h of gameplay. However, we did not see any improvement of problem solving skill. Furthermore, Lumosity's specific in-game measures of problem solving and flexibility did not correlate with any of our three external measures. For these reasons, we would recommend Portal 2 over Lumosity to anyone wanting to practice, in an enjoyable way, their problem-solving skills.

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Chapter 3
iPads in Inclusive Classrooms: Ecologies of Learning

Bente Meyer

3.1 Introduction

Though iPads were originally intended for consumption and entertainment, they are increasingly used for learning in formal education (Meyer 2013). This brings new challenges and potentials to classrooms, where the use of technology often has been associated with computer labs and with 'learning in a bubble' (Traxler 2010, p. 5). With the advent of the iPad technology is increasingly taking center stage in the daily life of pupils, including how they can learn, interact and create content in formal educational settings. The promise of the iPad therefore seems to be the liberation and transformation of education at a time where mobile technology is defining most out of school activities of young learners. Consequently, the so-called affordances of the iPad, i.e. mobility, intuitive navigation and personalized content creation, has been the focus of many accounts of how the iPad can contribute to education and learning (e.g. Burden et al. 2012).

However, though the tablet seems to be an innovative and promising platform for twenty-first century learning environments, discussions about its affordances should focus on educational practice and not its 'inherent' qualities (Orlikowski 2010). This paper will argue that tablets, may contribute to enhancing inclusive educational settings by creating new relationships between existing technologies and learning resources for mobile learning. A general 'affordance' of the iPad therefore seems to be its flexibility and ability to enter into relationships with a variety of resources and learning contexts that make up a learning ecology for schools.

The paper builds on data from a project where iPads were used in a lower secondary school in Denmark for school development. The research discussed in the paper focuses on how the integration of iPads in teaching and learning can support inclusive educational settings in lower secondary school. The paper draws on data

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from fieldwork in five classes of seven graders (age 13–14), who were given iPads in the school year 2012–2013. Two of these classes were special needs classes.

3.2 iPads in Education

Since the iPad was introduced on the market in January 2010 it has received extensive attention for its role as a "game changer" (Furfie 2010) in the media field as well as in education. iPads can in this regard be compared to other mobile devices that are increasingly transforming the ways in which we access and create knowledge, communicate and collaborate and learn (Cook et al. 2011; Seipold and Pachler 2011; Pachler 2007). However, contrary to other mobile technologies, iPads have generally been admitted into educational settings, where they have become central to learning and to the development and transformation of schools and learning. In this sense iPads promise to 'revolutionise' education.

Though extensive empirical knowledge about the value of tablets is still lacking, several recent studies have confirmed the educational value of the iPad at different levels of education (Burden et al. 2012; Melhuish and Falloon 2010; Heinrich 2012; Kinash et al. 2012). Generally, these studies argue that the significance of the iPad for teaching and learning resides in two significant affordances of the device, i.e. (1) providing new forms of personal ownership and (2) ubiquitous and easy access to technology. These are affordances that support the integration of iPads as resources in formal learning as well as across formal and informal learning contexts.

Ownership is central to learning in that it allows the user to personalize devices and contributes to supporting learners' own knowledge and conceptual frameworks (Melhuish and Falloon 2010). Mobile devices may in this sense support 'constructivist' learner-centered approaches to learning and be useful to young learners who are already immersed in technology through everyday uses of for instance smartphone devices. In addition to this the use of app-based teaching promises a shift from content based, skill and drill learning to web 2.0 approaches to learning where the learner is more creative and independent (Burden et al. 2012). Finally, the low tech, intuitive and multimodal feel of the iPad targets a variety of learners and learning styles, which may support more inclusive classrooms and learning environments.

Ubiquitous access to technology may likewise revolutionize education as it allows teachers and learners to redefine learning spaces in moving technology use from confined, fixed places and times to situated, just in time usage, where technology is "Woven into all the times and places of students' lives" (Traxler 2010, p. 5). Thus, Burden et al. (2012) argue that the shift in technology use in schools linked directly to the allocation of the iPad can be characterized as a shift from a 'just in case' model where technology is made available from a remote location from the location itself to a 'just in time' model where technology is at hand, immediately accessible to the pupil (see also Johri 2011; Meyer 2013).

Though the affordances of the iPad accounted for and explored by the studies mentioned above are highly relevant in understanding how iPads and other emergent mobile technologies can support education, the idea that iPads are isolated and unique actors in school development must and can be challenged. A recent study of the use of iPod touch devices in primary education in Australia thus underlines that in many cases teachers integrate the use mobile devices with other ICT technologies such as desktop computers and laptops, Nintendo Wiis, digital cameras, podcasting software, video editing suites, etc. (Murray and Sloan 2008). The mobile device in this way emerges as one of a range of tools that the teachers employ to motivate and stimulate student learning. Similarly, Burden et al. argue from their experience with the use of iPads in primary and secondary education in Scotland that "results suggest students use the device as part of a wider ecology of learning resources, integrating the iPad with existing tools such as the jotter" (2012, p. 51). A perspective on the ecology of learning can therefore, as I shall argue below, help us to understand how mobile devices are appropriated in changing sociomaterial environments of learning and how this supports learners in creating new and personalized learning environments.

3.3 Arguing for an Ecology of Learning with iPads

The ecology of learning can be conceptualized and approached from different perspectives, for instance from within the field of mobile learning or from sociomaterial approaches to learning (Fenwick and Edwards 2012; Fenwick et al. 2011; Johri 2011; Sørensen 2009). Speaking from a position within the field of mobile learning Cook et al. (2011) argue that looking at mobile devices as cultural resources for learning opens up the educational field for "an epistemological debate about the ecological nature of resources and meaning-making in and across everyday life and school" (182). This perspective draws on an understanding of ecologies as complex organic systems in which resources interact and in which "users of mobile digital devices are being "afforded" synergies of knowledge distributed across people, communities, locations, time (life course), social contexts, sites of practice" (187).

Though an understanding of how mobile devices are embedded resources in learners' life worlds is significant for understanding how mobile devices contribute to learning, the idea of a socio-cultural ecology of learning with mobile devices to some extent fails to account for the role of mobile learning in formal education. Cook et al (2011) for instance point out that mobile phones are often banned in formal education because of their association with banal media content and entertainment. They therefore argue that schools must lift their ban on smartphones in order to take advantage of the learning potential associated with mobile learning.

Whereas smartphones to some extent have failed to become a resource in formal education, the iPad, as argued above, seems to have gained access to education, though this may be a local (Danish) phenomenon. Thus iPads participate in the material cultures of schools where they become enrolled in a variety of formal learning activities. These activities can, inspired by Actor-Network Theory (ANT) (Latour 2005), be understood as sociomaterial practices that involve elaborate systems of related technologies that are socially enacted in education. I conceptualize these systems of related technologies as ecologies of learning as they present themselves as carefully balanced sociomaterial systems in which educational resources circulate in different ways that make sense to learners' needs. I use the term socio-material bricolage (Johri 2011) as an analytical framework to describe this 'ecological' entanglement of material and social aspects of teaching and learning with technologies which will underline the emergent and improvisational nature of change when seen from a practice perspective.

3.4 iPads and School Development

In Denmark, so-called 'iPad-schools' have become a growing phenomenon in the field of school development across the country. A number of schools and municipalities are thus investing in iPads on a one pupil one device basis. Earlier this year a municipality in the west of Denmark invested in iPads for all pupils and teachers in the municipality. Other municipalities and schools have followed, however, most schools have opted for a less costly investment, by for instance focusing on buying tablets for specific groups of learners or teachers. Therefore, ownership models may vary in different schools, and even within schools.

What seems to be the argument for investing in tablets for school development is complex, in that schools are seeing technology both as a way to improve their economy in a time of recession, a way to enhance the profiles and reputation of especially state financed schools and an approach to transforming teaching and learning in classrooms and beyond. Economic considerations usually focus on the fact that ubiquitous technologies can help schools save money on resources such as paper copies and books, and that iPads require less maintenance than other technologies. In terms of school profiles and reputation the move in Denmark (as well as in other parts of the world, see for instance Anderson-Levitt 2003) towards decentralization has made it more urgent for schools to attract sufficient numbers of pupils and to marketize their pedagogical visions and principles.

In relation to education, a general political focus on basic education has underlined the need for school reform and for increased access to learning resources that can support the learning needs of different learners. A lot of political interest in Denmark has thus lately been focused on primary school and pre-school levels, in order to create more continuation between these levels of education, and in order to bring more learning into preschool levels, to prepare students for formal learning (Jensen et al. 2010). In formal learning, there has been an increased pressure on pupils' literacies in for instance Danish and Maths and in assessing pupils' competences at different levels of schooling. The role of iPads in this educational environment is, it can be argued, to support the general reform of schooling in making technology more accessible to students and more integrated into the everyday life of schooling. Giving tablets to children according to a one child one device principle is for instance thought to increase the engagement and participation of children in learning. In addition to this, mobile and personalized tablets support, it is argued, the transformation of learning spaces that will allow schools to be more inclusive of different learners and learners' needs, including children with cognitive challenges. These are some of the contextual realities for the research described below.

3.5 Tablets in the Classroom—Middletown School

Middletown school is a lower secondary school in the west of Denmark in a municipality that has a high profile in school development and integration of ICT into education. The school has recently been through a process of merge where pupils from an associated school for children with special needs were integrated into the school. The school has not had a prominent ICT profile before the project, mostly due to budget restrictions.

The school teaches pupils at three levels, i.e. 7th, 8th and 9th year of schooling. Pupils come to the school from other schools in the area, and it is therefore important for the school to accommodate pupils from different neighborhoods and backgrounds.

At the beginning of the school year (2012) all pupils in the 7th form (3 classes) as well as two special needs classes were given iPads to keep for the entire school year. Teachers in the seventh form were given iPads before the summer holiday, so that they would have time to explore the tablet before using it in classes with pupils. The municipality had decided that this initiative should be followed by research, in order to investigate the role and learning potential of iPads at this level of schooling. The research was aimed specifically at understanding how tablets can support the inclusion of pupils within a variety of learning environments and subjects, as inclusion is a challenge that is currently at the center of policy at both municipal and state levels. In this project inclusion is understood as a broad concept, i.e. with a focus on inclusive educational settings where all pupils are valuable and active participants in the learning community (Tetler and Baltzer 2011).

I followed pupils in all five classes for three months, observing them in their daily life in school and interviewing groups of pupils and teachers as well as the school leader in the process.

At the time when tablets were distributed to teachers, technology was, as mentioned above, not a widely used tool in the daily life of the school. What was available to pupils and teachers at this school was primarily two computer labs in the basement of the school as well as whiteboards in all classes. When the school decided to invest in iPads for the seventh grade pupils and teachers, it was however necessary to install Wi-Fi in major parts of the school, which immediately enhanced teachers' and pupils' access to the internet. The investment in iPads therefore initiated something the school had wanted for years, i.e. the opportunity to integrate technology on a more general basis in teaching and learning. The iPads therefore became significant actors in moving school development in the direction of a more innovative and ubiquitous use of technology.

In Middletown school both teachers and pupils were excited about the new technology and were open to the many ways in which it could be used in different subjects and different learning contexts. However, knowledge of how the iPad can be used for education takes time, and has been mostly experiential for both teachers and pupils in this school, though teachers did have courses in using the technology and using relevant apps before starting the school year with the pupils. This means that use of the iPad has to some extent been adapted to existing ways of organizing learning and that transformation of teaching and learning has been strongly linked with having the technology available in classrooms and at home. I shall proceed to describe how personal ownership and ubiquitous access influenced the ways in which teaching and learning were done and to some extent transformed during the three months that I was doing fieldwork at the school.

3.5.1 Classroom Resources and iPad Usage—Socio-Material Bricolage

iPads are, as argued above, often seen as transformative technologies that replace or marginalize other technologies in order to redefine learning spaces and reform teaching and learning. However, as I followed teachers, pupils and iPads into the classrooms of Middletown school, it became immediately obvious that the iPad would have to make a place for itself in a space where many different learning materials and media had historically been significant for practice. In this sense the iPad was neither entering an empty space, nor entirely replacing tools that had been used for decades for different kinds of subjects.

Apart from the whiteboards mentioned above, what was significant for teachers was for instance to use books and paper (for teaching Danish and literacy), jotters, rulers and calculators (for math), flasks and burners (for chemistry) and maps (for geography). These learning materials were not easily replaced by the iPad, though some of them might change their function over time, as pupils and teachers became more familiar with the technology. For instance, many pupils quickly learned to use their iPads to take notes, and therefore made some uses of jotters superfluous. Similarly, some teachers insisted that pupils should pick up and hand in their assignments through for instance Dropbox, activities that might change the ways in which paper and paper copies were used.

Though the presence of the iPad in the classroom therefore generally did change and redefine uses of and relationships between used learning tools and resources, my observations also showed that teachers and pupils persisted in using a number of different learning materials with their iPads, implying that the tablet technology had not replaced but rather interacted with other learning tools and resources. Pupils for instance often connected the use of their iPads for various kinds of learning with checking their books, copies that the teacher had given them or even using calculators or pencils. In fact, pupils were in a number of cases assembling their personal combination of learning materials, when they were working on assignments. In these combinations of learning resources the iPad often had a central position as a tool that would allow them to for instance read tasks that the teacher had posted in Dropbox, check Google or record German vocabulary. I call these personal assemblages and combinations of learning materials socio-material bricolage (Johri 2011), and will provide some illustrations of how pupils constructed these below.

3.5.2 Bricolage in the Ecology of Learning Resources

Johri uses the term socio-material bricolage to show how artefacts derive their meaning and are constituted through social agency, i.e. how tools become 'tools in socio-material context' or socio-material assemblages. Building on Levi-Strauss, Johri argues that educational actors often use the tools that are available to them, i.e. they make do with what is at hand, rather than sticking to planned approaches that would require them to use tools that are not immediately available in their local space of practice. In this sense assemblages—or socio-material bricolage—of tools in practice become emergent designs of technology in use, adapted over time. Johri proposes that the idea of socio-material bricolage can help us to make distinctions between practice-as-designed and practice-as-practiced, where the latter highlights the improvisational and emergent aspects of practice. The concept of bricolage may therefore support understandings of "the emergent and socially and materially intertwined nature of human practices" (2011, p. 212).

In Middletown school teachers often used visual representations such as posters in their teaching. Posters are creative, often pupil-produced visual representations that illustrate and collect aspects of a specific theme or issue. Posters usually represent an end-product of a creative process or learning process in which the learner exhibits aspects of the knowledge gained to the teacher or to a wider audience of for instance parents at an exhibition (White 2005). Posters are crafted assemblages of information and impressions that contain traces of processes of translations between different modalities, for instance reading, writing, and drawing. In Middletown school, posters are deeply embedded in the teaching and learning processes, partly as an aspect of project pedagogy, which usually involves some kind of crafting where pupils are required to work on their own in finding knowledge about a specific topic.

Posters are visual representations of the ways in which learning is constituted through sociomaterial processes. Posters involve the association of both simple objects such as pens, paper, cardboard and technologies such as iPads. As assemblages of materialities and modes, posters both represent and involve a number of translations between materials, modes and activities that make up a topic or a field of knowledge. As a representation the poster is a "socio-material bricolage" (Johri 2011), i.e. it is produced as the result of a number of processes in which translations are made between different kinds of materials that act as mediators for learning.

Fig. 3.1 Using the iPad with paper and colouring pens for bricolaging in geography

Figure 3.1 shows how a boy worked with producing a poster for geography about Ecuador. This boy was very particular in getting the facts right. He used Google for checking the colours and patterns of the flag, which he then translated into his own, artistic expression on cardboard, using colouring pencils and supporting images with pencil written textual explanations. The interaction between iPad usage and cardboard usage in this way allowed him to both find and understand information about Ecuador, and translate and organize his knowledge onto a different material, the cardboard. In this way he appropriated different aspects of the materials at hand to his learning needs, i.e. he engaged in socio-material bricolage. The availability of different materials in the ecology of learning resources in this way allowed him to personalize his engagement with the resources and practices of learning.

Figure 3.2 shows a different approach to the poster and different appropriations of the resources available. For the girl in Fig. 3.2, learning about geography became a process of finding and selecting relevant facts about Iceland to present on her poster. She used her iPad to access Google and Wikipedia and focused on reading

Fig. 3.2 Using the iPad for project work—bricolaging to make the poster

Fig. 3.3 Using the iPad for learning German—bricolaging as an aspect of practicing pronunciation

through information which she then copied onto her poster. Like the boy above, she was essentially engaged in processes of understanding information and then translating and copying it onto a poster, her own expression of knowledge and content. Her use of the iPad together with paper and pen allowed her to access different kinds of information about her chosen theme as well as to translate it into something that could be presented to the class.

In language learning the engagement in bricolage may enroll the iPad in a different role from that described above, i.e. as a recorder or media player. The two girls in Fig. 3.3 were for instance collaborating on practicing German sentences by asking each other questions in German. They used their iPads for writing down vocabulary and for recording their pronunciation of the sentences in the PuppetPals app. They used their books to check spelling and vocabulary, as the teacher had asked them to practice specific areas of vocabulary in the book. They therefore constructed their unique combination of books and iPads to be able to check information, record, listen and write down while they were working on their task.

It can be concluded from the examples above that in a number of cases pupils constructed their unique socio-material bricolage, i.e. relationships between iPads and other resources such as books, pens and paper, to find and understand information, copy and translate it into their own context and in turn produce their own presentations of the knowledge, for instance as German sentences or geographical area knowledge. The processes involved in constructing these unique combinations of resources for learning were therefore about translating, processing and disseminating knowledge. In engaging in these processes of bricolage the iPad acted as a flexible technology in terms of both size, form and functionality, allowing pupils to for instance use it as a tape recorder, a jotter, a dictionary, a display etc. In this way the iPad became part of pupils' emergent and shifting uses of different kinds of resources that were relevant for their specific learning needs. These socio-material practices become possible as an aspect of having various resources available and at hand as part of the ecology of classroom resources.

3.5.3 Whiteboard to iPad: Small Screen to Big Screen Relationships

Middletown school is a school that for a long time has relied on whiteboards, computer labs and occasionally pupils' personal laptops to support teaching and learning. These technologies have to some extent been connected with a more fragmented, occasional, use of the technology. The iPad project promised an immediate change in the occasional use of technology in the school transforming technology use from a 'just in case' approach to a ubiquitous activity by supplying teachers and pupils with respectively a stable wireless connection and the portable, personal technology of the iPad.

For teachers and pupils the iPad project was generally an opportunity to integrate technology on a more daily basis into teaching and learning as well as making connections between school learning and out of school learning and entertainment. Pupils' choice of apps and other personal resources such as photos and desktop images would for instance illustrate their entertainment and leisure time preferences, family relations etc.—in the same way that they would generally use their smartphones for easy access to social media, games etc. out of school.

However, in the case of Middletown School the move from whiteboards, notebooks and computer labs was a more complex situation than could initially be anticipated by the transition to 'just in time' approaches. First of all, whiteboards and other kinds of resources remained in the space where pupils were learning, i.e. in classrooms, and some pupils would still prefer to use their laptops or other resources for reasons explained below. Also, on occasion the computer lab would have to be used for printing out material that could not be printed from the iPad itself. In effect, what had appeared was not a new situation where iPads and mobile technology had entirely replaced prior technologies, but a situation where the availability of technologies had multiplied and new relationships had been established between 'old' and 'new' uses of technology. These relationships created new opportunities for teaching and for tailoring learning processes to individual pupils, i.e. for inclusive educational settings.

It can be argued that the presence of iPads in the classrooms of Middletown School to a great extent moved the use of technology from the bounded space of the computer lab into the more personalized learning space of classrooms, but that the presence of iPads in the classroom did not necessarily make the use of other resources in the classroom, such as e.g. the whiteboard superfluous. What emerged from this situation where a new technology had found a place in the classroom was therefore not a replacement of existing resources by a new technology, but a novel and possibly innovative relationship between resources such as for instance the whiteboard and the mobile technology. The whiteboard was one of the significant technologies involved in this new relationship, because the whiteboard had been available to teachers for some time, and because it was placed in a dominant position in the classroom and generally acted as an integrated tool in many teachers' planning and classroom performance. In effect, the role of the whiteboard was largely maintained in the classroom when iPads entered the learning space.

Whiteboards are to some extent tools that support the role of the teacher in the classroom, and situate the teacher as the authority of the learning space and of disseminating knowledge (Jensen 2010). In the special education classes in particular, teachers had been accustomed to using the whiteboard as a point of reference and connection in the classroom, where different kinds of relevant information, presentations, multimedia etc. could be displayed. The teachers would for instance use the whiteboard to display tasks that all pupils had to solve, show films and websites and summarize discussions.

According to a teacher in one of the special education classes, the whiteboard was a good tool for focusing students' attention on tasks, help them memorize and give instructions for assignments. In this way the big screen could support teachers in managing curriculum activities and assessment. However, this teacher also told me that for some pupils it might be difficult due to cognitive challenges to keep track of and focus attention on what was going on on the big screen. These pupils had, prior to the introduction of the iPad in the school, often worked on their own or with the teacher on their laptops where they could work on assignments in their own pace and for instance have text read aloud to them by software on their device.

When the iPad entered this classroom it however became evident that the iPad could contribute to making access to the internet and the relevant software much more easy for the pupils, and on top of this that the tablet could act as a personalized small screen for pupils who had cognitive and other kinds of challenges. In the class I observed how for some of the pupils it would be useful to sit with the teacher or on their own and use the iPad as a smaller screen that could help them learn in a more self-directed way. The tablet could be used as a personal screen, the pupil's own screen or a screen that could be shared between the teacher and the pupil. In this way the smaller screen helped pupils and teachers to display, interact with or produce relevant knowledge.

This is not to say that teaching in this class took place primarily as an activity where the whiteboard would dominate and the iPad would act as a supplementary tool to the whiteboard screen—very often it would be the other way around, or the big screen might not be used at all. Sometimes pupils would for instance produce presentations on their tablets that would then be displayed from the iPad onto the whiteboard, in order to share with the class. At other times, pupils would get their instructions for assignments from Dropbox or from the internet rather than from the whiteboard screen. What emerges from this analysis of how iPads were integrated into the classroom is that teachers and pupils were able to use the technologies available to them in ways that made sense to them for specific learning purposes and contexts at specific times. There is no doubt that the advent of the tablet enhanced the learning processes in this classroom considerably, for instance by providing pupils with a personal device that could support them in producing context, accessing information and managing tasks. However, the experience that emerges from these activities is that the presence of the iPad generally enhanced relationships between teachers and learners, between learners as well as between learning resources available to teachers and learners rather than acting 'on its own' as a separate device in teaching and learning.

3.6 Conclusions

In this paper I have argued that research in the educational value of iPads can be qualified by understanding their situated contribution to learning, i.e. the complexities of how the technology is embedded into the contexts specific to its use. iPads, understood as technologies that are not clearly bounded by 'affordances' but participate in various ways in educational activities, contribute to school development and the transformation of learning, as described above. iPads for instance participate in transformative teaching and learning processes in the sense that they become part of the ecologies of activities and learning resources constituted by teachers, learners and schools. In the cases described above the iPad becomes part of the dynamics of classrooms in which many kinds of resources are used, for instance whiteboards, paper, books, pens, jotters and laptops. As a flexible technology, the iPad allows pupils to construct their own systems of related resources or processes of socio-material bricolage that suit their particular and shifting learning needs. In this sense the iPad contributes to inclusive uses of technologies and educational resources that may enhance inclusive educational settings.

My research indicates that one of the things at stake in looking at the ways in which mobile devices are used in formal education is identifying new relationships between existing learning materials and new learning technologies such as the iPad. This perspective could be reflected in research as well as in practice—courses aimed at teachers' professional development ought for instance not primarily to focus on how to use the iPad as an isolated device in education, but on the significance of ecologies—i.e. the relationships between devices and other learning materials and how these make sense for pupils. In continuation of this argument, pupils might be included in courses, as teachers may learn from the ways in which pupils assemble and bricolage with flexible devices such as the iPad that are personalized and 'at hand'.

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Chapter 4
Supporting the Strengths and Activity of Children with Autism Spectrum Disorders in a Technology-Enhanced Learning Environment

Virpi Vellonen, Eija Kärnä and Marjo Virnes

4.1 Introduction

The contents of this paper reflect a research project that investigated the actions of children with ASD in a strength-based technology-enhanced learning environment (Vellonen et al. 2013; Voutilainen et al. 2011). The structure of the paper is twofold. First, the paper will introduce four principles for the establishment of a strength-based technology-enhanced learning environment, and second, it will present and discuss the findings of how such a learning environment worked for children with ASD. The term ASD refers to abnormalities in the areas of social interaction, communication and repetitive behaviors (American Psychiatric Association 2000; World Health Organization 1992). In addition, speech is typically delayed and some children are nonverbal or have sparse, limited speech (Rapin and Tuchman 2008). Children participating in this project had various autistic features and limited verbal communication.

Learning environment is a term used both in connection with a range of specific areas of education and to convey broad ideas about learning. The project rests on Barry Frazer's (1998) broad definition of a learning environment. According to Frazer (1998), learning environment refers to the social, psychological and pedagogical contexts in which learning occurs and which affect student achievement and attitudes. In addition, information technology (IT) learning environments are included explicitly (Frazer 1998). However, this paper focuses on the pedagogical and technical aspects of the learning environment.

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A crucial component of a good learning environment is assessment as systematic preparation for effective intervention. Assessment, planning, and facilitation need to focus on helping children on the autism spectrum develop the understanding and skills that will enable them to access the curriculum, engage in learning, and experience true inclusion. While a diagnosis might give a signpost to the needs of a child or young person on the autism spectrum, identification of those needs can only arise from an understanding of how the condition affects the individual at a particular time and in a particular learning environment (Parsons et al. 2009, 2011).

A learning environment's characteristics, for example, class arrangements, computers, laboratory experiment kits, teaching methods, learning styles, and assessment methods, influence learners' academic achievements, and other learning outcomes in cognitive and affective domains (Doppelt 2006, 2004; Doppelt and Schunn 2008). The impact is even more remarkable when learners have special needs such as autism (Sze 2009; Verdonschot et al. 2009; Williams 2008; Williams et al. 2006). A growing number of studies suggest that interactive causal multisensory environments are stimulating for people with disabilities (Williams 2008; Williams et al. 2006). In addition, recent research indicates that children with ASD, for example, benefit from environments that provide structure while allowing them to express their personalities in the learning choices they make (Sze 2009).

There is evidence that an "autism friendly" environment needs to be based on individual assessment and focus on social understanding and communication, be developmental and structured, and use visual supports (Guldberg 2010; Parsons et al. 2011, 2009). Potential sensory processing difficulties must be taken into account and environments adapted accordingly (Bogdashina 2003; Frith 2003). It is also important to consider a number of other dimensions, including teaching practices, learning contexts, and child characteristics, when building a supportive and activating learning environment for children with ASD.

The technology-enhanced learning environment of the project introduced in this paper included four technology solutions for children's learning. The versatility of the technology solutions meant possibilities to foster children's creativity and potential skills which a single technology solution might not have been able to emerge. With respect to its strength-based learning environment focus, this paper stresses the importance of establishing and developing a learning environment based on the strengths (e.g., special skills, interests) and creativity of children with ASD rather than on the problems and deficits associated with autism. This emphasis on strengths and creativity is important as these aspects have been less researched and understood than other features of autism (Happé and Frith 2009).

4.2 Strength-Based Technology-Enhanced Learning Environment

There were four main principles that established the learning environment in this research project: (1) Children's creativity and active roles; (2) Children's strengths; (3) Modifiability of technologies; and (4) Transformability of technological solutions to everyday life contexts. The findings of previous studies (e.g., Jormanainen et al. 2007; Kärnä-Lin et al. 2007) provided the criteria for the selection of these four principles. Previous research further suggests that flexible, choice-based, and tangible technologies in cooperation with appropriate and inspiring pedagogical content can compensate for learning challenges, and change the child's role from technology user to active participant and creator in a technology-enhanced learning environment (Robins et al. 2005).

1. *Children's creativity and active roles as participants and developers in a technology-enhanced learning environment*. This first principle investigated the diversity and creativity in children's behavior—aspects that have been less researched compared to the more typical features of ASD (e.g., repetitive and invariant behavior) (Napolitano et al. 2010). The learning environment enabled the children's active role by letting the children interact with many kinds of technologies. The technologies were selected to be diverse so that the children could use them in various ways through different kinds of interfaces (e.g., touchscreen, mouse, physical tiles, and motion-based interface). The various and changing pedagogical contents of technology applications (e.g., funny games, number and picture tasks, creating stories, building models) were to tempt the children's engagement and creativity.
2. *Comprehensive support of the emergence of children's strengths*. The majority of research on children with autism and technology attempts to find solutions to problems connected to ASD (e.g., Austin et al. 2008; Bernard-Opitz et al. 2001; Powers 2006). This learning environment, however, focused on children's strengths during activities in the environment, and there were several ways to support the emergence of children's strengths. The use of multimodal interaction, the utilization of different senses (visual, auditory, tactile, and kinesthetic), and the individual modifiability of technical solutions could help determine the children's individual strengths. In addition, a roomy space with minimal external stimuli was provided to support children's concentration on activities at workstations and give them a chance to monitor or to interact with other children while working in the environment. Also, action group session routines (e.g., joint beginning of the session) were to enhance the clarity of the learning environment. However, as the environment was meant to be as natural as possible, changes in routines and the organization of the environment were possible when needed.

   Another important means of supporting the emergence of children's strengths was the use of augmentative and alternative communication (AAC) methods in the learning environment. First, AAC methods (especially pictures and signs) were used adaptably in instructing the children according to the children's teachers' and school assistants' evaluations. Second, the children had a picture of the action group in their weekly timetables so they knew the date and time of the session in advance. Third, the applications used a variety of pictures (e.g., hand-drawn pictures, photos) so that the children became familiar with different kinds of visual symbols and representations. Fourth, pictures were used to clarify the structure of the sessions; for example, each child used a pictured map that presented the order of the workstations as a guide to move from one station to another. Fifth, the children provided workstation feedback by way of picture symbols.

3. *Modifiability of technologies*. This principle emphasized the children's active role and creative actions in the learning environment. Pedagogical content and technological implementation of applications are often predefined before use in learning environments because they are often designed for specific purposes and certain learning objectives; therefore, children and teachers rarely have opportunities to modify physical technology devices or content. Technology solutions with specific purposes for children with ASD are, for example, mobile devices to improve communication skills (see De Leo and Leroy 2008) and scheduling (see Hayes et al. 2008), virtual learning environments and computer games for developing social skills (see Battocchi et al. 2009; Cheng et al. 2010) and games for exercising (see Finkelstein et al. 2010), and robotics for improving social skills (see Fujimoto et al. 2010). These technology solutions have indicated advantage for children with ASD within the specific purpose, but by enabling the modification of the pedagogical content, the solutions might be applicable to other educational domains.
   The learning environment established in this research project realized the modifiability of technologies by enabling modification of physical elements (e.g., physical tiles) and pedagogical content (e.g., tasks and visual content) to applications by both children and adults. Choices for modification were based on the children's interests and iterative feedback after participation at the workstations and observations of the children's actions at the workstations. Thus, the participating children had an untraditional and unique role in the study since they operated as innovative and active research partners (Druin 2002; Marti and Bannon 2009; Olkin 2004) rather than just as objects of inquiry. The teachers' and school assistants' roles were also important in the development of the technologies since they knew the children's individual pedagogical goals in school.
4. *Transformability of technology solutions to everyday life contexts*. Commercially available technologies (e.g., robotics) are often too expensive to use in education (Bryant et al. 2010). Another obstacle to applying and transforming technology solutions to everyday life contexts is how time-consuming technologies are for teachers to learn and how difficult they are to use (Copley and Ziviani 2004). Research on advanced technologies confirms children with ASD benefit from various technologies (Finkelstein et al. 2010; Williams et al. 2006; Williams et al. 2002) and thus, supports applying technologies in education for them. It is therefore important that applications are easy to use and modify without technical expertise or external support to fit children's needs and wishes in everyday life contexts, like school.

4.3 Method

The research participants included two groups ($N=8$) in one comprehensive school for children with special needs. Group A participated in the research from the beginning of the project, February 2011. This group included four children with autistic features and limited verbal communication. Two were boys (ages 8 and 10 years at the beginning of the project) and two were girls (ages 7 and 12 years at the beginning of the project). Group B was included in September of 2013 to evaluate the development of the learning environment thus far with novel participants. Group B included four boys with autism (ages 8, 10, 11 and 11 years at the beginning of their participation).

The children faced many challenges in their actions and learning, yet had multiple strengths, such as good visual senses, and a variety of skills in information and communication technologies (ICT). Each child had various ways of communicating despite limitations in verbal language skills. All of the children used augmentative and alternative communication methods, especially picture symbols, in various situations.

The children's teachers and school assistants participated in the research project by providing valuable information about the children's interests and needs, and knowledge about their actions in their respective classrooms. They knew the children better than the project researchers did and were, therefore, ready to support the children when needed. In addition, the teachers and school assistants provided feedback about the learning environment during the study and were involved in the technology development process. By participating in the project with the children, the teachers and school assistants received firsthand knowledge about the children's actions in the technology-enhanced learning environment.

The study was conducted following generally accepted ethical principles for scientific research. Participation in the study was voluntary, and written informed consent was obtained from the children's legal guardians. Additionally, the teachers and school assistants were asked for written informed consent. Respecting the rights of the participants was given the first priority in the study.

4.3.1 Settings

The research project ran one-hour group sessions, called action groups, weekly, nine times each semester. At the beginning of each session, there was a short warm-up with greetings and the researchers gave the children a pictured map of the workstations. Though the order of the workstations was predetermined, the children could choose a variety of tasks or games to work with at each workstation. The children worked individually at each station for 10–15 min, and the adults were advised to help if needed (e.g., setting the difficulty level of the task). The order of the workstations varied for each child every session. After group B joined the study, the children were divided in two groups according to their school schedule and thus, the project ran two one-hour group sessions in a row.

A technology-enhanced learning environment was set up in a spacious room in the school building (Fig. 4.1). There were four technology workstations in the learning environment: symbol matching, LEGO® building, storytelling, and Kinect playing (Figs. 4.1 and 4.2).

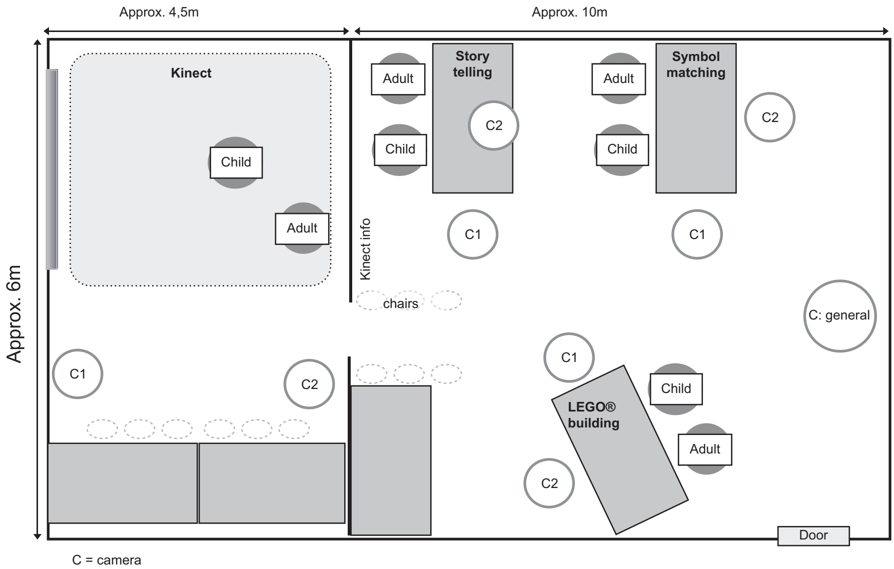

Fig. 4.1 Ground plan of the technology-enhanced learning environment

Fig. 4.2 Symbol matching, LEGO® building, storytelling, and Kinect playing

At the symbol matching workstation, the children had tasks of matching a symbol from the computer application to the corresponding symbol or a theme by pressing one of six tiles. The children chose the topic for the tasks and changed the symbol cards on the tiles according to their selection by themselves. The tasks included, for instance, recognizing hiding creatures, categorizing according to hypernyms (e.g., space, animals, musical instruments), recognizing initial letters of words, and matching a certain amount of objects to corresponding numbers.

At the LEGO® building workstation, the children built a LEGO® Duplo or basic LEGO® construction from the model on the computer application. The children chose a task from three alternatives: (1) building from the picture of the whole model; (2) step-by-step building of the model; or (3) a memory game that hid the model during the child's construction. In addition, the children chose between building a model according to a certain character (e.g., various animals) or a random model. The children adjusted the difficulty level by changing the number of the bricks in the application. During the project, new character models were included.

At the storytelling workstation, the children created stories by using a picture-based computer application and a touchscreen. The pictures were categorized, and the children created stories by dragging and dropping the hand-drawn pictures into the story's timeline, as well as by drawing pictures of their own. During the project, the application was modified and, in fall 2012, the children could also write the name of the story above the storyline, write text under the pictures and record the story to be listened to later. The stories were saved to the story library where the children could review and continue their own stories, and review the stories created by other children. The children could print out their stories and put together their own story books.

At the Kinect playing workstation, the children played games that used Microsoft's Kinect sensor. During 2011 and 2012, the children played short Kinect Adventures! games by Microsoft Game Studios. During 2012, a new catching game was developed in the project and, in fall 2012, it replaced the previously used commercial games. The children played the catching game by picking moving objects (e.g., fishes, birds, letters). In the new game, the background and objects were modifiable based on the children's individual skills and interests. The children played both the previously used commercial games as well as the project's catching game by using their whole bodies to control the game, for instance, jumping, dodging, and using their hands. In addition, all games allowed using a variety of movements as long as the player stayed within the play area.

The pedagogical aspects were carefully considered in developing the technology-based workstations. These aspects included, for example, supporting children's communication and using visual supports (e.g., Guldberg 2010; Parsons et al. 2011, 2009), supporting the children to use various senses (e.g., Bogdashina 2003; Frith 2003), providing structure but also allowing the children to make choices (e.g., Sze 2009), and emphasizing the children's strengths and creativity instead of difficulties (e.g., Happé and Frith 2009). There are examples of the advantages of the workstations with regard to supporting the children's strengths and activities, and in applying the workstations in a school context in Table 4.1.

Table 4.1 Examples of the pedagogical possibilities in applying the workstations in a school context

Workstation	Examples of the advantages of the workstation considering a school context
Symbol matching	Various visual symbols in the tasks (e.g., photographs, a variety of drawn pictures) to attract attention and to get familiar with working with different kinds of visual symbols. Working with visual or auditory instructions allows using individual strengths. Written words or instructions in the tasks support developing reading skills. Interaction and communication supported by means of doing the tasks with another person. Using creativity by reconstructing the tiles (see Korhonen et al. 2010). By modifying the contents of the application, the workstation could be integrated into almost any school subject
LEGO® building	Working with smaller LEGO® basic bricks or bigger LEGO® Duplo bricks according to skills and preferences allows using individual strengths. Selecting models according to individual strengths and interests. Building with bricks practices working with colors, sizes, numbers, and spatial directions. Visual instructions of the models (e.g., stable or rotating model, direction of the model) could be adjusted by the builders themselves according to their interests and needs. Interaction and communication supported by means of constructing LEGO® models with another person. School subjects like mathematics could utilize this kind of workstation
Storytelling	Expressing oneself by creating stories with different kinds of pictures (e.g., drawn pictures, photographs) and one's own drawings. Recording sounds, words and phrases in relation to pictorial stories to encourage verbal expression and creativity. By creating stories, practicing categorizing, conceptualizing, and naming. By naming the stories, practicing writing. Choices and actions in a free or more structured way according to individual strengths and interests. Interaction and communication supported by means of making stories together and sharing stories. Visually supported social stories to different kinds of everyday life situations. This kind of workstation could be applied especially in the mother tongue but, by modifying the contents, could be integrated into almost any subject

Table 4.1 (continued)

Workstation	Examples of the advantages of the workstation considering a school context
Kinect playing	By playing amusing games, attracting attention, exercising and practicing perceiving and targeting motions. Interaction and communication supported by means of playing with another person. Using creativity by modifying the games, for instance, by drawing the background of the game. The workstation could be applied especially in physical education (various movements while playing), studying languages (e.g., collecting letters for a word) and mathematics (e.g., amounts and numbers). By modifying the content, it could be applied to almost any school subject

The children gave immediate feedback about the workstations after interacting with the technologies. The feedback system consisted of a black piece of cardboard with three picture-word feedback cards and a photo of the workstation. The feedback cards had drawn pictures of facial expressions (linked with matching words): very happy face (I liked it a lot), neutral face (I liked it a little), and sad face (I didn't like it). In this respect, the feedback scale was similar to one used with children in technology development projects using a participatory design model (see Nissinen et al. 2012; Read and MacFarlane 2006; Read et al. 2002).

4.3.2 Data Collection and Analysis

The project conducted qualitative action research (Heron and Reason 2001; Ladkin 2004). The main research data were collected by videotaping each child's actions using two video cameras per workstation: one facing the child in front of him/her, and the other facing the child with the screen sideways. The purpose of this was to be able to analyze the child's actions while seeing what was happening on the screen at the same time. The additional data were collected by observing the children during the action group sessions, and by interviewing teachers and school assistants.

This paper's findings are based on the data collected in the action group sessions between February, 2011, and December, 2013. The researchers analyzed the data via content analysis (e.g., Bauer 2000) by organizing and reviewing the data according to the four principles that guided the establishment of the learning environment. Thus, the categories of organizing and reviewing the data were the following: the emergence of the children's creativity and activity, the emergence of the children's strengths, the modifiability of the technologies, and the transformability of technological solutions to an everyday life context. A few short examples of the transcriptions of the video data clips and observation notes have been included in the following results section. The examples have been transcribed into English and the children's names changed to pseudonyms to protect their identities.

4.4 Results

According to results, the project's strength-based technology-enhanced learning environment facilitated the emergence of the children's activity and creativity; the first principle of the establishment of the learning environment. For instance, the children immediately started using the applications or choosing equipment linked to the workstations (e.g., cards for the tiles) upon arriving at the stations, and quickly learned compensatory ways to proceed if there were problems with the technologies (e.g., using buttons on the keyboard instead of out-of-order tiles) or the equipment (e.g., using red bricks instead of missing orange bricks). Similar to many previous studies (e.g., Finkelstein et al. 2010; Williams et al. 2006; Williams et al. 2002), the technology itself was motivating for all children participating in the project. According to the findings, the versatility of the workstations in the environment and the possibility of making choices at each workstation seemed to support the active role of the children.

All of the participating children showed interest in the new application features and new tasks or games in the environment. The participating children's interest in novelty was remarkable considering many researchers report that children with ASD have restricted interests (see Ala'i-Rosales and Zeug 2008; Baron-Cohen and Wheelwright 1999; Folstein and Rosen-Sheidley 2001). While the researchers executed changes in the learning environment based on routines familiar to the children, the children's interest in change emerged from the beginning of the project, even when the workstations and procedures were novel to them. The children usually explored the new application features or tasks introduced to them and, if they found them appealing, chose them again. Below is an example of group A's actions regarding a new task.

> At the beginning of the session, we presented a new task for the symbol matching workstation called "Hypernyms task." Iris, Ian, and Olivia chose the new task as the first task at the workstation. Eric scanned the new cards during his turn. The school assistant asked if he wanted to take on the new task. Eric immediately started to place the new cards into the tiles. (Observation notes, March, 2012)

The role of the teacher or school assistant working with the child in the technology-enhanced learning environment was also significant in many respects. The teachers' and assistants' contributions were important in helping the children overcome possible problems in an application's functionality or a task's difficulty. In addition, the school assistant's positive tutoring and feedback were relevant in helping the given child grasp a new task and learn to do the task by him/herself, as the next example illustrates.

> The school assistant takes Ian's finger and points with it on the screen and they count together: "one, two, three, four, five, six." The assistant asks Ian, "Where is six?" Ian presses the tile number 6 and the assistant whispers, "Good."
> When the next photo appears, the assistant whispers, "Let's count," and points at the screen from farther away. Ian counts the number of the objects on the screen by pointing at the objects himself and says, "one, two, three, four, five." Ian presses the tile numbered 5.

> The assistant whispers, "Good," and shows her thumb up. Ian smiles. (Transcription of a video data clip, November, 2011)

It was also important that the adults provided room for the children's actions to support their activity and creativity. As a consequence, over time the need for tutoring decreased and the children were able to work at the stations more independently even though there were individual differences in the amount of time and the nature of the activities during which each child could work more independently. For example, during the data collection period of this study, two of the children from group A occasionally worked totally independently in the environment, as long as there were no problems with the technologies. The children in both groups also discovered novel features of the tasks. Once the content of the task was interesting, or if the task started to become familiar, some of the children initiated variation and multiple means to complete the tasks, for instance, by verbally describing pictures on the screen in various ways. In addition, the children found varied ways to use the technologies by themselves, for example, pressing the tiles or controlling the touchscreen with either of the hands, by the tips of different fingers, or by using the side of the hand. Thus, the children showed creativity in their actions.

Considering the results, the technology-enhanced learning environment also brought out the children's potentials and strengths; the second principle in the establishment of the learning environment. As knowledge of the children's strengths, and often of the children's interests, was iteratively executed, both in the content of the tasks (e.g., appealing themes) and games (e.g., modifiable objects and background), and in the workstations' technical aspects (e.g., sensitive touchscreen for drawing, microphone for recording expressions by voice), the environment kept changing and thus continuously fostered emergence of the children's strengths. Their strengths varied from good visual perception to creating detailed drawings to athletic skills. Below is an example of one child's (group A) skills in making choices independently and moving fluently; skills which emerged especially in this environment since his actions were not very self-directed in the classroom setting.

> Ian trots to the play area at the Kinect playing workstation, chooses the first game, and plays it independently. Ian moves fluently and quickly in different directions during the game (stepping left and right, hands up, hands down, hands diagonally, stepping forward and backward, jumping) and collects lots of points. When he finishes the game, the school assistant says, "Really well, Ian, great," and claps her hands. (Transcription of a video data clip, November, 2011)

According to the results, the versatility of the environment quickly brought out strengths and potential regarding the children in the new group (B) as well. For instance, one of them turned out to be very skilled in drawing and telling stories. He also acted very fluently with the technologies, as the next example of the storytelling workstation illustrates.

> Aron picked up several pictures of the folder containing his own drawings to the storyline and pressed the symbol indicating that the story was ready. He took the microphone and started recording verbal expressions, some of them indicating conversation (question and answers), and also sounds. During recording, he moved the pictures of the story forward on the touchscreen. At the end of the storyline he had a picture in which he had written "the

> end", and he said it aloud. He recorded for 1 min 25 s. He then listened to his own story and moved the storyline on the screen accordingly. (Transcription of a video data clip, December, 2013)

The project iteratively realized and fulfilled the modifiability of technologies; the third principle of the establishment of the learning environment. The children's iterative feedback was utilized in the modification process; however, the challenge at the beginning of the project was to get feedback from the children. Because the children were inexperienced in giving feedback, the researchers needed to carefully consider how to ask them for feedback. The feedback system described above seemed to work, as the next example shows.

> After acting at the LEGO® building workstation, Olivia takes the feedback board by herself and the school assistant asks, "What did you like?" and at the same time Olivia says in a clear voice, "I liked it a lot!" The school assistant confirms, "You liked it a lot." Olivia then attaches the photograph of the workstation under the happy face and says again, "I liked it a lot." (Transcription of a video data clip, February, 2012)

Overall, the majority of the children's feedback at the workstations was positive. This may indicate that the development of the learning environment succeeded well. On the other hand, not all of the children's feedback was positive. For instance, if there were technical problems with the applications, some of the children gave negative feedback, sometimes even spontaneously, by pointing to the sad face on the feedback board, as the next example illustrates.

> Iris immediately moves her finger straight back on the sad face. She points at it several times until the researcher names the picture, "I didn't like it." Iris then leaves the feedback board and takes the session map into her hands. (Transcription of a video data clip, April, 2012)

Regarding children's inclusion in the modification process, their overall participation in the development of the project's technology-enriched environment got stronger during the project. However, their participation was still limited. Therefore, the need to develop more elaborate means of participation remained to be solved in the future. Since the children did not give verbal reasons for their feedback, we did not know what precisely they were rating. They may have evaluated the station as a whole, a certain task or game, succeeding at a game or, for instance, creating a story, or interaction with the adult. The children's feedback used in this study served, nevertheless, as a good starting point for increasing children's participation in the development process, since it is unusual for children with ASD to be involved in the evaluation of their learning environments.

The researchers also improved the environment by interviewing the teachers and school assistants and taking their suggestions into account in technology modifications. The teachers' and assistants' contributions were important in developing the pedagogical contents of the applications and the environment as a whole. Although the teachers' and school assistants' suggestions were good and many-sided, most were rather difficult to implement at the school without extra technological support; therefore, the teachers' and assistants' participation in technology modification in practice must be developed. The next examples illustrate suggestions by teachers and school assistants.

> Iris would benefit if she had a building plate at the LEGO® building workstation and models of figures with only three or four blocks. She likes birds, for instance. (An idea from Iris's teacher and school assistant, written down in April, 2012)
> There could be a task with matching capitals with lower-case letters at the symbol matching workstation. (An idea from Ian's, Olivia's, and Eric's teachers, written down in April, 2012)
> The Feelings task at the symbol matching workstation could be modified so that there would be both drawn pictures and photos. After the tasks are completed, there could be a smiling face or a picture of a thumb up or clapping hands enclosed with the applause sound. (Ideas from the school assistant in Eric's class, written down in April, 2012)

The technologies' modifiability relates to the fourth principle in the establishment of a learning environment: the transformability of technological solutions to everyday life contexts. The feedback from the children and adults participating in the study indicated that technologies had to be easy to use for both children and adults in order to be truly transformable to a school context. For example, if the application was too complex, the adult was not able to tutor the child on how to use the application appropriately or help the child perform the task purposefully. In addition, using only pictures in the applications did not seem to be informative enough to explain the task's purpose. According to the data, clear instructions minimized the need for teachers and school assistants to obtain support from technical experts or task designers, and prevented misunderstandings in the usage or technology content. It was also helpful if the instructions were in sight in the tasks and games themselves, and not hidden somewhere in the menus. The availability of written language was also found important since some of the children learned to recognize written instructions while working with the technologies. This, in turn, increased the technologies' advantages considering the school context.

4.5 Conclusions

The purpose of this study was to present principles related to children's activity, creativity and strengths, and the technology's modifiability and transformability for the establishment of a strength-based technology-enhanced learning environment with and for children with ASD, as well as to introduce results on how the project succeeded in actualizing the principles in relation to children's actions in the learning environment. The findings indicate that the technology-enhanced learning environment introduced in this paper provided many opportunities for facilitating the emergence of potential skills, active participation, and the learning of children with ASD. In addition, the strength-based environment facilitated a chance to see the children's strengths rather than their challenges and to find diversified ways of supporting their learning. The modifiable and transferable technical solutions also facilitated individualized learning and teaching, thus increasing the possibility of the children's inclusion both in the school context and in society.

As technology plays an increasingly important role in children's lives in modern societies, children who are left out of this process are in danger of being disconnected from peers, cut-off from various opportunities, disadvantaged, and unskilled in terms of future work (Montgomery 2007, p. 210; Vicente and Lopéz 2010). It is crucial that technologies are continuously modifiable according to the interests, strengths, and needs of children with special needs, including autism. To meet the criteria of children's various situations, learning environments should contain multiple technologies. Every part of a learning environment should be taken into account: the people, the technologies, and the pedagogy.

Technologies should be developed with children with ASD, not just for them. Every child is entitled to an opportunity to make choices and affect their environment. It is crucial to establish multiple ways in which children with ASD can provide feedback and truly participate in the modification and development of technologies. Some recent studies (see López-Mencía et al. 2010; Nissinen et al. 2012) indicate that participatory evaluation, design, and development of technologies are possible for children with different special needs, including autism. An environment with multiple technologies provides a challenging yet promising starting point for participatory design. Since technologies interest children with ASD, the aim of the near future is to develop technical solutions that facilitate and diversify the children's inclusion in the development of their learning environments.

The transformability of technological solutions to everyday life contexts also calls for the involvement of all participants in the development process. Knowledge of the technologies and skills to use them in various ways increase the possibility that school personnel could also use technologies in everyday school contexts. As this study's results indicate, applications have to be easy to use and modify, from the viewpoint of both the children and the adults.

Although the results are very promising, there are several limitations in this study. The emphasis of this article was on describing the establishment of the learning environment and its technologies and on the research's overall results, instead of focusing on an exact research area. The number of participating children was low, which has an effect on the generalizability of the results; however, the project's learning environment worked as an experimental environment and the results can be further studied. Future research will give more detailed information about the actions of children with ASD, and the benefits and limitations of the project's technology-enhanced learning environment.

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Chapter 5
Learning with the Simpleshow

Dirk Ifenthaler

5.1 Introduction

The rapid development of information and communication technology (ICT) has strongly influenced advances and implications for learning and instruction. Schools began reacting to this challenge in the 1990s and made systematic efforts to improve the information technology competence of their students. *Computer literacy*, the ability to work competently and effectively with computer technologies and programs, advanced increasingly to the fore of pedagogical interests (Seel and Casey 2003), and a *basic education in information technology* became a real hit in these years (Altermann-Köster et al. 1990). Educators tried just about everything they could to teach their students how to use computers. More important than these changes in the classroom, however, was the fact that ICT were increasingly becoming a part of the daily lives of children and teenagers (Ifenthaler 2010).

Today, there is widespread agreement among educational theorists on the point that educational applications of ICT can be made more effective when they are embedded in *learning environments* created to enable productive learning. Learning environments should be designed to enable learners to explore them with various amounts of guidance and construct knowledge and develop problem-solving methods independently (Pirnay-Dummer et al. 2012; Seel et al. 2009).

Accordingly, the technological possibilities for designing learning environments are doubtlessly great, but the pedagogically significant question as to how learning can be supported effectively is sometimes left out of the picture. Another important factor is the usability of ICT in the everyday classroom of schools. Students and teacher may be overwhelmed with the features and possibilities of ICT and are therefore not able to focus on the importance of learning objectives (Blömeke 2003; Ifenthaler and Schweinbenz 2013; Reinmann-Rothmeier 2001).

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This project, learning with the simpleshow, uses ICT in a simple and easy way for an everyday classroom use. The innovative characteristic is a short video format that explains a complex phenomenon in question in an authentic and creative way. With the simpleshow, meaningful learning may be fostered by activating the learners' prior knowledge and inducing the construction of mental models and schemata (Bransford 1984; Ifenthaler et al. 2011; Ifenthaler and Seel 2011, 2013; Seel et al. 2009).

5.2 The Simpleshow

The simple show is a video format that explains things in the simplest ways. It illustrates a topic, product, or problem in a maximum of 5 min (see Fig. 5.1). The learner gets an overview of the facts and relationships of a specific phenomenon in question. However, it is not intended to explain a topic all-encompassing and in every detail. Rather, it aims to generate interest for details of the phenomenon in question. The simpleshow is realized with a simple visual language which is

Fig. 5.1 The simpleshow explaining the "Fall o the Berlin Wall"

intuitive and memorable. Keywords, events, or persons are represented as comic-like scribbles. The scribbles are brought to stage and moved around by a “hand actor”. Accordingly, the visual language is reduced to the essential components of the phenomenon in question, and is therefore very easy to follow. Additionally, the simpleshow includes spoken explanations and sound effects.

The simpleshow originated from industrial usage in the business-to-business area: A client had the problem that the newly developed product was very innovative, however, visitors of the website only spent three clicks and 25 s on the website (GoogleAnalytics; www.google.com/analytics) —a classic communication problem. Therefore, a communication tool had to be implemented which was able to present the innovative features of the product in a entertaining way and within a short amount of time. With the integration of the simpleshow on the website of the client, an increase to an average of twelve clicks and 2.15 min on the website was found (GoogleAnalytics; www.google.com/analytics). Meanwhile, the simpleshow is applied by prestigious companies, such as Mercedes Benz, Novartis, PricewaterhouseCoopers, or Microsoft.

Accordingly, the simpleshow offers an added value for viral marketing. The simpleshow “Financial Crises” (explaining the causes of the financial crises) was accessed on the video portal *youtube* (www.youtube.com) over 30.000 times within the first 3 months. A heated discussion started in the comments section of the video portal with regard to the financial crises. Additionally, the creators of the simpleshow receive a lot of positive feedback from school and university students with regard to the entertaining and well-grounded information provided by the video format.

5.3 Empirical Investigation

This initial empirical investigation of the simpleshow addresses (1) the effectiveness for learning and (2) the acceptance amongst teachers and students. Accordingly, the reported study was conducted to answer the following research questions:

1. Does the simpleshow induce a learning process and fosters the understanding of the phenomenon in question?
2. Do teachers and students accept the simpleshow as a medium for learning?

This initial empirical investigation of the simpleshow included three studies. (1) A pilot study focusing on the study design and applied instruments. (2) A school study including two different subject domains. (3) A qualitative study with teachers.

5.3.1 Pilot Study

The pilot study was used to test the study design and the applied instruments. Ten university students (four female and six male) took part. Their average age was 26.2 years ($SD = 5.05$).

First, the demographic data was collected. Then, participants answered the ten multiple-choice questions of the domain-specific knowledge test on "Parliamentary Election" (pretest). Immediately after, the simpleshow focusing on "Parliamentary Election" was shown (length: 4.03 min). After a short relaxation phase, the participants answered the domain-specific knowledge test on "Parliamentary Election" (posttest). The pre- and posttest included identical questions (1 correct, 3 incorrect), however, the questions appeared in different order. Last, participants completed a questionnaire focusing on the acceptance of the simpleshow.

In both versions of the domain-specific knowledge test (pre- and posttest), participants could score a maximum of ten correct answers. In the pretest, they scored an average of $M=4.6$ ($SD=1.96$) correct answers and in the posttest $M=7.2$ ($SD=2.49$) correct answers. The increase in correct answers was significant, $z=-2.120$, $p=0.034$.

Regarding acceptance of the simpleshow, the following results were found. The design of the simpleshow was rated as good (50 % agree; 50 % strongly agree). The balancing of the drawings with the content was rated as good (50 % agree; 50 % strongly agree). Effectiveness, meaningfulness, and motivation originated from the drawings were rated as positive by the participants (20 % somewhat agree; 40 % agree; 40 % strongly agree). The content of the spoken explanation was rated good (20 % somewhat agree; 80 % agree). However, the speed of the spoken explanation was rated as too fast (10 % somewhat agree; 50 % agree; 40 % strongly agree).

Based on the results of the domain-specific knowledge test (pre- and posttest), we assume that the test is appropriate for the larger school study. Additionally, the questionnaire focusing on the acceptance of the simpleshow provided a good overview on the quality of the video format.

5.3.2 School Study

The school study was conducted in cooperation with interested high schools in the state of Baden-Wuerttemberg, Germany. All participating schools received information materials regarding the simpleshow. The following parameters were set for the school study:

- 45 min total time of empirical testing
- Two topics of the simpleshow to choose from
  - Parliamentary Election
  - Fall of the Berlin Wall
- Integration of the simpleshow into the curriculum/ teaching unit
- Participants should be K-12 students grade 10 and above

The procedure of the school study included a fixed sequence of testing and learning. All participating teachers were introduced to the procedure, instruments, and the application of the simpleshow. First, participants completed a demographic data survey. Then, they answered the ten multiple-choice questions of the domain-specific knowledge test on "Parliamentary Election" or "Fall of the Berlin Wall" (pretest).

Immediately after, the simpleshow focusing on “Parliamentary Election” (length: 4.03 min) or “Fall of the Berlin Wall” (length: 4.45 min) was shown. After a short relaxation phase, the participants answered the domain-specific knowledge test on “Parliamentary Election” or “Fall of the Berlin Wall” (posttest). The pre- and posttest included identical questions (1 correct, 3 incorrect), however, the questions appeared in different order. Finally, participants completed a questionnaire focusing on the acceptance of the simpleshow. After the data collection, teachers started a discussion with their students on the phenomenon in question.

5.3.2.1 Study “Parliamentary Election”

64 students (43 female and 21 male) took part in this study. Their average age was 16.7 years ($SD = 1.00$). 43 students were eleventh graders and 21 were twelfth graders. 64 % of the students reported that they are interested in political issues.

In both versions of the domain-specific knowledge test (pre- and posttest), participants could score a maximum of ten correct answers. In the pretest, they scored an average of $M = 6.4$ ($SD = 1.87$) correct answers and in the posttest $M = 8.4$ ($SD = 1.13$) correct answers (see Figs. 5.2 and 5.3). The increase in correct answers was significant, $z = -6.363$, $p < 0.001$.

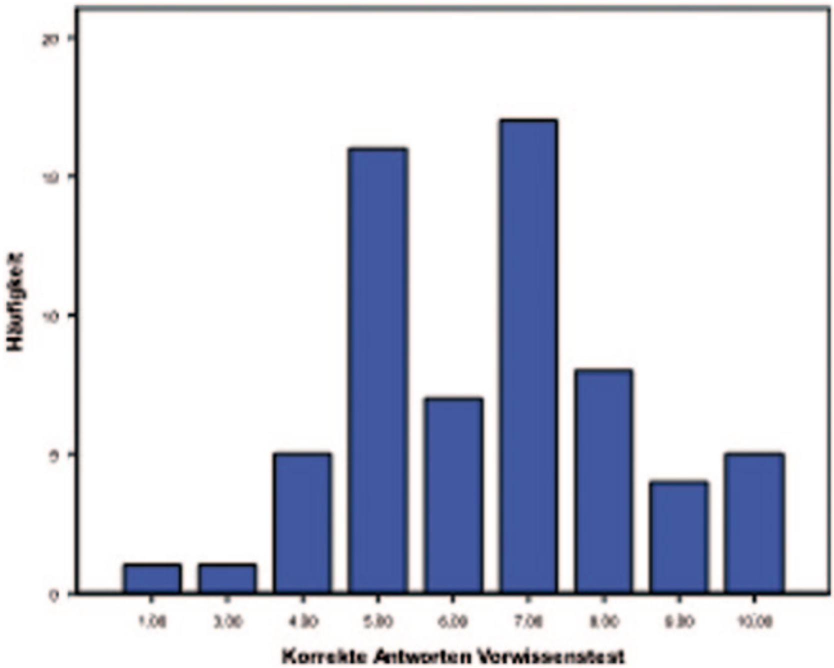

Fig. 5.2 Results of the domain-specific knowledge test (pretest) “Parliamentary Election”

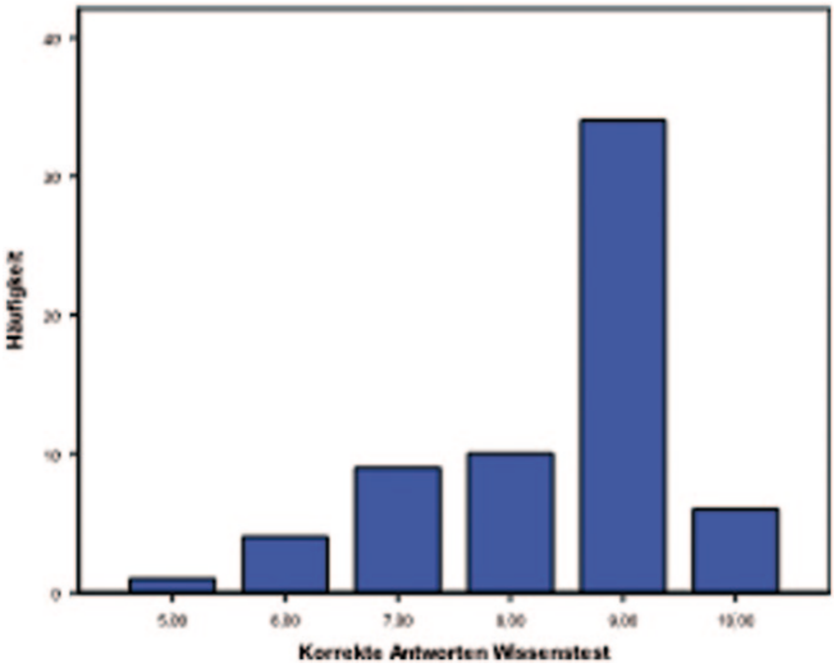

Fig. 5.3 Results of the domain-specific knowledge test (posttest) "Parliamentary Election"

Regarding acceptance and motivation of the simpleshow, the following results were found. The simpleshow motivated 75 % of the participants to follow up and get more information about the phenomenon on question. 85 % of the participants found the video format interesting. Almost all students (97 %) reported that they learn meaningful and important aspects of "Parliamentary Election". Interest in politics in general is facilitated for 61 % of the participants. 67 % of the participants reported that they were encouraged to critically reflect on the phenomenon in question.

The visual design of the simpleshow was rated by 75 % of the participants as very attractive. 90 % of the participants reported that the graphics were well aligned with the content of the simpleshow. Effectiveness, meaningfulness, and motivation of the simpleshow were highly valued by 77 % of the participants. 87 % of the participants assessed the content of the spoken explanation as well comprehensible. However, 28 % of the participants criticized the speed of the spoken explanation as too fast.

5.3.2.2 Study "Fall of the Berlin Wall"

149 students (85 female and 64 male) took part in this study. Their average age was 16.5 years ($SD = 1.40$). 63 students were tenth graders, 28 students were eleventh

graders, and 39 were twelfth graders. 55 % of the students reported that they are interested in political issues.

In both versions of the domain-specific knowledge test (pre- and posttest), participants could score a maximum of ten correct answers. In the pretest, they scored an average of $M = 6.2$ ($SD = 1.96$) correct answers and in the posttest $M = 8.6$ ($SD = 1.29$) correct answers (see Figs. 5.4 and 5.5). The increase in correct answers was significant, $z = -9.761$, $p < 0.001$.

Regarding acceptance and motivation of the simpleshow, the following results were found. The simpleshow motivated 70 % of the participants to follow up and get more information about the phenomenon on question. 79 % of the participants found the video format interesting. 90 % of the participants reported that they learn meaningful and important aspects of "Fall of the Berlin Wall". Interest in politics in general is facilitated for 58 % of all participants. 48 % of all participants reported that they were encouraged to critically reflect on the phenomenon in question.

The visual design of the simpleshow was rated by 71 % of the participants as very attractive. 87 % of the participants reported that the graphics were well aligned with the content of the simpleshow. Effectiveness, meaningfulness, and motivation of the simpleshow were highly valued by 79 % of the participants. 87 % of the participants assessed the content of the spoken explanation as well comprehensible. Only 3 % of the participants rated the spoken explanation as less comprehensible. However, 16 % of the participants criticized the speed of the spoken explanation as too fast.

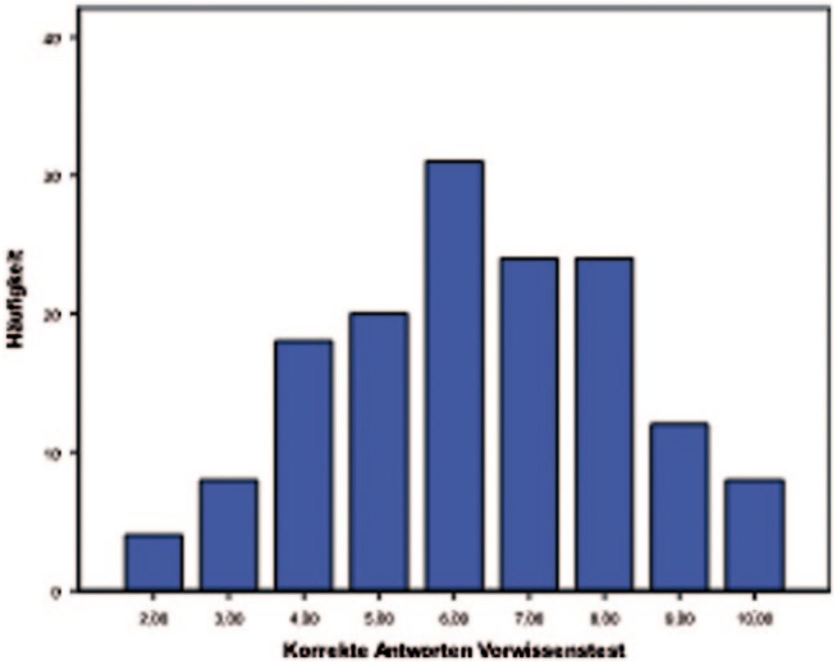

Fig. 5.4 Results of the domain-specific knowledge test (pretest) "Fall of the Berlin Wall"

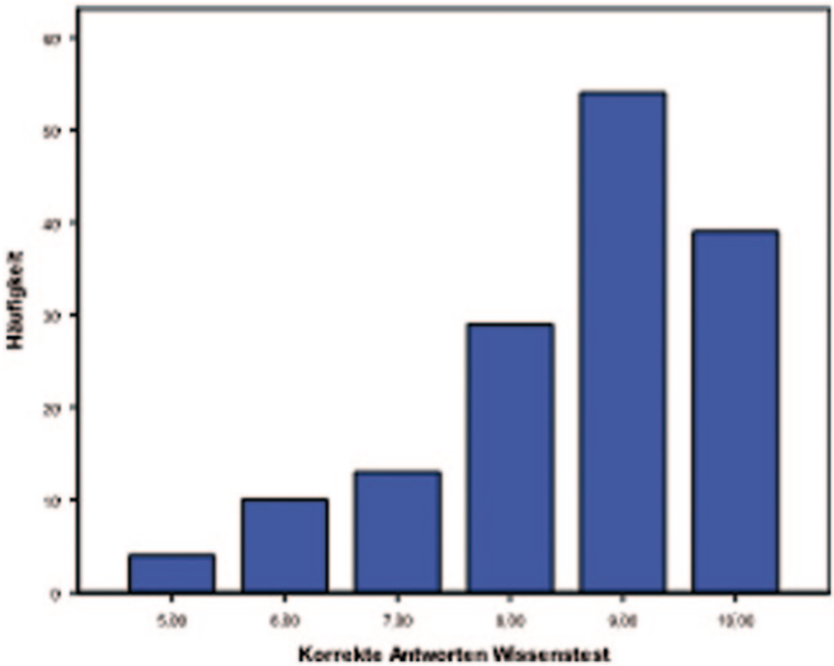

Fig. 5.5 Results of the domain-specific knowledge test (posttest) "Fall of the Berlin Wall"

5.3.3 Teachers' Perspectives

A total of eight teachers (3 female and 5 male) with a mean age of 41.5 years ($SD = 10.45$) took part in this qualitative study. All teachers were teaching at a German Gymnasium (high school). The qualitative study was conducted via phone and email interviews.

75 % of the teachers reported that the simpleshow encouraged students to critically reflect on the presented topics. All teachers valued the high quality of the video format. 70 % of the teachers concluded that the students learn meaningful and important aspects of the phenomenon in question. 63 % of the teachers believe that the simpleshow fosters the interest of students for a specific topic domain. A critical reflection of the phenomenon in question by their students is reported by 38 % of the teachers.

The visual design of the simpleshow was valued by 88 % of the teachers as very attractive. All teachers reported that the graphics were well aligned with the content of the simpleshow. Effectiveness, meaningfulness, and motivation of the simpleshow were highly valued by all teachers. 75 % of the teachers assessed the content of the spoken explanation as well comprehensible. However, 63 % of the teachers criticized the speed of the spoken explanation as too fast.

5.3.4 Discussion

A total of 213 students took part in the school study. For both versions of the simpleshow, we found a significant increase of domain-specific knowledge after its implementation in a teaching unit. Accordingly, besides the activation of prior knowledge and thereby inducing the construction of mental models and schemata (Bransford 1984; Ifenthaler et al. 2011; Ifenthaler and Seel 2011; Seel et al. 2009), the simpleshow also fosters domain-specific understanding of a phenomenon in question.

Both students and teachers highly valued the visual design and the motivational components of the simpleshow. They clearly rated the simpleshow as a good alternative compared to conventional didactical methods. Teachers also valued the high usability of the simpleshow.

The design and development of the simpleshow is easy to realize and only takes little technical equipment and know how. Further, students may also produce the simpleshow as a project within a teaching unit where they present their fellow students a topic of special interest. This possibility will be investigated in future studies.

Teachers suggested that the simpleshow may be used for other subject domains, such as European Union, United Nations, political systems, goals of a welfare state, historical events, economics and finance, legislation, jurisdiction, treaties, and much more.

5.4 Conclusion

The simpleshow is a video format that explains things in the simplest of ways. The innovative characteristic of the simpleshow is the authentic and at the same moment creative visualization of a complex phenomenon within a short sequence. The main objective of the simpleshow is the activation of prior knowledge and thereby inducing the construction of mental models and schemata (Bransford 1984; Ifenthaler et al. 2011; Ifenthaler and Seel 2011; Seel et al. 2009). Initial empirical investigations of the simpleshow found that the innovative video format can be successfully integrated into classroom teaching as an advance organizer (Ausubel 1963). Accordingly, the simpleshow fosters meaningful learning by activating the learners' prior knowledge.

A great number of students value the motivating design of implemented visual and auditive components. Accordingly, the simpleshow provides a good alternative for a creative kick-off or for a summary of a teaching unit.

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Part II
E-Learning Social Web Design

Chapter 6
Live, Laugh and Love to Learn Turning Learning from Traditional to Transformational

Merja Meriläinen and Maarika Piispanen

6.1 Towards Authentic and Creative Learning Environments

As Meriläinen and Piispanen (2013) state, living and working in the twenty first century challenges teachers to see life outside the school and recognize not only core subjects but also key skills needed for success. The report Learning for the twenty first Century (Crane 2011) identifies nine types of learning skills divided into three different key areas (see Table 6.1). In different learning contexts in a rapidly changing society, schools need to stay abreast of changes and to help students to learn not only curriculum content but also to learn the skills and matters that one needs in today's and future society (Levin 2011; Zhao 2011). A multi-dimensional education that integrates twenty first century skills with knowledge is more important than a huge amount of detailed information is (Meriläinen and Piispanen 2012). There is a gap between the knowledge and skills students learn in school and the knowledge and skills they need in typical twenty first century communities and at working places. Today's education system faces irrelevance unless we bridge the gap between how students live and how they learn. Moving from content knowledge to learning and life skills is essential when training students to be successful in their lives after school.

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Table 6.1 21st Century learning skills

Information and communication skills	Thinking and problem solving skills	Interpersonal and self-directional skills
Information and media literacy skills Accessing and managing informationIntegrating and creating information Evaluating and analyzing information Communication skills Understanding, managing, and creating effective communications Orally Written Using multimedia	Critical thinking and systems thinking Exercising sound reasoning Making complex choices Understanding the interconnections among systems Problem Identification, Formulation and solution Ability to frame analyze solve problems Creativity and intellectual curiosity Develop Implement Communicate New ideas to others	Interpersonal and collaborative skills Demonstrating teamwork and working productively with others. Demonstrating and the ability to adapt to varied roles and responsibilities Exercise empathy and respecting diverse perspectives Self-direction Monitoring one's own understanding and learning needs Locating resources Transferring learning from one domain to another Accountability and Adaptability Exercising personal responsibility and flexibility in personal, workplace and community contexts Setting and meeting high standards and goals for one's self and others Social responsibility Acting responsibly with the interests of the larger community in mind Demonstrating ethical behavior in personal, workplace and community contexts

6.2 Dimensions of twentieth Century Teaching

The teacher's challenge in today's education is to strengthen the students' natural ways to learn and produce information in new learning environments. Learning is thus seen as something happening in connection with an individual and his or her environment. Norrena et al. (2011) argue that there has to be a significant pedagogical change in school routines and pedagogical operations to move from teaching to learning and towards twenty first century requirements. How will this change become true in school contexts—what are those pedagogical changes in the fields of curriculum, planning and implementing as well as the roles of teachers and students? As Meriläinen and Piispanen (2013) highlights, the Figure of twenty first

Century Civil Skills Pedagogical Content Knowledge (21st Century CSPCK) (Fig. 6.1) attempts to identify the nature of vast pedagogical knowledge required when turning learning from traditional to transformational i.e. blending the twenty first century civil skills in to the authentic learning contexts and the curriculum.

The basis of the framework is the understanding that teaching is a highly complex activity that draws on many kinds of knowledge. This knowledge is diverse

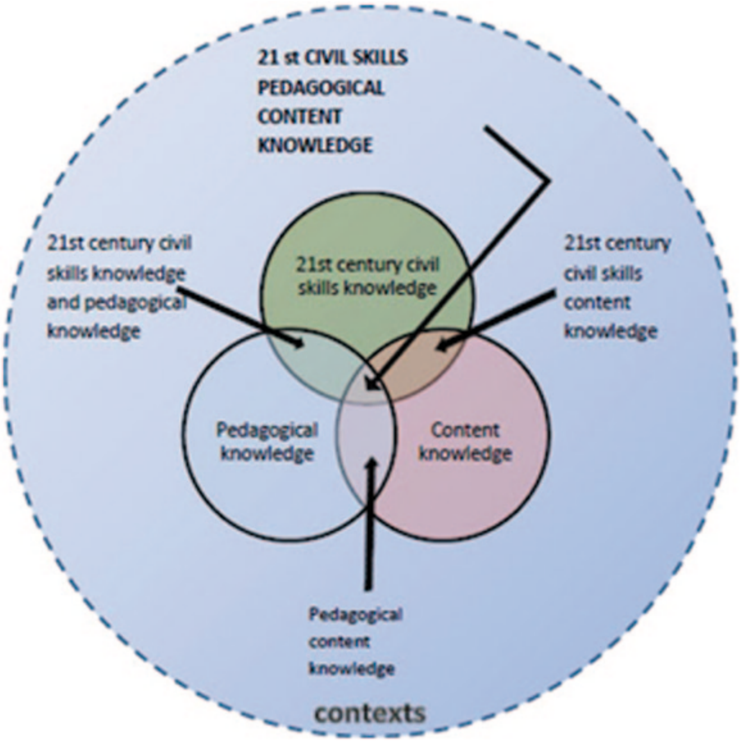

Fig. 6.1 The 21st century civic skills pedagogical content knowledge (21st Century CSPCK). (Following Mishra and Koehler 2006, 2009)

and includes both content and pedagogical knowledge. In recent years, the new types of knowledge and skills have been recognized by the Finnish National Board of Education. CSPCK (see Fig. 6.1) articulates the role of 21st civil skills in the process of teaching and learning in a really blended manner. The CSPCK model emphasizes competency, performance and capabilities; the key question is not what the knowledge is but rather how it will be used.

At the heart of CSPCK is the complex interplay of three primary forms of knowledge: Civil Skills Knowledge (CSK), Pedagogical Knowledge (PK), and Curriculum Content Knowledge (CCK). It is important to elaborate the twenty first Century Civil Skills Pedagogical Content Knowledge points of intersect (where the three primary forms of knowledge meet each other) and use those as a starting point when designing new learning situations. (Koehler and Mishra 2009; Mishra and Koehler 2006) As Meriläinen and Piispanen (2012) highlight, the planning process can be viewed from at least three different angles (see Fig. 6.1). This means that the emphasis should be on how content provides knowledge and skills for accomplishing twenty first century civil tasks. The twenty first century civil skills should be examined as visible parts of a learning context. Together all the three knowledge areas create a successful and pedagogically meaningful learning process for students (Meriläinen and Piispanen 2013).

6.3 From Traditional to Transformational Learning

When creating and supporting transformational learning, one has to imagine new ways to think about teaching and learning. According to Chaltain (2011), traditional schools assume that students bear the primary responsibility for learning while transformational approaches emphasize a learning team that includes and extends beyond teachers and students. In terms of student achievement, a traditional school emphasizes test results. In transformational school, the target is on building a foundation for life-long learning success in the workplace. Still, student achievement is a primary focus in all teaching and learning situations. Learning experiences should, according to Drake and Burns (2004), be relevant to student's interests. When students are engaged in learning, as the writers highlight (2004), students will manage well in multiple academic areas.

When moving from traditional pedagogy towards transformational education, the use of the twenty first Century CSPCK framework will expand the learning process to include the twenty first Century civil skills knowledge as one of the three key elements in all planning, learning, teaching and assessing. Transitioning from traditional pedagogy (subject- or theme-based learning) to transformational pedagogy (contextual pedagogical approach to learning) includes differences in planning and implementation as well as differences in learning tasks, assessment and learning environments (Meriläinen and Piispanen 2012).

Traditional, subject-centered or multidisciplinary integration, which is commonly known as theme-teaching, focuses primary on the disciplines. In the traditional pedagogical model, one can recognize different disciplines, but assignments, content and activities are based on the use of textbooks, and they emphasize learning concepts and facts rather than emphasizing the application of concepts and facts to solve problems. Learning outcomes are typically linked to declarative knowledge. The assessment happens mainly at the end of the learning unit through knowledge-based tests, with a little emphasis on formative assessment and feedback. Multidisciplinary planning in school contexts draws on knowledge from different disciplines but stays within their boundaries i.e. multidisciplinary approaches focus primarily on the disciplines. Teachers who use this approach organize standards from the disciplines around a theme. As Drake and Burns (2004) states, there are many different ways to create multidisciplinary curriculum, and they tend to differ in the level of intensity of the integration effort.

Highly structured and disciplined schooling systems do not necessarily prepare students well for the challenges of the future. Transformational pedagogy, as writers highlight, will significantly contribute to the preparation of a future workforce (Marandos 2013, Marandos and Randall 2012, Meriläinen and Piispanen 2012).

Transformational, trans disciplinary integration focuses on three different knowledge areas as presented in Fig. 6.1. In the trans disciplinary approach to integration, a teacher will organize curriculum around student questions and real-life phenomena and operation cultures (Drake and Burns 2004; Meriläinen and Piispanen 2012). Instead of one discipline, the examination is directed to the phenomenon at a trans disciplinary point of view. In the trans disciplinary approach

Fig. 6.2 Contextual pedagogical approach to learning. (Meriläinen and Piispanen 2012)

to integration, teachers organize curriculum around student questions and concerns. Students develop life skills as they apply interdisciplinary and disciplinary skills in a real-life context. Two routes lead to trans disciplinary integration: project-based learning and negotiating the curriculum in contextual pedagogical learning environments.

The contextual pedagogical approach (see Fig. 6.2) based on real-life phenomena is a way to examine the curriculum in the relation to the surrounding society. The curriculum and different content will be examined with regard to connections between the curriculum and surrounding society. As a result, the school culture will reflect the external world. (Meriläinen et al. 2013.) The curriculum will be as authentic as possible with real-life tasks, roles and environments. In a transformational model of pedagogy, students will naturally develop life skills. In authentic learning tasks (e.g., planning guided tours around the city), the emphasis is on the skills rather than on the content although both skills and content knowledge are targeted for learning and assessed. In the model of transformational learning, the content acts as a tool or mechanism to promote the development of twenty first century civil skills. The assessment for knowing and understanding in transformational pedagogy is performance-based. Instead of testing the memory and seeking one right answer, the assessment focuses on interdisciplinary concepts and skills and the culminating activity will reflect this. The assessment criteria are presented to students at the beginning of a project so that each student can and will do well on it. As Baker (1998) argues, this so called performance assessment can direct the attention of teachers and learners to the important forest and not the trivial trees.

Table 6.2 presents the typical features of traditional and transformational teaching and learning from the teachers and students points of view throughout the process.

6.3.1 At the Heart of the Knowledge Acquisition

In a contextual-pedagogical approach towards learning, special attention is paid to the growth of twenty first Century CSPCK knowledge (Meriläinen and Piispanen 2013. The skills, context and pedagogy have crucial significance in all learning situations. Whereas traditional pedagogy and multidisciplinary approaches to integration emphasize pedagogy and curriculum as tools for creating learning situations, transformational pedagogy connects the three knowledge areas together. The learning situations are at the heart of the expanded knowledge acquisition as shown in Fig. 6.2.

The child, the pedagogical expert (the teacher), content expertise from the actual contexts, society, and the curriculum are at the heart of the contextual-pedagogical approach to learning-model. The planning begins with individual student skills, knowledge, interests and enthusiasm, unlike traditional planning that begins with school constraints, timing, textbooks, classrooms, and so on. In this model, the teacher relates curriculum content with the surrounding world and connects the curriculum to real-life phenomena. The real-life phenomena studied at school will help students to understand and link learning with life outside school and help develop twenty first century civil skills in authentic learning situations. (Meriläinen and Piispanen 2013)

The teacher's role is to be a pedagogical expert who creates learning situations based on the twenty first Century CSPCK framework by identifying individual needs, designing authentic learning tasks, and supporting multiple civil skills needed in real life (Meriläinen et al. 2013).

In the contextual-pedagogical approach to learning, the essential change concerns the student role as knowledge constructor. The culture of working largely alone with individual learning tasks is transferred to a culture of collaboration with high levels of collegiality, team work, and dialogue. (Meriläinen et al. 2013). Instead of just accomplishing the learning tasks, students are directed to be active collaborative learners. This implies a huge change in teacher and student roles. The teacher's primary role will be to help students find and interpret information, foster enthusiasm, and promote collaboration (Meriläinen and Piispanen 2013, p. 14).

It is essential to activate the students to work together so that the given tasks will support twenty first century civil skills (Kostiainen and Rautiainen 2011, p. 190). As Meriläinen et al. (2013) highlight the learning tasks should be closely connected to student's real lives, interesting, challenging and enable student's natural creativity

Table 6.2 From planning to assessment in traditional and transformational pedagogical models

	Teachers role	Students role	Teachers role	Students role
Basis for planning	Core curriculum, text books, teacher handbooks	Not involved	Students interests, surrounding society, real life habits and skills	Strengths, students profiles
Tools for planning	Different subject contents learning materials (books, text books, learning games, etc. Teacher handbooks -schedule external structures -multidisciplinary approach	Not involved	21st Century CKPCK trans-diciplinary approach-real life experts	Strengths, students profiles
Learning situations in the beginning of the process during the process in the end of the process	Teacher driven, group instructions teacher has the knowledge –knows what is meant to learn and how teacher presents the learning case teacher centered The interaction in the classroom from teacher to student, from student the teacher testing the knowledge with self-made or ready make tests. Gives feedback with test numbers	Receiving information acting according to teacher driven instructions using material given by the teacher working with text books and materials made by someone else every-one working according the instructions approximately at the same time-talented students will have additional tasks weak students will do less or leave tasks unfinished Everyone has done well-nigh the same tasks in the end of the process	Teacher as a motivator presenting the project, mission, aims and assessment criteria Leader of the learning community feedback by discussing with learners supporting when needed aware of each child’s strengths and weaknesses, willing and able to support during the learning process Support towards the goals discussion of learning assessment as learning	Personalized learning plans students themselves set the goals Students working collaboratively as a team multiple ways to show learning-multiple use of ICT -learning by working with real life task in real life roles with real life experts Students build exhibitions, festivals, workshops etc. to show what they have done during the learning process
Assessment	Teacher knows the assessment criteria -Teacher provides feedback -The final assessment is based on activity, outcomes and test -Teacher emphasis the assessment of learning	Students don’t know the assessment criteria -students will get the information about learning by doing tests students are divided to weak and good learners according to success in different tests	The assessment criteria will be visible and presented to students in the beginning with the process -assessment as learning –towards life options The assessment is an integral part of the learning process	Students are aware of the assessment criteria from the beginning of the process students will get the information about learning discussing with the teacher and peer students. Students are aware that they learn differently and that every child can learn

and know-how to develop. It is important that students have a possibility to act in roles that are naturally associated with authentic learning tasks. That will motivate and help students to accomplish the tasks in the expected manner, similar to that in the authentic context (See also Lave and Wenger 1990; Brown et al. 1989).

In the contextual–pedagogical model of learning, the presence and use of twenty first century civil skills will lay a solid foundation for deeper understanding, learning, knowing and creativity (Hargreaves 2007; Kumpulainen et al. 2011; Sahlberg 2011; Zhao 2011). When planning a learning process and paying attention to the development of these skills with other two knowledge acquisition areas (CCK and PK) will make it possible to create learning environments and learning situations that will support the twenty first Century civil skills content knowledge to develop in a school context.

It is a central matter to pay attention to individual student needs in a contextual-pedagogical approach to learning. The transformational learning process enables diverse students to learn according to individual abilities, knowledge and experience. The paths toward learning goals will be as unique and diverse as the students involved. The paths will naturally be differentiated. When the curriculum approach is trans-disciplinary and centered on authentic learning, students have the possibility to pursue various paths to accomplish goals in a manner consistent with their interests and abilities. The flexible examination of phenomena and the multiple choices of individual learning paths will create a possibility to learn and understand phenomena from student's individual perspective in collaboration with others (Meriläinen and Piispanen 2013).

6.4 The Contextual-Pedagogical Learning Process

Where to begin? How to put emphasis on needed skills? What is the connection between disciplines and real life? What is an authentic learning environment? These are some of the questions that a teacher will have to pay attention to when moving from traditional pedagogy towards transformational pedagogy. The emphasis shifts from curriculum content to the skills that are needed in authentic learning environments and learning situations. The planning begins from the perspective of the individual student's skills, knowledge, interests and enthusiasm (see Table 6.2). Integrating twenty first Century civil skills into a study plan become natural when school-based learning tasks are associated with real-life tasks (see Table 6.3).

In this model, as Meriläinen and Piispanen (2012) states, the teacher reflects the curriculum contents with the surrounding world and connects the curriculum contents with real life phenomena. This will help students to understand and link the curriculum contents with the life outside of the school. The curriculum contents act as tools for developing twenty first century civil skills as explained in Fig. 6.1. The twenty first Century CSPCK-framework will focus on a variety of different knowledge areas to develop both skills and content understanding. The

Table 6.3 Contextual-pedagogical study plan in a nutshell (5th grade)

Phenomenon (authentic/outside the curriculum/learning environment)	Students role (authentic-rises from the phenomenon)	Task (authentic-supports twenty first Century civil skills to develop)
To plan a summer camp in a ranch	Ranch owner/camp director	To create an enthusiastic camp program, marketing plan, web & mobile pages and radio/television commercial

Table 6.4 Contextual-pedagogical learning task

PHENOMENON: To plan a summer camp on the Ranch				
TASK: To create an enthusiastic camp program, marketing plan, web and mobile pages and radio/television commercial				
CROSS CURRICULAR THEMES Media skills and communication, participatory citizenship and entrepreneurship and technology and the individual				
Mother tongue and literature: Interaction skills The pupil will learn skills of active listening and communication in various communication situations; they will feel encouraged to take part in discussions and will try to consider the recipients in their own communication The pupil will learn to work with text environments in which words, illustrations, and sounds interact Skills in producing text The pupil will learn to create a variety of texts, both orally and in writing Relationship with languageliterature, and other culture The pupil will gain a basic knowledge of the media and utilize communications media purposefully	Biology and Geography The pupil will learn to move about in the natural environment and observe and investigate nature outdoors The pupil will learn to draw and interpret maps, and use statistics, diagrams, pictures, and electronic messages as source of geographic information	Music The pupil will build his/her creative relationship with music and its expressive possibilities, by means of composing	Arts The pupil will learn to evaluate their own and other's visual expression and working approaches, such as visual, content, and technical solutions, and to employ the key concepts of art The pupil will work independently and as a community member in art projects	Mathematics The pupil will learn to understand that concepts form structures

pedagogical knowledge has to meet the twenty first century skills as well as the curriculum contents to be able to create learning situations, task and environments that will develop twenty first century civil skills pedagogical content knowledge in a school context.

Table 6.4 presents an example of a learning task, which will fit into the twenty firstcentury CSPCK-framework and illustrates the Contextual pedagogical approach to learning concretely. The task is planned for 5th grade students and the curriculum contents meet the 5th grade standards (Finnish National Core Curriculum for Basic Education 2004). (Meriläinen and Piispanen 2013, p. 167).

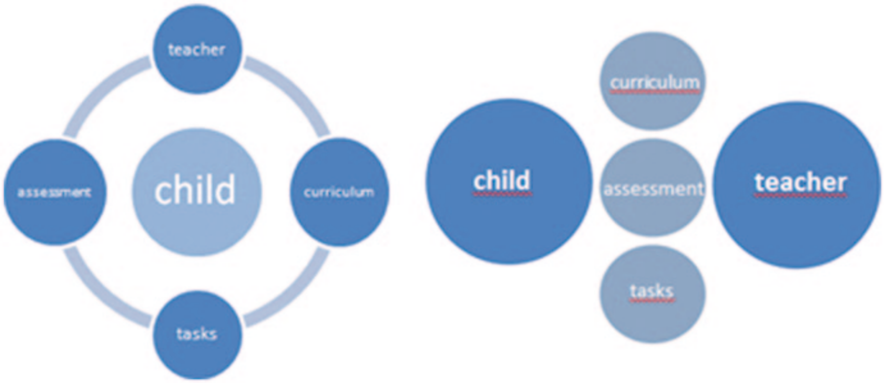

Fig. 6.3 Individual learners and assessment in traditional and transformational planning processes. (Piispanen and Meriläinen 2013)

6.4.1 Assessment

According to Piispanen and Meriläinen (2013, pp. 3054–3055), once desired learning outcomes are known, the next step is to develop the means to assess progress and evaluate outcomes. To be able to do that, the teacher needs to know what assessment options are available and suitable and consider how to construct or select an appropriate assessment, how to get these assessments to yield reliable and useful information, how to interpret the information and help students to interpret it, and how to use the information and help students to use it (Bookhart 2004). The teacher should follow this cycle through the learning process to get the collected information used. Otherwise, as Bookhart (2004) states, the student's time and the teacher's time are wasted. The difference between the traditional and transformational planning processes in the perspective of a child and assessment is shown in Fig. 6.3.

The planning process is built up from several variables which join together more or less tight and with a little or lots of interaction between them. When one thinks of teaching and learning in primary school, the variables in the planning processes consist of at least of six different variables: (a) a teacher, (b) a child, (c) a curriculum, (d) learning tasks, (e) learning environments, and (f) assessment and evaluation. Traditionally, the teacher begins the learning process by seeking information from books and the curriculum. The learning contents and theme areas will rise up from the curriculum or from the books and text books. At its worst, when talking of assessment, the ready-made summative evaluation tests can be found at the end of a chapter or at the end of the book and used as the evaluation criteria of the learning process. The interaction between the process and child is minimal. The child can be seen as a stable variable—the one who accomplish the given tasks without knowing where these tasks are guiding one, where they come and how to best accomplish them. At the end of a learning unit, as Beyer (1987) notes, the child takes an exam;

the test, which has been kept secret, is administered, and students quietly fill in the answers. The teacher watches carefully to make sure that no students refer to their notes or ask classmates for help. This common method of assessment is familiar to most students, teachers, parents, and administrators, but it fails to provide teachers or students with the information and feedback they need to develop knowledge and skills or promote deep understanding. In short, traditional emphasis has been placed on summative assessment and evaluation, whereas in a transformational approach, the emphasis is on on-going formative assessment and feedback as explained underneath.

In the contextual-pedagogical learning process, the child and learning are the core activators in planning and supporting progress, with the formative assessments considered part of the learning activities. In this model, the assessing criteria will be visible and well known at the beginning of the learning process. Assessing will act as a tool for guiding students through the learning path; the learning aims will be achieved through the learning tasks based on formative assessment and publicized criteria. As Meriläinen and Piispanen (2012) state, this is particularly important in order that students will understand and recognize what the learning expectations are and how will the assessment come true. According to Beyer (1987), as students' progress through a unit, the teacher continually provides opportunities for them to think about their learning and to ask questions; the teacher designs a performance task which requires students to show that they understand the concepts associated with the unit.

6.5 Conclusion

In the contextual-pedagogical approach to learning, planning begins by paying attention to student's individuality, which directs choices related to both learning context and pedagogy. Phenomena that relate to student's everyday life will be central to planning learning activities. These phenomena will be reflected in the curriculum and created to learning processes based on student interests. When comparing these two models of learning (traditional and transformational), there are several reversed issues throughout the process from planning to implement. One of the most significant differences lies on the assessment and the role of that in a learning process. In contextual pedagogical learning process assessing will act as a tool for guiding students through the learning path –the learning aims will come true through the learning tasks based on assessing criteria. As Meriläinen and Piispanen (2012) state, this is particularly important in order that students will understand and recognize what the learning expectations are and how the assessment will come true. The aim of the assessment is to support learning after the initial learning process. Each learning process is a journey that leads to further learning and the development, refinement and use of skills.

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Chapter 7
The Configuration Process of a Community of Practice in the Collective Text Editor

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7.1 Introduction

The term 'community' may bring to mind something that is increasingly less experienced in large urban centers—namely, the sense of community as a meeting, in person, of people effectively united by something in common. For Burbules (2004), it is a nostalgic memory of the community, as it relates to the "memory of a time when affiliation was based on proximity, on relative homogeneity and familiarity: the community of a small town, a neighborhood, a large family" (p. 209).

Nowadays the term community is most frequently used together with other nouns or adjectives (school community, virtual community, etc.) and reflects what is understood, in different spheres, as the best strategy for achieving results and cooperation (efficient, effective, etc.). In this sense, whether to increase the productivity of businesses or to enhance learning processes, or to pursue other goals, people seek to meet (or are reunited) in order to form communities.

One type of community that has emerged from these interests is a Community of Practice (CoP). CoPs generally unite people interested in specific learning goals and in the practical application of learning (Terra 2005).

When the objective is uniting people, the Internet and Web 2.0 provide strong support for a variety of interaction modalities and means. Communities of Practice take advantage of the opportunities of (a) connection anytime, anywhere, (b) collective construction of artifacts, and (c) free software.

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The idea of configuring the CoP discussed here arose in part from the needs of a group of postgraduate students from the Federal University of Rio Grande do Sul (UFRGS), to meet virtually, to give continuity to the discussions realized in person and to share and produce new texts and study topics. Thus, the focus of this paper is to relate the configuration process of this Community in the Collective Text Editor (CTE).

The Collective Text Editor aims to provide a space for collective elaboration of texts, synchronously or asynchronously, by users dispersed geographically. This tool was developed by NUTED (Nucleus of Digital Technology applied to Education) of the Federal University of Rio Grande do Sul. The first version of CTE was built in 2001. Since then, the editor has been used in different teaching-learning situations, considering a variety of work groups, among teachers and students from graduate, extension and post graduate courses in different areas of knowledge.

Throughout its use, NUTED has always prioritized the improvement of the tool following evaluations made by users. Several actions, in this sense (Behar et al. 2005, 2006, 2007) have been developed and implemented in order to enhance the editor and to contemplate the demands presented. The research group team is currently readapting the CTE´s visual interface and navigation, aiming to update and innovate.

So it is hoped that this study points out the reasons why the Collective Text Editor is suitable for this group of postgraduate students and presents this environment as a possible space for the establishment of an effective Community of Practice. As such, the first section of this article discusses the Communities of Practice. The second presents the CTE. The third section presents the reasons for the selection of CTE as best suited to the needs, values, knowledge and expertise of the members of the CoP. Lastly, concluding remarks are presented.

7.2 Community of Practice

According to Wenger (2006, p. 01), “Communities of Practice are groups of people who share an interest or a passion for something which they learn to better by interacting regularly”. Terra (2005) says that “CoPs consist of people who are connected, informally as well as contextually, by a common interest in learning, and principally in practical application” (p. 1).

Wenger (2006) points out that the Communities of Practice have these three major characteristics:

1. Domain: the theme or topic of interest to the community, to which the members of the CoP feel committed.
2. Community: formed through the relationships between members and allows individuals to learn from each other.
3. Practice: A CoP goes beyond areas of interest; a COP represents set of shared resources (experiences, stories, tools and mode of referring to current problems, among other things) that form the repertoire for the use of members in the resolution of problems.

According to Schlemmer (2012), when the project upon which the Community of Practice is working ends, the CoP also ends. Wenger (1998, as cited in Ribeiro et al. 2011) and Terra (2005) note that CoPs have cycles or stages of existence.

According to Wenger (1998, as cited in Ribeiro et al. 2011), these cycles are called creation, expansion, maturation, activity and dispersal. According to Terra (2005), CoP cycles include birth, growth, maturity, decline and death. However, although the CoP has "a well-defined life cycle, in relation to its stages, […] there are no limits on the temporal scope for the definition of each of the stages" (Ribeiro et al. 2011, p. 696).

In this sense, for a CoP to remain active during its period of maturation or maturity, Wenger et al. (2002) propose seven principles of management:

1. Planning for evolution: thinking that in the future the CoP may have new and different needs;
2. Maintaining the dialogue between the internal and external perspective: opening possibilities for other exchanges, encouraging them among members and among other people and communities;
3. Inviting different levels of participation: understanding that people are different, and therefore, interact in different ways and degrees;
4. Developing public and private spaces (one-on-one) for the community members;
5. Focusing on the value of the CoP: The communities survive because, as well as their members, they are valued. As the authors point out, the value is important because, in the majority of communities, adhesion and permanence are free;
6. Combining familiarity and stimulation: Familiarity with tools and activities is great for members to feel comfortable in the CoP, but it is also necessary to offer new things and to encourage participation;
7. Creating rhythm for the community: maintaining regular events and avoiding overloading.

In view of the principles mentioned by Wenger et al. (2002), one realizes that the life cycle of a CoP is strictly related to its members and the interactions between them. It is in this sense that Wenger et al. (2005) point out how it is necessary and fundamental to know the members as well as the activities they perform to choose the most appropriate tools for the CoP. After all, when the user does not learn the technologies with ease, he or she may feel discouraged to participate. Thus, the tools can play a role in optimizing the interactions and giving support to collective work or, conversely, may discourage the participation of members as well as harming the collective work.

For Wenger et al. (2005) a perfect technological configuration does not exist. The most appropriate configurations will always vary from community to community. Thus, one should take into account (a) the level of access to and command over the technologies that participants have, (b) the capacity to connect, (c) the browser used, (d) the availability of purchase or the preference for free software, and (e) the need for technical and other support.

Besides these aspects, the type of activity that the community realizes and which the technology mediates, must be analyzed. Examples include interaction activities, publishing, sharing, and so on. From this understanding, it is possible to choose the tools focused on the needs (and possibilities) of the members of the community.

The Web 2.0 tools have long been used by the CoP. As pointed out by Kirkwood (2006), Web 2.0 allows people with a particular interest in common to find other people with the same interest and form their communities.

It is noteworthy also that, besides providing tools for interaction, Web 2.0 encouraged the development of free software. This, in Brazilian terms, may be fundamental to the existence of CoPs focused on learning outside educational platforms such as Moodleor Sakai.

It should be noted also that the free tools of Web 2.0 have become very popular and are part of everyday life for many people. For CoPs focused on learning, using these tools provides students a sense of familiarity. By providing this feeling, students are free to make relationships, encouraging them to create, share, publish and cooperate—fundamental principles of pedagogical theories based on the transmission of knowledge, that go beyond traditional teaching.

Thus, tools like blogs and wikis, which allow both collective and individual creation and publication, can be highlighted; synchronous tools like MSN Messenger and Skype, along with audio and video streaming-, enable the exercise of creativity and move away from text-only activities. It is possible to find all these resources, as well as forum, polls and others, free on the Web. Using them or not in a CoP will depend on factors related to the command and characteristics of the participants.

Given the above, the next section presents the Collective Text Editor (CTE), an environment of collective construction of texts, coupled with synchronous and asynchronous tools, free and available on the Web.

7.3 The Collective Text Editor—CTE

In the last few years the number of collaborative writing tools has proliferated, especially with all the services and interactive features made possible by the Web 2.0. At the same time, educators have realized the potential of such tools in learning activities. Among other advantages, the use of collaborative writing tools may increase group awareness, making group members more informed about other member's writings and more conscious about being engaged in a cooperative team work.

From a teacher's perspective, the possibility of getting students to work collaboratively through the use of computational tools is both attractive, from a learning perspective, and convenient: each student's progress may be monitored through historical records without too much difficulty.

The appeal of collaborative writing in learning activities is particularly interesting as the act of producing a text in a collaborative way can motivate writers to work in a recurring process of critique and re-elaboration of their work in the persuit of better results. The Web-based tool called the Collective Text Editor (CTE), was designed and developed at the Center for Digital Technology and applied to education at the Federal University of Rio Grande do Sul (NUTED/UFRGS—http://www.

nuted.ufrgs.br/); it has been designed specifically to be used by teachers as a collaborative learning tool in distance learning courses. It is online, and therefore does not need installation in a server or local computer.

CTE's main features are:

- Administration control to allow only registered users to access each text;
- Simultaneous access to enable several user edit the same text at the same time;
- Text mining feature enabling graphs to be extracted from student's writings;
- Conventional text formatting functions.

CTE is a collaborative tool to support text editing. In this sense, it is necessary to define what the present article understands by such concept. The term 'collective' depends on the kind of interaction that takes place. In this case, this study deals with the inter-individual relations occurring among participants in an activity, in other words, the collective elaboration of a text supported by Piaget's premises (Piaget 1973).

The collective construction of a text implies a dynamic interaction among people involved. It is understood that an interaction occurs between subject and object. This is a dialectical movement and is part of a process of knowledge construction.

In a process of collective authorship, there are moments when subjects communicate different viewpoints. This is understood as a movement of displacement of perspectives, of opening to new meanings, new relations and connections between writing objects, between events and characters, building new and permanent authorship possibilities. In this social relation the subject is "we" and the object is the other subjects. Thus, "(…) social facts are exactly parallel to mental facts, with an only difference that "we" is always referred to as "I" and cooperation, by simple operations" (Piaget 1973, p. 35). To coordinate different perspectives about the same theme, the subject needs to decentralize and analyze different viewpoints through a view that is not his/her own. Aiming to support this kind of interaction, the CTE makes functionalities available that favor synchronous and asynchronous communication. The collective text editor offers conditions for a dynamic self-organization of the group so that the common goal is a coherent and meaningful whole. Therefore, collective construction implicates eminently in the actions of subjects. Such actions refer to physical and cognitive coordination that can change each subject in particular as well as one in relation to the other (Piaget 1995). This collective movement forms a contribution network and exhibits a relevant construction process in that it centralizes ideas and reveals propositions based on different life experiences.

Fully developed within the philosophy of free software, the CTE employs PHP language and uses the related database management system (DBMS) MySQL and the Apache Web server, both with open source code. It also has customer focused technologies, such as *JavaScript*, *Dynamic* HTML and *Cookies*, among others (Macedo et al. 2010).

Constant technological innovations make software and hardware easily obsolete and cause an endless search for new systems. It is no different with systems developed for Education that need constant recycling. Such is the trend that it has been observed that the editor needed to be updated through suggestions made by users of CTE since 2002.

The previous project of the editor presented navigation problems with links that were difficult to identify because they were scattered through the pages. The visual information lacked unity and coherence, with an excess of dispensable elements and without any hierarchical definition. User performance was harmed due to time lost trying to understand how the system worked. In 2009, the CTE was completely restructured, becoming reliant upon a new interface, new interaction features and a new logo.

The project of interaction for CTE's new version, therefore, to cut down on noise in communication and brought a cleaner and clearer interface, as shown in Fig. 7.1. The new design meant to create a non-polluted environment with blank areas, driving the look of the users to the content that matters.

In the revised CTE, there was an effort to reduce the number of clicks concentrating management previously done in about 11 pages to only one page of general content administration. Moreover, files are now organized following a folder structure, as shown in Fig. 7.1.

The page meant for text editing (see Fig. 7.2) is where all the actions of users are concentrated as it is on this page that the collective text productions take place. Fleming apud Memória (2005) highlights that the most important characteristic of a tool is that it works to help the user reach targeted objectives. It is necessary, therefore, that the interface be simplified and lead the user, clearly, to the functions that help him/her.

In this version, the text can be viewed and edited entirely and can still be written by different users simultaneously, which relies on different tools of interaction and communication, among these: (a) Message: allows participants to send messages via e-mail to each other, (b) Forum: has search and editing features, as well as different viewing options (c) Comments: tool located on text editing screen, allows users to leave messages for each other or make observations about the writing (d) Communicator: tool that displays *online* users, allowing them to converse in real-time and simultaneously to the editing.

Fig. 7.1 CTE home page

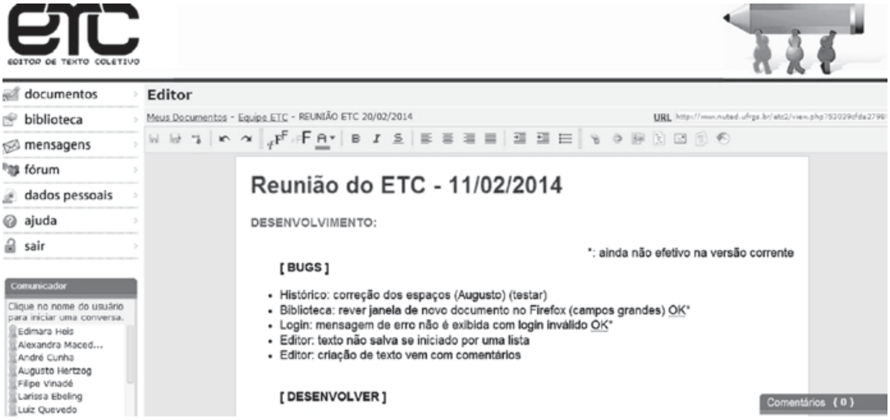

Fig. 7.2 CTE text editing page

Other highlights of the CTE are the new interface, which follows usability criteria that make it very intuitive, and the tools *Concepts Network* and *MineraFórum*, which are based on the technology of Text Mining. The first allows the extraction and relation of the principal terms discussed in the textual productions. Meanwhile, the MineraFórum extracts and relates the principal terms discussed in a forum, as well as attributing a relevance value for each message posted.

7.4 The Choice of the Collective Text Editor

Based on the concept of Wenger (2006) for a CoP, the reasons why the CTE was chosen are discussed next.

The community is composed of a teacher and five students of the PPGEDU/UFRGS (Postgraduate Program in Education at the Federal University of Rio Grande do Sul), which have studies and research related to Professional Education in common. The CoP is provisionally titled, the “Community of Practice of Professional Education and Technology” or CoP PET.

According to the characteristics of CoP proposed by Wenger (2006), it can be said that this group already has a domain of interest, Professional Education, but that it is still forming as a community. What they lack, entirely, is the characteristic of practice. In this sense, even if the community is not yet established in a virtual space, it is possible to consider that it already exists, since students meet in person. Based on Wenger (1998, as cited in Ribeiro et al. 2011) and Terra (2005), it appears, therefore, that the community is moving towards a phase of expansion/growth.

In order for this CoP to be constituted entirely and arrive in the phases of activity (Wenger 1998, as cited in Ribeiro et al. 2011) and maturity (Terra 2005), it was decided to observe the principles laid down by Wenger, Mcdermott and Snyder (2002) for the management of CoPs in addition to the suggestions of Wenger et al. (2005).

Table 7.1 Correspondence between the necessities, values, knowledge and command of the Community of Practice members in relation to the TIC and CTE

Necessities, values and knowledge of members of the CoP	Collective Text Editor—CTE
Effective use of ICT, Internet and social networks a) Don't use nor master many technological resources. The majority of members (5 people) use only e-mail. Half (3 people) have an account in a social network, although only one uses it frequently	Is available online (download not necessary); Has an interface familiar to other editors, which facilitates its use and makes learning how to use it fast. Has a friendly interface and is intuitive
Command of the English Language a) The six members stated that they had some knowledge of the English language but prefer to use tools and environments available in Portuguese	Available in Portuguese
Payment a) Don't wish to pay for the virtual space	It is a free software and therefore is free of cost
Activities most realized a) Discussions, publication and sharing	Possesses synchronized and unsynchronized tools which take account of these activities and needs

Thus, to choose the environment and tools, it was necessary to obtain some data with community members. Accordingly, a questionnaire was created to infer information about: the degree of command over the Information and Communication technologies and the Internet and the values and activities that the group intends to perform (Wenger et al. 2005; Wenger 2006). In relation to the values, it was sought to identify whether the CoP members would agree to pay for the technological resources and use environments and/or tools available only in English.

The questionnaire was answered by six people, the teacher and five advisees. The collected data was compared with the characteristics of the Collective Text Editor, a free online virtual environment developed within the University in order to verify that the CTE could be a space option for community practice. This comparison showed that the CTE will meet the needs, values, knowledge and mastery of the members of the CoP regarding Information and Communication Technologies (ICT), as shown in Table 7.1.

Beyond the domain of the community and also of the needs, values and knowledge of the members, the possible styles that the CoP covers must be taken into account in order to choose the environment or the tools that will be used. The styles relate to the group of activities that are performed by members of the community and that should result in a set of tools to support these activities.

Based on Wenger et al. (2009), it is understood that this community covers *meeting*, *open conversations* and *content* activities. The functions, tools that can give support to these activities and corresponding tools in the CTE are presented below (Table 7.2):

Table 7.2 Activities and tools—style "Meeting"

Activities which contribute to characterizing the style "Meeting"	Tools which would give support to these activities	Corresponding tool (s) available in the CTE
Booking	Shared calendar; E-mail; utility software for booking	Message
Synchronized interactions	Video-conference: web-conference and webcasting; teleconference and VoIP; chat rooms	Communicator
Unsynchronized interactions	Discussion forum; wikis; E-mail lists	Forum; message
Presence/attendance	Attendance tools; folders; photos of the participants	Communicator; personal details
Participation in and taking of decisions	Poll	Without corresponding tool

1. **Meeting**—Strong activity and feature of the community. However, part of the regular scheduled meetings will continue to be conducted in person (face to face). Thus, the CoP will be mixed, since there will be face to face and virtual encounters.

2. **Open Discussions**—The conversations between members remain permanently open, being extremely important to everyone's learning (Table 7.3).

3. **Content**—The greatest interest of the CoP with respect to the environment will be in the opportunity to share and give/have access to documents, tools, and diverse content. It is thought that the possibility for collective writing motivates the production of scientific articles in the group (Table 7.4).

Given the above, it was understood that the CTE could correspond to the needs, values and knowledge of the members and could also give support to the activities of the community. It shows itself, therefore, as an appropriate space for the CoP to form completely and reach the phases of activity (Wenger 1998, as cited in Ribeiro et al. 2011) and maturity (Terra 2005).

7.5 Final Thoughts

This article describes the configuration process of a CoP in the CTE. To this end, the first section sought to present what the Communities of Practice are and how they are configured. Next, the Editor was presented. In sequence, the needs and opportunities of the members of the CoP regarding technological resources as well as the

Table 7.3 Activities and tools—style "Open Conversations"

Activities which contribute to characterising the style "Open Conversations"	Tools which would give support to these activities	Corresponding tool (s) available in the CTE
Conversations about a topic at a time	Email; email lists; chat; functionality of blog comments; etc.	Message; communicator
Conversations about multiple topics	Forums on the web; wikis; discussion trails in blogs; categories; aggregation services; microblogging	Forum—collective text editing
Sub-groups/privacy	Access control report mechanisms for the wider group	Access control for the texts (definition of the participants) and message for the participants of the folder
Highlighting key learning points → utilization of features which highlight the most recent/active collective discussions and constructions	FAQs; wikis for summaries; tags; categories; evaluation mechanisms of the posts; tools which highlight the active discussions	Forum; editing of collective text; wall with new posts (Forum), new contributions in the collective texts and new messages
Filing	Web repositories for email lists; automatic filing for the forum; permanent links in blogs; tag clouds	Automatic filing of the forums; history of messages sent and received; history of the versions of the collective texts

Table 7.4 Activities and tools—style "Content"

Activities which contribute to characterising the style "Content"	Tools that would give support to these activities	Corresponding tool (s) available in the CTE
Sharing of document files	Independent document repositories; discussion annexes	Library
Comments, notes and content discussions	Discussion forums; wikis for notes; blogs with comment features; web page noting tools	Forum, collective text editing and comments
Publication of content of one's production	File sharing; blogs; Web pages; Wikis	Collective text editing, text url, and library (also as a portfolio)
Distributed editorial capacities	Tagging; evaluation; comments	Comments
Filing	News with time control; automatic filing	Automatic filing of the forums; history of messages sent and received; history of the versions of the collective texts

activities to be performed and the tools that can give support to these activities were dealt with, indicating the corresponding tools and activities in the CTE.

The CoP in question is formed by a group of postgraduate students. These students already meet in person in order to discuss issues relating to Professional Education. Based on Wenger (2006), it is understood, therefore, that this group, in addition to already possessing knowledge, is now also forming itself into a community.

The CTE is a virtual environment that is freely available on the web. The Editor was initially developed with the aim of promoting collective writing. However, also relying on interaction and communication tools, both synchronous and asynchronous, the editor can serve as a meeting and work space of a CoP.

Through the new CTE interface design, we look for greater efficacy in the system so as to live up to expectations and, still, we intend it to be more efficient as far as helping the users to perform their tasks. Moreover, the changes presented in this article also aim to adequate it to current Web 2.0. Interface and navigation logic in Web 2.0 tend to be simpler due to international patterns and protocols. Thus, code-free tools can be easily incorporated one to another after being tested by many users. This way, we hope the Editor can become more user-friendly and accessible to a larger number of Communities of Practice and that it can help them in their productivity.

The data analysis collected in questionnaires, which were answered by community members, point to the Collective Text Editor (CTE) as an appropriate environment for the needs of the group. Likewise, the Editor can respond to the needs and difficulties of the members regarding foreign languages and command of digital resources. It is further added that the CTE corresponds to the styles that the CoP covers, that is, it relies on tools that can give support to the activities groups *Meetings*, *Open Conversations* and *Content*.

For these reasons, the CoP was implanted in the CTE and is already active. The interactions are occurring frequently, primarily through the Forum and Message tools. In light of this, data is being collected. The analysis of this data can then validate the Editor as a space for the formation of Communities of Practice.

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Chapter 8
Using an Ontological and Rule-Based Approach for Contextual Semantic Annotations in Online Communities

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8.1 Introduction

Today collaboration and knowledge exchange and sharing are considered as one of the most important factors of success for individuals and organizations. Recently, there has been an increased recognition of the importance of Communities of Practice (CoPs) in several domains, including education, engineering, management, health, and so on. CoPs have a huge impact on learning as well as on knowledge creation and sharing. In such environments, individuals, experts and novices, learn together to develop and enhance their professional practices and skills.

We are interested in CoPs of e-learning (CoPEs), considered as a virtual framework for exchanging and sharing techno-pedagogic knowledge and know-how between actors of e-learning (Chikh et al. 2007). Through their participation, COPEs members create a shared repository, including both tacit and explicit knowledge assets. They need to reuse and take advantage from the repository in order to carry out their activities more effectively. Berkani and Chikh (2010) addressed the knowledge reuse issue in terms of organization of this process with regard to facilitating

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knowledge access and reuse. Pertinent reuse would facilitate learning of members, increase their productivity, and improve the quality of their artifacts.

The state of the art shows that most proposals for CoPEs are ontological-based approaches. These approaches are useful to model explicit knowledge and are widely adopted in indexing resources (Benayach 2005; Leblanc and Abel 2008; Tifous et al. 2007). However, they are limited in modeling tacit knowledge, which requires externalization mechanisms.

According to Azouaou (2006), semantic annotation approaches are more effective for modeling tacit and explicit knowledge. For instance, the document's annotation allows the creation of a tacit knowledge layer for sharing purposes. In this case, the annotation is considered as a way to externalize tacit knowledge. Otherwise, the annotation is related to the content of the document, and allows the classification and organization of documents.

The effectiveness of semantic approaches in modeling knowledge is appreciated. The reuse of that knowledge remains problematic. The preservation of the knowledge context can overcome this problem. This context refers to the parameters describing the situation in which the knowledge is modeled or reused. Few studies have explored this possibility. Azouaou (2006) and Ouadah et al. (2009) proposed knowledge capitalization approaches based on the semantic annotations and the knowledge context. These approaches are specific and are dedicated to teachers, giving them the possibility to capitalize their personal knowledge, without taking into account the knowledge sharing considerations. In addition, the context dimension has not been fully exploited and important facets like context reasoning haven't yet been considered.

We present in this chapter a knowledge capitalization approach, based on semantic annotations and taking into account the context dimension. Our main objective is to model the CoPEs members' tacit and explicit knowledge resources, in one side, and in the other side to improve the knowledge reusability using the context reasoning mechanisms such as ontological and rule based reasoning.

8.2 Background and Related Work

8.2.1 Knowledge Capitalization

Knowledge capitalization is defined as a process that supports reuse in relevant ways (e.g., storing and modeling domain knowledge) to support the performance tasks (Simon 1996). Knowledge capitalization enhances knowledge value by affording new possibilities based on reuse (Barthès 1997).

The model proposed by Grundstein (1995) describes four facets of knowledge capitalization: (a) location, (b) preservation, (c) exploitation, and (d) actualization. The SECI model proposed by Nonaka and Takeuchi (1997) focuses on knowledge creation, transformation and transmittal. Knowledge capitalization takes place through all stages of the SECI model (i.e., socialization, externalization, combination and internalization). There exist a large number of methodologies and techniques that can improve the knowledge creation, including: CommonKADS (Schreiber et al. 1999), REX (Malvache 1994; Eichenbaum-Violine and Tamisier 1997), MKSM (Ermine 1996), CYGMA (Ermine 1996), and more. Annotation is considered one of the most effective techniques for knowledge capitalization. According to Azouaou (2006), annotation is situated at the externalization stage; it can convert tacit knowledge into explicit, which can be transferred to other persons. Indeed when an annotator annotates a document, he or she externalizes personal knowledge and making them accessible to others. However, annotation management is situated at the combination stage, either when a person classifies his/her own annotations, or in the case of annotations of a group that are institutionalized and formalized at the group level. The reuse and exploitation of annotations allows creation of new tacit knowledge, which concerns the internalization mode, as well as sharing annotations via discussions may contribute to the socialization stage.

8.2.2 Related Work

In the field of e–Learning, the MEMORAe Project (Organisational Memory Applied to the e–Learning; (Benayache 2005) aims to capitalize knowledge related to training as well as facilitate the retrieval of relevant information and documents for learners and teachers. The proposed approach is based on ontologies, which are used to define a common vocabulary. Topic Maps, the standard of knowledge representation, is also used for navigation and access to educational resources.

The MEMORAe project (Leblanc 2007) focuses on capitalizing knowledge in a community of learners through the construction of an organizational memory. This memory is based on an ontological approach supported by Web 2.0 technologies to elicit tacit knowledge and facilitate exchanges among community members.

Azouaou (2006) proposes an external personal memory for the teacher, which aims to capitalize personal knowledge. A semantic annotation approach is adopted for the construction of this memory; annotation allows the externalization and explicitation of personal knowledge. Within the same framework, Ouadah et al. (2009) propose a context-aware annotation based-memory dedicated to teachers.

Within the PALETTE project, several knowledge management services are proposed to support CoPs. An ontology O’CoP (Tifous et al. 2007) has been proposed to annotate resources of the CoP in order to facilitate knowledge transfer and sharing. SweetWiki (Makni et al. 2008; El Ghali et al. 2008) is a semantic wiki proposed for the purpose of capitalization. The wiki is used to build knowledge in the CoP and constitutes a suitable environment for knowledge creation, transfer and sharing.

The topic of knowledge capitalization has become prominent within CoPEs. Quénu-Joiron and Condamines (2009) developed a Web community platform for knowledge capitalization and skill transfer between expert and novice teachers. The proposed approach for knowledge capitalization is based on case-based reasoning

(CBR). Berkani et al. (2011) proposed an ontology-based framework to capitalize knowledge in a CoPE. The proposed framework is used to annotate resources in order to facilitate retrieval and reuse. A semantic annotation is adopted to capture members' experience and feedback.

The following points have been brought out by this literature review:

- Most examined proposals are semantic approaches, based on ontologies and annotations, except for the approach proposed (Quénu-Joiron and Condamines 2009) that is based on case based reasoning.
- Ontological approaches are effective for the representation of explicit knowledge, and they are often adopted for indexing resources. However, these approaches are limited in modeling tacit knowledge, which require mechanisms to externalize and make explicit this knowledge.
- Semantic annotation approaches are more effective for modeling both tacit and explicit knowledge. On the one hand, the annotation provides a description of the resource. Therefore, it is used to represent the explicit knowledge. On the other hand, the annotation is a way to externalize tacit knowledge. It reflects the annotator's points of view, experiences and know-how about the annotated resource. Thus it serves as a means to model the tacit knowledge.
- The effectiveness of semantic approaches in modeling knowledge is recognized, but the reuse of that knowledge remains problematic. The preservation of knowledge context can be very useful for reuse. The context refers to parameters describing the situation in which the knowledge is modeled or reused. However, few studies have introduced this notion of context. Azouaou (2006) and Ouadah et al. (2009) propose knowledge capitalization approaches based on semantic annotations and context. However, these approaches are specific and are dedicated to the teacher. Their aim is to build his personal knowledge and they don't take into account the aspects of knowledge sharing. In addition, the notion of context has not been rigorously exploited. Indeed, important issues such as context reasoning and inference are not considered.

8.3 A New Approach

8.3.1 Knowledge Capitalization Process

The knowledge capitalization process we propose is based on the knowledge capitalization model proposed by Grundstein (1995). The process is organized as a five-step cycle, where each step aims to address a range of co-existing issues in the three facets of Grundstein's model: preservation, exploitation and update.

1. **Acquisition and Modeling:** annotation of the resources after their storage in the repository of CoPE. The resource is annotated based on a contextual annotation model. The latter allows describing the resource, externalizing tacit knowledge and representing the context of members' activity during the annotation process.

2. **Storage:** knowledge that represents resources and annotations are stored in a knowledge base, which includes a repository of resources and ontological knowledge bases of annotation and context.
3. **Share and Reuse:** the ontological annotation model provides advanced reuse of knowledge. Reasoning capabilities on context ontology permits to adapt research, navigation and recommendation of annotated resources in accordance with members' activity context.
4. **Evaluation:** ensures the relevance and the quality of knowledge. Members may assess reused knowledge by means of annotations. These later allow the evaluation and enrichment of the knowledge base.
5. **Update:** Updating the knowledge base in order to ensure that the content still relevant for CoPE members. Resources and annotations can be modified or deleted when it becomes obsolete. The modification of an annotation is considered as the creation of a new annotation, which is translated to the acquisition step.

8.3.2 Contextual Annotation Model

We propose a contextual annotation model to deal with the knowledge capitalization process. The model represents the important aspects of annotation, which includes the description of the annotated resource, the representation of various elements of annotation and their links to the controlled vocabularies, as well as the description of members' context during the process of creation, evaluation or reuse of annotations. The model is implemented using ontology. It consists of four dimensions: (a) resource, (b) annotation, (c) controlled vocabulary, and (d) context.

8.3.2.1 Resource

This dimension represents the resource or the part of the annotated resource. It includes the following attributes (see Fig. 8.1):

- URL: is the Unique Resource Identifier.
- Title: designation distinguishing the resource.
- Authors: creator(s) of the resource.
- Description: represents a summary about the resource content.
- Type: describes the type of resource (e.g., course, exercise, presentation etc.).

8.3.2.2 Annotation

This dimension represents the externalized knowledge which reflects personal knowledge of the annotator, and also those of recipients of annotation. Thus, those who reuse the annotation may express their judgments and feedback about the annotation via another annotation. This dimension is formalized based on the annotation

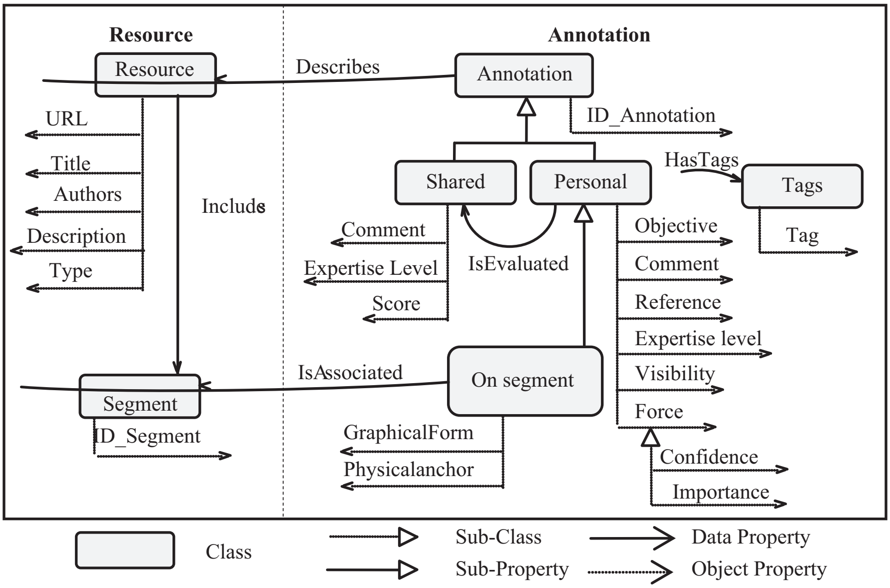

Fig. 8.1 Conceptual model of resource and annotation

models in Azouaou (2006) and Mille (2005). The conceptual model of annotation (see Fig. 8.1) distinguishes two categories of annotation: personal and shared.

1. **Personal annotation:** Is associated to the author of the annotation. In the case of annotation on the whole resource, the annotation has the following attributes:

   – Tags: this is one or more keywords associated to the resource. It can better organize the annotated resources and provides also a simple and effective browsing technique.
   – Objective: represents the reason why the annotation is created.It serves to reuse the annotation, and it is associated with a controlled vocabulary.
   – Comment: contains free text, allowing the annotator to freely express his points of views, opinions and expertise about the annotated resource.
   – Reference: represents a link to another resource, this element allows the annotator to justify his opinion, argue or enrich his annotations. It may be a reference book, a citation, URL… etc.
   – Expertise level: this attribute is important; people tend to trust an expert over a novice.
   – Visibility: refers to access rights to the annotation, we distinguish three types private, public and group.
   – Force: represents the value that represents the annotation for the annotator including importance and confidence. Based on this attribute recipients of the annotation can judge the relevance of the annotation.
     In the case of annotation on a segment of the resource, the annotation includes also the following attributes:

- Graphical form: it represents the graphical aspect of annotation (highlighting, underlining, etc.). That is used to change the appearance of information to make it more visible (Mille 2005).
- Physical anchor describing the annotated segment in the resource.

2. **Shared annotation:** this dimension of annotation doesn't exist in the previous models of annotation. It allows members to evaluate and enhance the annotation. It includes the following attributes:
   - Comment: a free text provided by the recipient, which allows him to express his points of view, interpretations, judgments about the annotation.
   - Expertise level: of the member who evaluates the annotation.
   - Score: appreciation of the value (i.e. a relevance measure) given to the annotation.

8.3.2.3 Context

By context we mean a set of data characterizing the situation in which the member annotates, evaluates or reuses (view or edit) an annotation. This dimension is inspired from Azouaou (2006) and Ouadah et al. (2009). The conceptual model of context represented in Fig. 8.2 includes two levels of context.

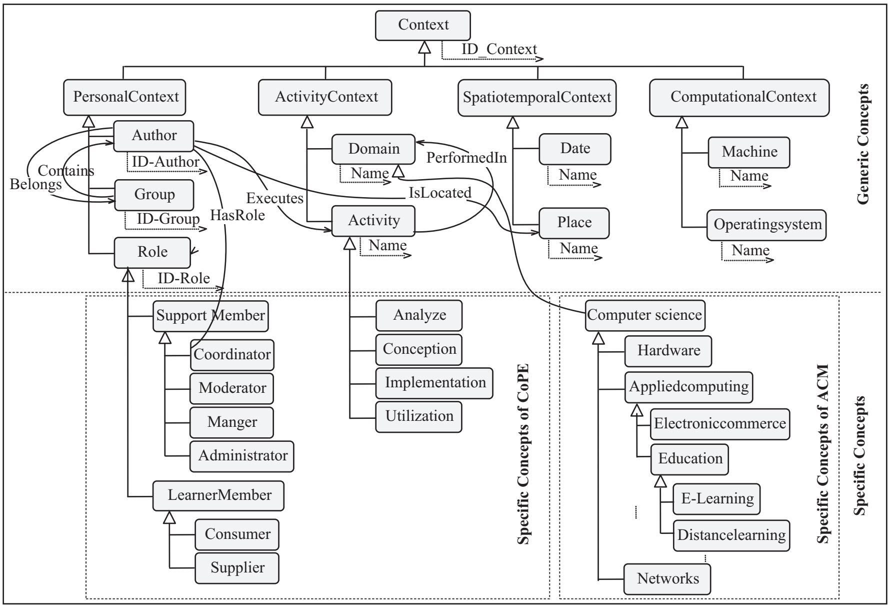

Fig. 8.2 Conceptual model of context

The first level represents the generic concepts of context describing the context of annotation in general and it can be applied to numerous fields. It is composed of four components:

1. **Personal Context:** includes the “Author” which represents the member of the CoPE, the member’s “Role” in the CoPE and the “Group” to which the member belongs to.
2. **Activity Context:** includes the “Domain” which represents the knowledge domain (e.g. mathematics, physics, computer science etc.) and member’s “Activity” in the CoPE.
3. **Spatiotemporal Context:** describes the following information: the “Date” and “Place” in which the member creates, evaluates or reuses the annotation.
4. **Computing Context:** includes the “Operating system” installed on the host (Windows, Linux, etc.) and the “Machine” on which turns the annotation tool.

The second level represents ontologies describing specific concepts of context. The ontology of CoPE (Berkani and Chikh 2009) describes the concepts related to CoPE, such as: member, role, activity. ACM Computer Classification System (ACM CCS) (ACM 2012) is used to describe computer science domain. But, other ontologies of location and time for instance can be also considered.

8.3.2.4 Controlled Vocabulary

This dimension represents the ontologies associated with the different elements of annotation like tags and attributes (e.g., graphical form, objective of annotation, etc.). We opt for the ontology proposed in Mille (2005), which presents a rather comprehensive list of annotation graphical forms. As far as vocabulary associated to the objective of annotation, we reuse the ontologies proposed in Azouaou (2006), describing teachers’ annotation objectives. Thereafter, other controlled vocabularies can be developed.

8.3.3 Context Reasoning

Formal approaches for context modelling offer many advantages. The foremost advantage is the inference capabilities. Context Reasoning aims to check consistency of the model as well as to infer new information about context and to derive high level of context. Indeed, the contextual information provided by the environment (system, user, sensors, etc.) leads to elementary data about context, whereas some contextual information is useful only if it is combined with other elementary or composite contexts. The reasoning tasks in this work are grouped into two categories, ontological and rule based reasoning.

8.3.3.1 Ontological Reasoning

Context ontology is represented using OWL-DL language. The standard reasoning rules supported by this language are, in particular, subClasseOf, subPropertyOf, TransitiveProperty, disjointWith, inverseOf, etc.

Figure 8.3 shows a part of ontological reasoning rules represented in first order logic, this with some examples illustrating the use of these rules. According to the context ontology, we can define the concept “Activity” as subclass of the concept “Context” using “subClassOf” rule. Furthermore, we can use ontological reasoning via the rule “disjointWith” to infer a contradiction when the instance “Scenario-Conception” is defined as instance of both classes at the same time. Also, a new context that “Group1” “Contains” “Author1” can be implicitly deduced based on “inverseOf” rule.

8.3.3.2 Rule-Based Reasoning

Some contextual information cannot be easily inferred using ontological reasoning. Accordingly, we propose to use a flexible reasoning mechanism based on predefined rules. These latter are described with Generic Rule Language specified by Jena API and based on first order logic, aiming to deal with the third step in the knowledge capitalization process. It allows deducing additional information about the current context of members and consequently adapting the reuse of annotated resources.

Ontological reasoning rules

```
subClassOf:(?A rdfs:subClassOf ?B),(?B rdfs:subClassOf ?C) -> (?A rdfs:subClassOf ?C)
disjointWith:(?A owl:disjointWith ?B),(?X rdf:type ?A),(?Y rdf:type ?B)->
(?X owl:differentFrom ?Y)
inverseOf:(?Powl:inverseOf ?Q), (?X ?P ?Y) -> (?Y ?Q ?X)
```

Explicit context

```
<owl:Classrdf:ID="ActivityContext">
<rdfs:subClassOf>
<owl:Classrdf:ID="Context"/>
</rdfs:subClassOf>
</owl:Class>
<owl:Classrdf:ID="Activity">
<rdfs:subClassOf>
<owl:Classrdf:ID="ActivityContext"/>
</rdfs:subClassOf>
</owl:Class>
<owl:Classrdf:ID="Analyze">
<owl:disjointWith>
<owl:Classrdf:ID="Conception"/>
</owl:disjointWith>
</owl:Class>
<owl:ObjectPropertyrdf:ID="Belongs">
<owl:inverseOf>
<owl:ObjectPropertyrdf:ID="Contains"/>
</owl:inverseOf>
<rdfs:rangerdf:resource="#Group"/>
<rdfs:domainrdf:resource="#Author"/>
</owl:ObjectProperty>
<Author rdf:ID="Author1">
<Belongs rdf:resource="#Group1"/>
</Author>
```

Implicit context

```
<owl:Classrdf:ID="Activity">
<rdfs:subClassOf>
<owl:Classrdf:ID="Context"/>
</rdfs:subClassOf>
</owl:Class>
<Conception rdf:ID="ScenarioConception">
<Analyze rdf:ID="ScenarioConception">
--- Error
<Group rdf:ID="Group1">
<Contains rdf:resource="#Author1"/>
</Group>
```

Fig. 8.3 Ontological reasoning

Table 8.1 Context tuples

ID_Context	ID_Author	ID_Group	Role_Name	Activity_Name	Domain_Name
C1	Author1	Group1	Manager	Conception	E-learning
C2	Author2	Group2	Coordinator	Conception	E-learning
C3	Author3	Group1	Moderator	Conception	Distance Learning

```
[R1: (?c1 prefix:ID_Context ?id_c1)(?c2 prefix:ID_Context ?id_c2)equal(?id_c1,?id_c2) -> (?c1
prefix:Sameidc ?c2)]
[R2: (?c rdf:typeprefix:Context)(?a rdf:typeprefix:Author)(?c prefix:Sameidc ?a)-> (?a prefix:InC
?c)]
[R2: (?a1 rdf:typeprefix:Author)(?a2 rdf:typeprefix:Author)(?a1 prefix:ID_Author ?ida1)(?a2
prefix:ID_Author ?ida2) equal(?ida1,?ida2)-> (?a1 prefix:SamePerson ?a2)]
[R3: (?g1 rdf:typeprefix:Group)(?g2 rdf:typeprefix:Group)(?g1 prefix:ID_Group ?idg1)(?g2
prefix:ID_Group ?idg2)equal(?idg1,?idg2) -> (?g1 prefix:SameGroup ?g2)]
[R4: (?ac1 rdf:typeprefix:Activity)(?ac2 rdf:typeprefix:Activity)(?ac1prefix:activity ?idac1)(?ac2
prefix:activity ?idac2)equal(?idac1,?idac2)-> (?ac1 prefix:SameActivity ?ac2)]
[R5:(?c1 rdf:typeprefix:Context)(?c2 rdf:typeprefix:Context)noValue(?c1 prefix:Sameidc ?c2)(?a1
rdf:typeprefix:Author)(?a2 rdf:typeprefix:Author)(?a1 prefix:InC ?c1)(?a2 prefix:InC ?c2)noValue(?a1
prefix:SamePerson ?a2)(?g1 rdf:typeprefix:Group)(?g2 rdf:typeprefix:Group)(?a1 prefix:Belongs
?g1)(?a2 prefix:Belongs ?g2)(?g1 prefix:SameGroup ?g2)(?ac1 rdf:typeprefix:Activity)(?ac2
rdf:typeprefix:Activity)(?a1 prefix:Executes ?ac1)(?a2 prefix:Executes ?ac2)(?ac1 prefix:SameActivity
?ac2) -> (?c1 prefix:SameGAc ?c2)]
```

Fig. 8.4 Reasoning rules

The tuples in Table 8.1 correspond to individuals of Context. The first tuple represents the current context of annotation "C1". Context reasoning basis on the other context tuples and the rule "R5" (Fig. 8.4) infers a new context that the context "C1" has the same group and the same activity as the context "C3". More precisely, the rule R5 defines the relationship "SameGAc" between two instances of "context" concept, when their authors belong to the same group and execute the same activity. This rule is based on the relationships defined in the other inference rules ("Sameidc", "InC", "SamePerson", "SameGroup" and "SameActivity").

8.3.4 Context-Aware Architecture for CoPEAnnot

Here, we propose a context-aware architecture for our annotation system called CoPEAnnot. Many researchers have proposed several context-aware architectures and most of them are proposed in pervasive and mobile computing domain. The authors in Azouaou and Desmoulins (2006) and Ouadah et al. (2009) proposed architectures for context-aware annotation systems. As most available architectures, they don't permit context reasoning and inference. The latter becomes a vital requirement for context-aware systems in order to facilitate the adaptation task. Our architecture (see Fig. 8.5) differs from the previous ones at the reasoning support that provides. It consists of two main components: context management and annotation management. This separation is inspired from (Chaari and Laforest 2005). The body of application must be designed in isolation from contextual data.

1. **Context management:** is responsible for context acquisition, reasoning and adaptation:

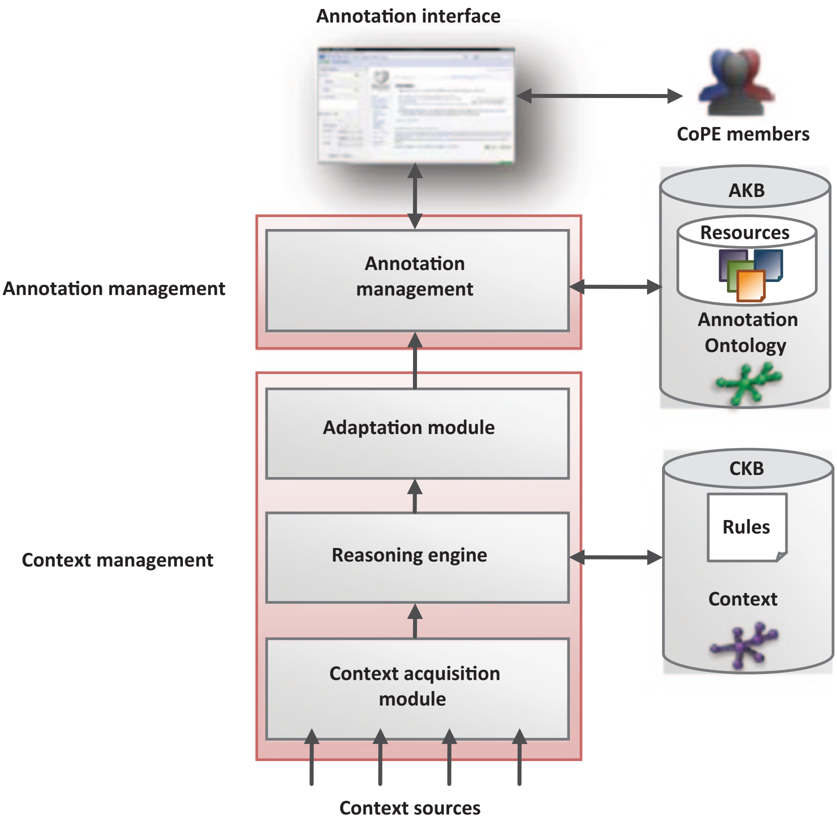

Fig. 8.5 CoPEAnnot architecture

- **Context acquisition:** this module is responsible for collecting contextual information from different sources (operating system, learning environment, user, user model, physical sensors, etc.), for interpreting contextual information (transform them into more useful and meaningful contextual information) and for their storage in accordance to the ontological model of context.
- **Reasoning engine:** is the brain of our architecture. It is in charge of reasoning about contextual information acquired by the acquisition module. Based on ontological reasoning and rule-based reasoning, the reasoning engine infers information about annotations' context which is semantically closest to the current context of annotation.
- **Adaptation module:** This module adapts the functionalities of context-aware system according to contextual information provided by the reasoning engine.

2. **Annotation management:** is in charge to manage annotations, it includes the following major steps:
   - **Annotation management module:** is in charge to insert, store and update, research, navigation and recommendation of annotations. These last three features are adapted according to the current context of the annotation.

– **Annotation interface:** represents the graphical interface that allows the exchange and the interaction between the CoPE members and the annotation tool.

The context knowledge base (CKB) contains the OWL ontology defining the context. It contains also a set of inference rules which is processed by the reasoning engine. The annotation knowledge base (AKB) includes the repository of resources and the OWL ontology defining the annotation model and their controlled vocabularies.

8.4 Implementation

A prototype system CoPEAnnothas been developed based on the above architecture and annotation model. CoPEAnnot is a context-aware annotation system aiming to capitalize knowledge in communities of practice of e-learning. Here we give a brief description about the implementation of CoPEAnnot and their functionalities.

The key element in our annotation system is the knowledge base, which consists of several ontological models. These latter are developed using Protégé ontology editor (see Fig. 8.6).

The system is implemented in client-server architecture. The client is the user who has as browser Mozilla Firefox, in which the annotation tool constitutes a browser extension (plug-in). Graphical interface was built using XUL, DOM, JavaScrip and CSS. AJAX technology is used to insure the communication between the client and the server which is sort of http://www.request/response. On the server side, we used Tomcat as a Servlet container as well as a web server. Servlet are java programs that used to handle http://requests/responses. Jena frame work provides a programming environment for RDF, RDFS, OWL and SPARQL and it also includes several internal reasoners, where the rules engine supports generic inference based rules.

The annotation extension (shown in Fig. 8.7) constitutes of tow toolbars, the first one provides the following main features: CoPEAnnot (Home), Resource, Annotation, Navigate, search and help. The second one provides a graphical form palette, including: highlighting, underlining, strikethrough, insert text or some graphical objects.

Home sidebar of CoPEAnnot shows the tag cloud and the recommended annotations adapted to the current context of the member (see Fig. 8.8).

Members can annotate any resource already exists in the knowledge base. The tool enables annotation of different types of resources (html, pdf, images, etc.); annotation on segment is also considered for only html resources (see Fig. 8.9). Thereafter, members can also edit, share, and evaluate annotation (see Fig. 8.10).

In addition to the standard features of navigation, the tag cloud facilitates access to knowledge; it enables faster discovering of knowledge (see Fig. 8.11). The tool provides also contextual semantic search based on controlled vocabularies (see Fig. 8.12).

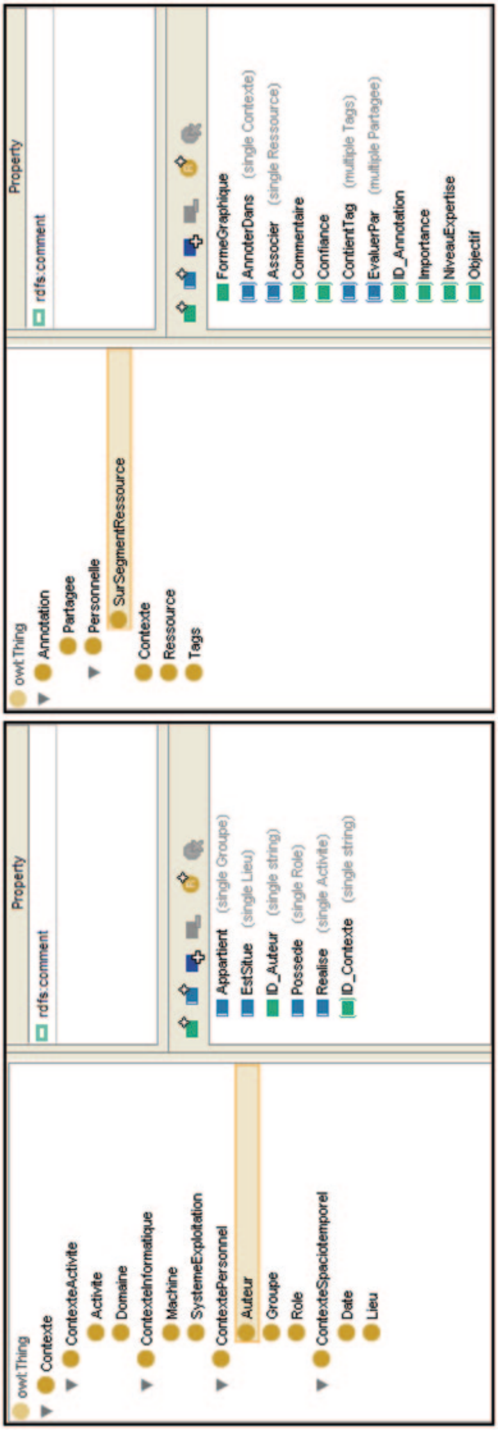

Fig. 8.6 Annotation and context ontologies

Fig. 8.7 CoPEAnnot toolbar

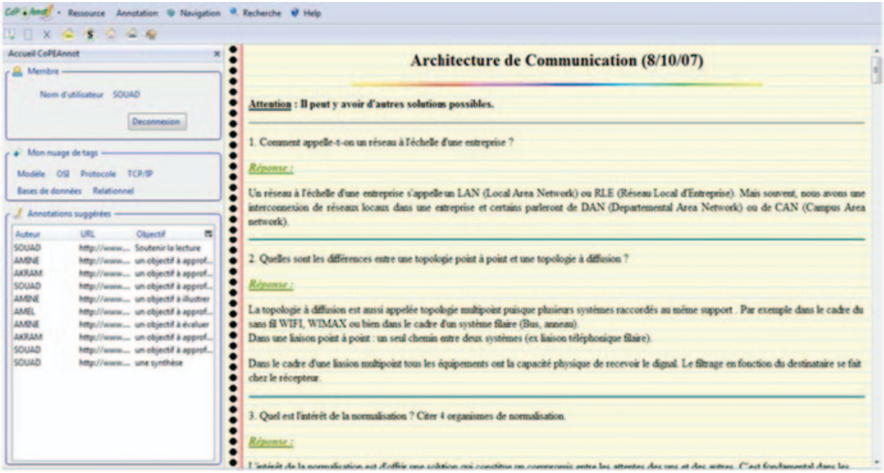

Fig. 8.8. CoPEAnnot home sidebar

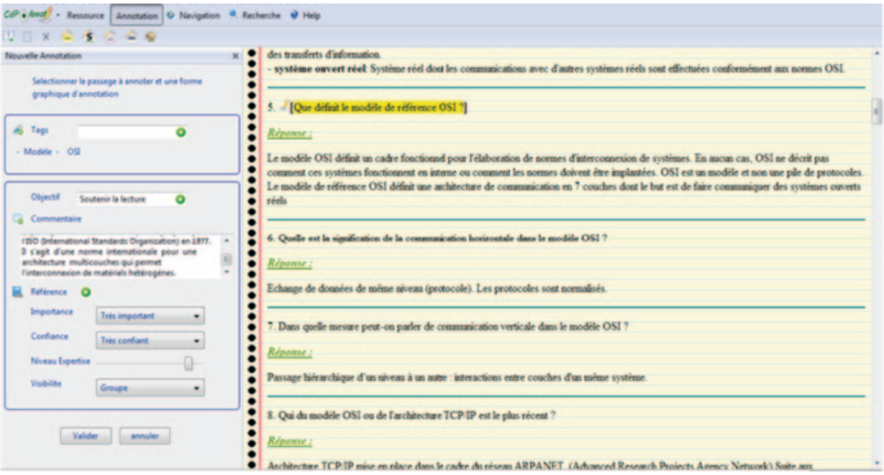

Fig. 8.9 Add new annotation

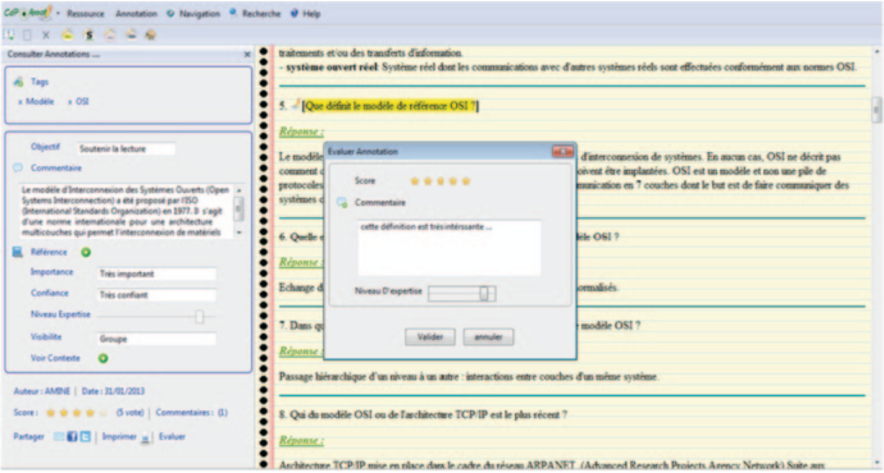

Fig. 8.10 Edit and evaluate an annotation

8.5 Evaluation

In order to evaluate the efficiency of COPEAnnot tool, we have proposed an evaluation approach based on a questionnaire. This approach involves three major steps, as presented below:

1. **Identify the key dimensions of evaluation:** The first step consists of identifying the key dimensions of the questionnaire. Satisfaction questions are divided

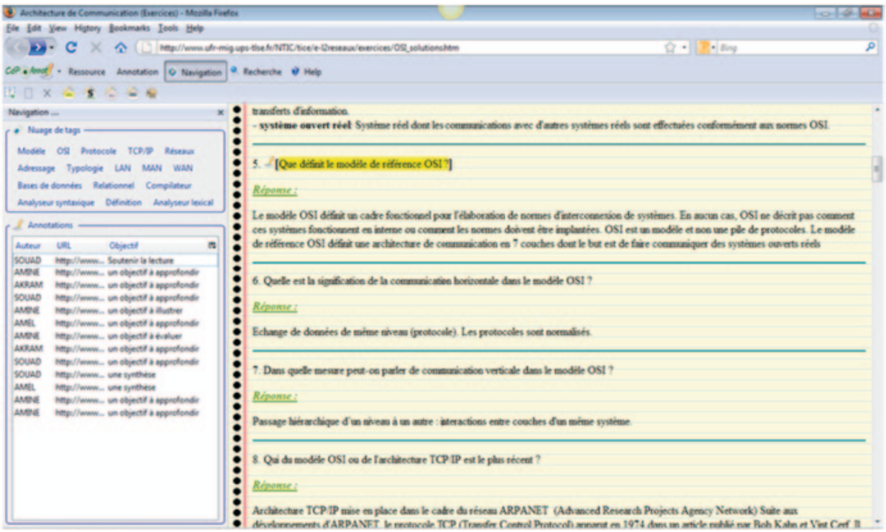

Fig. 8.11 Navigation sidebar

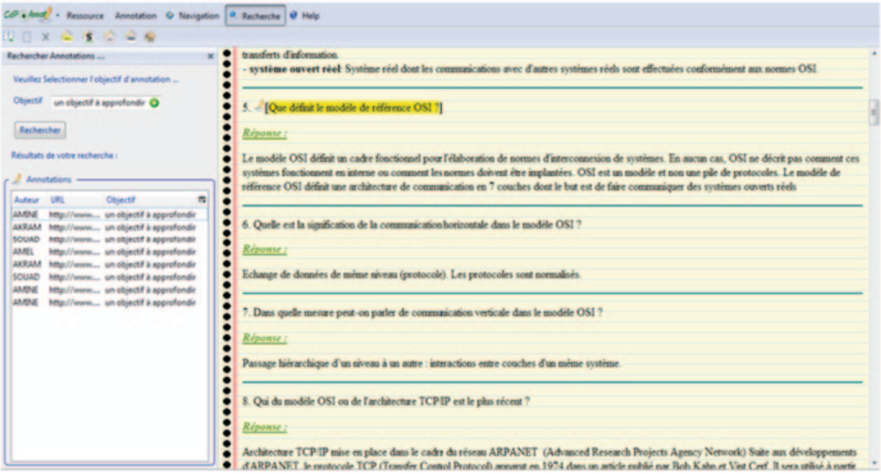

Fig. 8.12 Search sidebar

into three dimensions, where the respondents use afive likert scale (Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree):

- **Evaluate CoPEmembers' feedback on using CoPEAnnottool:** here we have based on the evaluation dimensions proposed in (Tricot et al. 2003): utility, usability and acceptability. The utility represents the accordance between the features offered by the system and those expected by the user, i.e. we evaluate members' satisfaction about each feature of CoPEAnnot (suggestion system; annotation insertion, edition, sharing and evaluation; adapted navigation via standard navigation or tags cloud, and contextual semantic search). The usability indicates the ability to learn and use the system, i.e.we measure tool's user-friendliness and simplicity, and we evaluate the time required to learn how to use the tool. Finally, the acceptability represents user's mental attitude towards the system, i.e. we measure members' satisfaction on using the tool and we see how often theywould liketo use it again.
- **Measure the context adaptation quality of the tool:** it indicates the appropriateness of CoPEAnnot features like tag cloud, annotation recommendation, navigation and search according to the current context of members.
- **Measure the quality of ontologies:**in this dimension, we evaluate the controlled vocabularies like the ontology of annotation objectives.

The table below describes a sample of questions corresponding to each dimension in the questionnaire (Table 8.2).

The questionnaire includes open-ended questions to have recommendations to improve the tool, detect problems and know what the population might think, here are some examples:

- Would you liketo improve the annotation form? If yes, which one?
- What improvements of CoPEAnnot tool would you suggest?

Table 8.2 Sample of questions in the questionnaire

Utility	The annotation allows you to better organize the community resources
	The annotation allows you to share your knowledge
	The annotation form allows you to express your needs
	The tag cloudprovides an effective navigation
	The recommendations help you to find the annotations I need
	Hierarchical search provides accurate results
Usability	Did you find that the interface of the tool was easy to use?
	Do you think that the other member will learn how to use the tool very quickly?
Acceptability	CoPEAnnot allows sharing of know-how and resources between the members of a community.
	Do you intend to use frequently the tool?
Context adaptation quality	The tag cloud provides tags appropriated to your context.
	The navigation list is adapted to your context.
	The recommended annotations are appropriated to your context.
	The hierarchical search provides relevant results which are appropriated to your context.
Quality of ontologies	How did you find the hierarchical list of annotation objective?

It also includes questions to describe the respondents and their level of expertise on using annotations, tags and semantic search, for example:

- Do you usually use the annotation?
- Do you usually annotate with graphical forms?
- Do you usually use tags?
- Do you usually use hierarchical search?

2. **Test Organization:**This step involves gathering information from members of a community of practice of e-learning. We have chosen a community of learners in the Algerian national Higher School of Computer Science. Thequestionnaireand the CoPEAnnot tool have been made available for the learners. This experiment was done between January and February 2013. 24 students were interviewed, among which 10 men and 14 women, of which 15 undergraduate students and 9 graduate students, and the average age is 25 years.

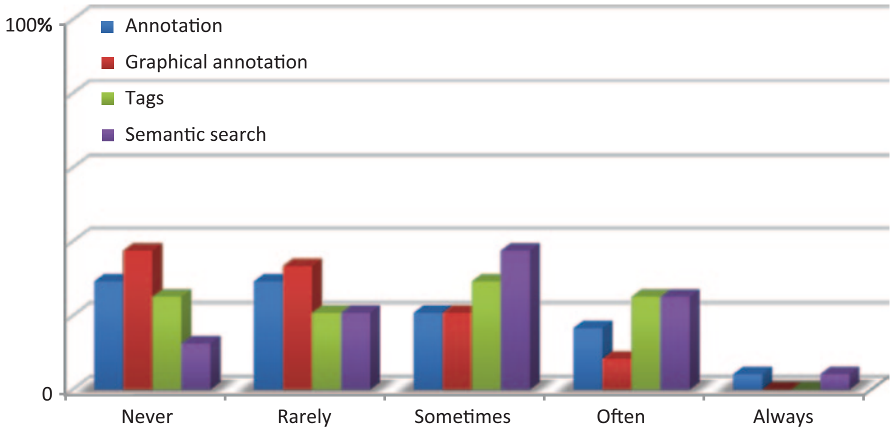

Fig. 8.13 Members' experience

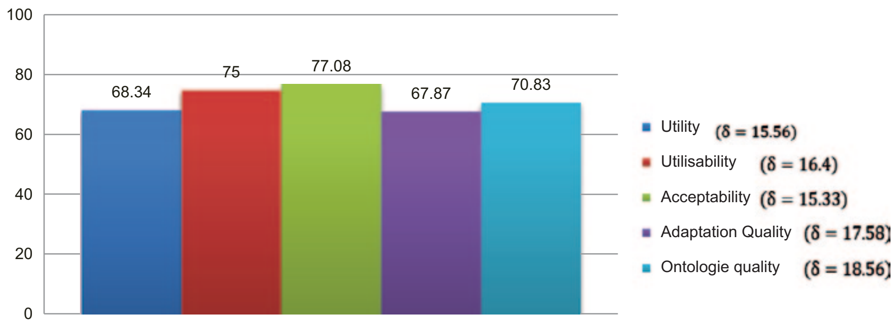

Fig. 8.14 Satisfaction rates

3. **Results Analysis:** this step includes descriptive and statistical analyses of experimental data. We have also considered the analyses of free comments, which were reviewed and divided by topics.

The Experimentation shows that respondents are less experienced on using annotations, graphic annotations, tags and semantic search. The average level of expertise is 36.2 %, with a low standard deviation of 5.76 which indicates a good homogeneity of members' experience (Fig. 8.13).

In general, the results of this experiment were quite encouraging. The learners have expressed a satisfaction rate around 70 % for each of the dimensions in the questionnaire.

Moreover, the standard deviations of each of the dimensions are relatively low. This indicates that the answers of respondents are homogeneous and thereby validating our experimental data. The figure below presents the satisfaction rates and standard deviations of each dimension in the questionnaire (Fig. 8.14).

8.6 Conclusion

In this chapter, we investigated how context-based semantic annotations can be used in a knowledge capitalization process, dedicated to a community of practice of e-learning. Semantic annotation is one of the most useful solutions for modeling knowledge. Furthermore, the preservation of knowledge context is very beneficial at their reuse. We have assembled the two components of semantic annotations and context, and we have proposed an approach, which first aims to organize the knowledge capitalization process in the CoPE, and to cover the whole life cycle of knowledge. Then, the proposed contextual annotation model serves for modeling tacit and explicit knowledge of CoPE, and it favors knowledge sharing. Ontological and rule-based reasoning represent the brain of the proposed context-ware architecture of CoPEAnnot. They have been used to adapt the annotation tool features according to the current activity context of members.

The proposed annotation tool CoPEAnnot generates many benefits to CoPEs. It improves knowledge capturing and reuse among experts of e-learning, by using a simple way: the annotations they create on their shared pedagogical resources. The experimental results with a community of learners revealed a high level of satisfaction about the utility, usability, acceptability, quality of CoPEAnnotadaptation and ontologies quality.

Our future work will focus on improvingCoPEAnnot. This current version includes reasoning about the activity context of member, thus, reasoning capabilities can be extended on other elements of context such as: location, member profile, etc. In addition, the adaptation module can be extended to support adaptation of user interface and other services. We also expect the development of the controlled vocabularies like tags and consequently we will convert tag cloud to semantic tag cloud where each item represents a concept of controlled vocabulary. Moreover, it will be also interesting to integrate mechanisms for semi-automatic annotation in order to facilitate the annotation activity.

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Chapter 9
Recognizing and Analyzing Emotional Expressions in Movements

Vladimir L. Rozaliev and Yulia A. Orlova

9.1 Introduction

Many modern information technologies are incorporated into human life, including the Internet, robotics, games, video streaming and recording, and so on. One purpose of these information technologies is to improve human-computer interaction. For instance, replacement of people by automated systems is impossible without overcoming the barrier of man-machine relationships (Orlova and Rozaliev 2011). The inability of machines to recognize and show emotions is an impediment to progress in automating robotic activities. The development of telecommunication technologies changes interpersonal communication. Very soon people will use virtual communications, which will be more effective and easy to learn but do not currently express emotions in a natural manner. At the same time emotions, play a vital role in human life. Emotions influence on cognitive processes (Bernhardt 2010) and decision making (Petrovsky 2009). So, it is important to recognize and identify human emotions and use them in human-computer systems as well as in machines that are replacing human activities.

We developed a new approach to the identification of human emotions that is based on description and analysis of body movements and the recognition of gestures and postures specific to different emotional states. We present the methodology, models and the automated system herein.

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9.2 Review of Systems For the Recognition of Emotions

We focus on systems for the identification, recognition or transfer of emotional reactions. The systems are divided into groups according to types of emotional reactions: (a) physiological indicators, (b) facial expressions, (c) body movements, (d) vocal indicators (Orlova and Rozaliev 2011).

1. 1. Physiological indicators

   1. Biological feedback is used for the clinical definition of emotions. The essence of biofeedback method is to "return" to a patient on a computer screen or in audio form the current values of its physiological parameters.
   2. The experimental device from NeuroSky worn on the head, containing a sensor of brain activity. It determines the degree of concentration, relaxation or restlessness of man, evaluating them on a scale from 1 to 100. Designed for connection to a video game console or PC.
   3. Control system of psycho-emotional state of the person (VibraImage) is designed for detection of aggressive and potentially dangerous people, using contactless scanning to ensure security at airports and other protected objects.
   4. A technology that uses a special sensor and the Peltier element, provides a physical transfer of emotions from one cell phone to another from a group of researchers from Tokyo University.
   5. The project AffQuake based product ID Software Quake II from Affective Computing Research Group expands possibilities of games by making the gameplay really experienced player experiences, modifying the game.
   6. The project researcher Christian Peter exhibited in March 2006 at the world exhibition CeBIT, uses video-recognition of human faces in combination with the measurement of its biological parameters to determine emotions.

2. 2. Facial expressions

   1. Automated system for recording movements of facial muscles from GfK is intended to improve understanding of human emotions and their means of expression.
   2. Online recognition of emotion and expression on pictures (FaceReader). Defines a neutral expression, sadness, surprise, disgust, happiness, anger, fear.
   3. Auto Smiley is a small application for the Mac platform, which automatically generates "smiles" in the text typed into a text editor or the Internet messenger.
   4. The device company Media Lab consists of a miniature camera, attached to the glasses and connected to the pocket PC. Intended for determining the reaction of people around the device owner. Useful for speakers, autistics.
   5. The video surveillance system from TruMedia defines human reaction viewed ads. The system keeps track of how long a person was sent to the monitor and determines gender, approximate age and race.

3. 3. Body movements (pantomime)

    1. The technology of Sony Computer Entertainment America, aimed at the definition of emotions such as laughter, anguish, sadness, anger and joy. Recognize emotions on the face and voice and movement, but without the ability to work in three dimensions, so the same is not with the highest accuracy.
    2. System to identify emotional States by mimicry and gestures from researchers Hatice Gunes, Massimo Piccardi and Maja Pantic from a group of Computer Vision Research in Sydney. Limitations: not taken into account movements of the torso, legs, and the inclination of the head.
    3. System to identify emotional States by mimicry and gestures from researchers C. Shan, S. Gong, and P. W. McOwan of the Department of Computer Science Institute of London. Limitations: the analysis is based only changing body position, static postures and positions are not counted.

4. 4. Vocal indicators

    1. The program Emotive Alert from Affective Computing Research Group recognizes the emotion in the voice. Is mounted directly to a voice mailbox owner and indexes incoming messages. Classifies each message as this or that emotional colouring.
    2. Software for cars from Affective Media, recognize the emotional state of the driver while driving. The technology allows to constantly monitor the emotional state of the driver, analyzing his intonation, tone of voice during his inquiries to the navigation system of the car.
    3. Technology the company's Sound Intelligence is applied London police to equip surveillance cameras smart voice sensors that can pick up the aggressive tone of the conversation. If the device will notice that one of the neighbors swears, it will inform the receptionist.
    4. Technology of recognition of emotions from the company Federal Express is used to determine how good or bad impression to clients. In based on verification of voice, analyzes the volume and height, and to find in the recorded calls words that sound like "wow".

Assessing the considered systems and technologies, we can conclude that at the moment there is no system fully implements the analysis of all means of transmission of emotional reactions, and hence no means a very precise definition of emotional reactions on several indicators. Developed by our group, models, techniques, and built on their basis the system can solve the problem. At the entrance of the system is supplied with the video, the audio signal and handwriting samples. At the output of the system operator is informed about the emotional state of the studied people.

The architecture of computer system developed for identification of human emotional reactions is shown on Fig. 9.1 (Zaboleeva-Zotova et al. 2011a). The input of the system are moving images, sound samples and handwriting texts. The output of the system is information about the emotional state of the real person, which is expressed in a limited natural language.

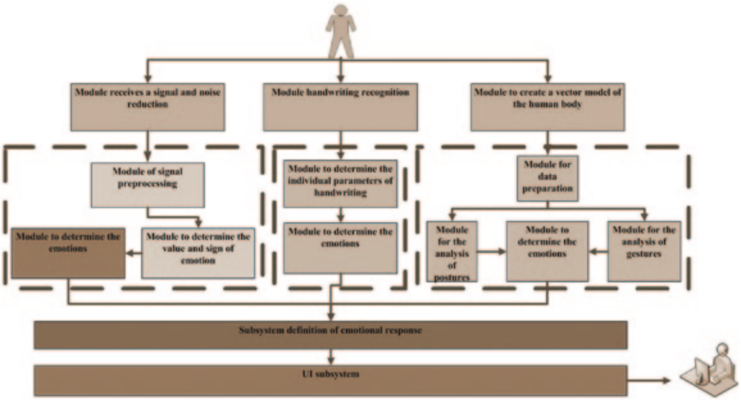


Fig. 9.1 The architecture of system for identification of human emotional reactions

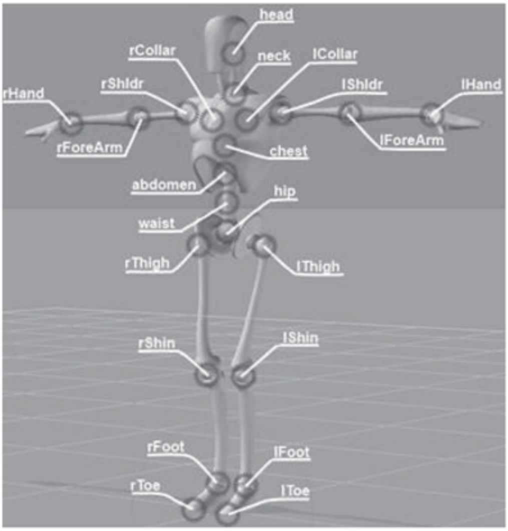
9.3 Identification of Human Body Movements

The process of identifying human emotional response is based on the idea of how the human manifests his/her emotions (Ilyin 2008; Rozaliev and Zaboleeva-Zotova 2010).

Now various companies are actively developing automated systems for recognition, identification and transmission of emotional reactions. Many of these systems use web solutions based on a model SaaS (Software as a Service). There are also different ways for determining emotional states such as by voice, facial expression, body movements, physiological parameters, and so on. (Bernhardt 2010; Coulson M 2004; Hadjikhani and Gelder 2003; Laban and Ullmann 1988)

The proposed approach to emotion identification are based on recognition and analysis of human gestures and poses. (Zaboleeva-Zotova et al. 2011b) First of all, we recognize a person on video images using a technology for markerless motion capture with the digital video camera Microsoft Kinect. Video pictures are presented in the special animation format—the BVH-file, which describes poses of body skeleton and contains motion data. Such technology allows visualizing and analyzing different movements of person, determining areas of static or dynamic postures of micro and macro movements.

To detect the borders of movements, the motor activity of person is analyzed. For the separation of postures, we suggest a special notion of activity, which depends on what part of body performs the movement. We describe the typical body movements with linguistic variables (linguistic variables are variables expressed in plain language words and statements, for example, the linguistic variable "Variation of rotation angle" from Sect. 5) and fuzzy hypergraphs (Kauffmann 1977) for temporal events, and transform these descriptions into the expressions in a limited natural language, which characterize the person emotions. We use fuzzy hypergraphs, because it combine advantages both fuzzy and graph models, it is



Anatomical part of body	Node of vector model
Cervical spine	Head
	Neck
Shoulder joint	Collar
	Shldr
Wrist, radiocarpal joint	Hand
Ulna, radioulnar joint	ForeArm
Thoracic spine	Chest
	Abdomen
The lumbar spine	Hip
	Waist
Hip	Thigh
Knee-joint	Shin
Ankle joint	Foot
Metatarsophalangeal and interphalangeal joints	Toe

Fig. 9.2 The vector model of body skeleton and correspondence between anatomical parts of body and nodes of the vector model

more natural for use and it allows to realise formal optimisation and logical procedures. The identification of human emotional reactions such as joy, sadness, anger, etc is provided by the detailed analysis of postures, gestures and motions.

9.4 A Vector Model of the Skeleton

In order to define human emotional reactions by body movements, we use the vector model of skeleton, which is obtained from video information captured with the digital video camera Microsoft Kinect.

Kinect camera allows obtaining three-dimensional image in all lighting conditions and without any requirement to the actor, who is in the frame. Data from Kinect represented as a hierarchy of nodes of the human skeleton. Rotation of one joint with the other, is presented in the form of quaternions (the role of the rotating vectors perform the bones of the skeleton) and the offset is represented as a three dimensional vectors in local to each node coordinate system. To obtain BVH-file, we have developed a new method consists of the following steps:

1. Getting data from the camera Kinect.
2. Determine the displacement of nodes relative to the parent node.
3. Record the hierarchy of key units in accordance with the specifics of the BVH-format.
4. Conversion of quaternions to the Euler angles.
5. The vector model of body movements, presented as a BVH-file, may work most of the currently existing animation packages (Fig. 9.2).

A vector model of the human body is a formalized representation of the movement of the person, where as vectors are presented bones of the human skeleton, and the angles between them correspond to the rotation angles of the main nodes of the human body in relation to each other. The vector model of skeleton consists of 22 nodes, which correspond to different anatomical joints with one, two or three axes of rotation.

Using information on structure of body skeleton presented in the vector model and motion data contained in BVH-files, which describe poses of skeleton, we formalize the concept of motor activity of person expressed in gestures as follows:

$$A(\Delta t) = \sum_{n=1}^{m} (T_n(\Delta t) \cdot k_n).$$

Here m is a number of time series describing movement of the body parts, $T_n(\Delta t)$ is a variation of the n-th time series for the time Δt, k_n is a coefficient that characterizes influence of the body parts on the body motion for the n-th time series.

The influence coefficient can be calculated as the following sum

$$k_n = \sum_{i=1}^{jn} (p_i \cdot q_{ni})$$

where i is a index of the body part, j is a number of the moving body parts, q_{ni} is a ratio of the body part in the total body mass, p_i is a gender coefficient of proportionality. According to biomechanical studies the averaged values of ratio q_{ni} for adults are equal to 6.9 % for head, 15.9 % for the upper section of trunk, 2.1 % for shoulder, 16.3 % for the middle section of trunk, 1.6 % fore forearm, 11.2 % for the lower section of trunk, 0.6 % for brush, 14.2 % for thigh, 4.3 % for lower leg, 1.4 % for foot. The gender coefficient p_i is equal approximately to one for all parts of man body, and differs for various parts of woman body.

Another important characteristic of body movement is a mobility of the joint, which is measured in morphology by values of the angles of flexion-extension, abduction-reduction, internal-external rotation as follows:

$$M_{joint} = angle\,(Fold + Straightening,\ Bringing + Abduction,\ In + Out).$$

The maximum spine mobility is a sum of the angles of the left and right rotation around the longitudinal axis of the body.

For automatic separation video districts of the individual poses and gestures, we introduce additional parameters, defined by the user: the minimum duration of the movement, the level of activity for poses, the level of activity for the movements. Next, we construct a graph of activity and find areas of the postures and movements.

Poses discussed in detail in the works B. Birkenbil, G. Wilson, D. Morrison, A. Pease, were merged into granules, based on a similar interpretation. As it is impossible to unequivocally define the current posture emotional state of a person, we define the granules, which belong to the posture. This allowed us to increase the reliability of a particular emotional state. Compliance granules poses and basic emotional states by K. Izard is shown on Fig. 9.3.

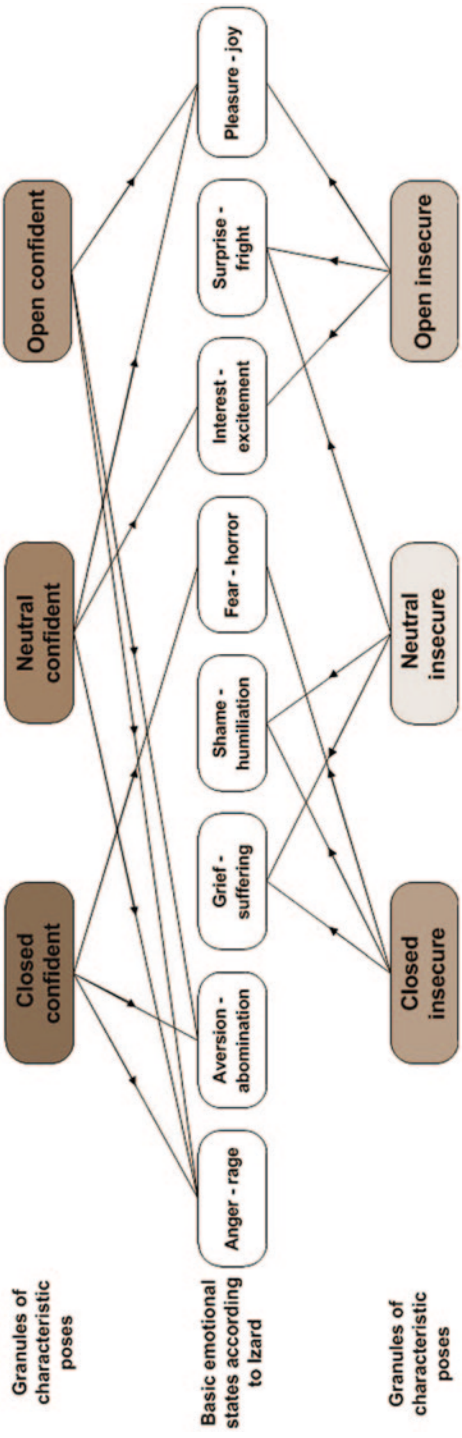


Fig. 9.3 Compliance granules poses and basic emotional states

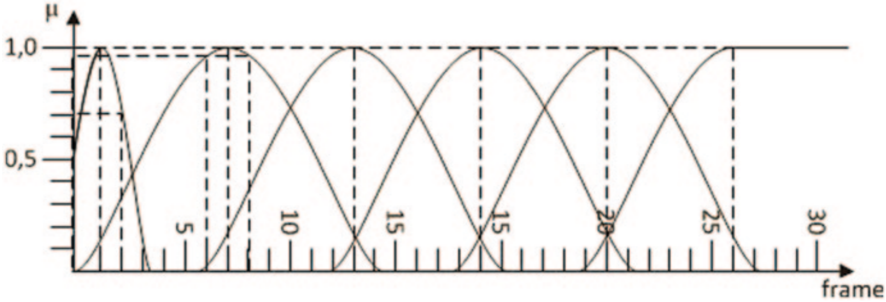


Fig. 9.4 The membership functions of the variable "Duration of event"

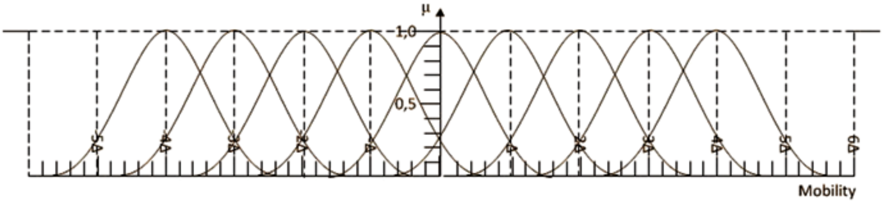


Fig. 9.5 The membership functions of the variable "Variation of rotation angle"

9.5 Formalization of Human Movements

In the vector model of skeleton, the movements of human body are described with the linguistic variables, which characterize duration of event, variation of rotation angle. The duration of event is measured in the frames of video image. The fuzzy temporal variable "Duration of event" includes the following set of terms: D_0 'Zero', D_1 'Very short', D_2 'Short', D_3 'Moderate', D_4 'Long', D_5 'Very long'. The membership functions of the variable "Duration of event" are presented on Fig. 9.4.

Each group of joints with the similar values of maximal mobility is presented with the linguistic variable "Variation of rotation angle" that consists of the following set of terms: B_0 'Stabilization', B_{+1} 'Very slow increasing', B_{+2} 'Slow increasing', B_{+3} 'Moderate increasing', B_{+4} 'Fast increasing', B_{+5} 'Very fast increasing', B_{-1} 'Very slow decreasing', B_{-2} 'Slow decreasing', B_{-3} 'Moderate decreasing', B_{-4} 'Fast decreasing', B_{-5} 'Very fast decreasing'. The membership functions of the variable "Variation of rotation angle" are presented in the Fig. 9.5. This linguistic variable can be adjusted on various types of the human movements and allow to describe, for instance, the small periodic fluctuations, such as tapping on the table, shaking hands or fingers, wiggle from foot to foot, and so on.

By specifying the name of the analyzed part of body, and the range of movements in the vector model of skeleton, one can obtain the values of rotation angles

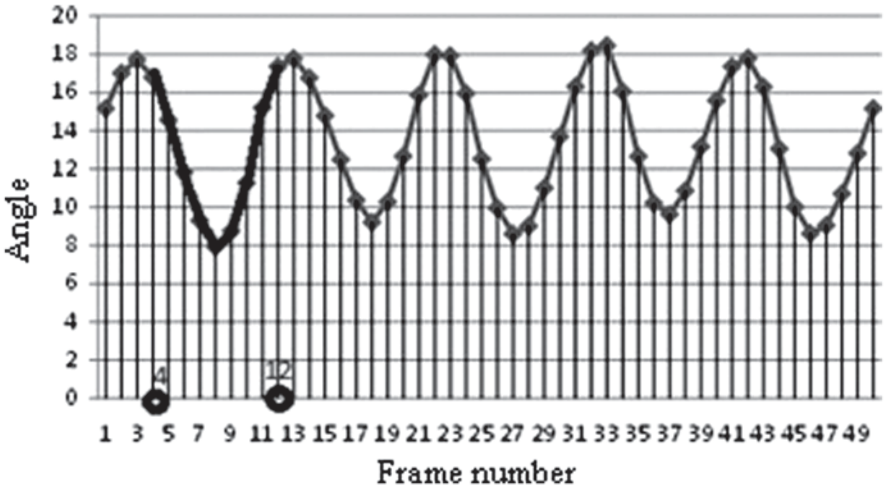


Fig. 9.6 Variation of the angle of rotation around the X-axis for the joint "right foot"

of the node relative to one of the axes X, Y or Z, which are stored in a separate data array. From this array there is selected a subarray, which contains the values of angles ρ_i falling in the range analyzed. The angles, belonging to different frames for the same node, form a triangular matrix, which elements is determined by the following rule: $\rho_{ij} = \rho_j - \rho_i$ for $j > i$, $\rho_{ij} = 0$ for $j \leq i$. This triangular matrix is used to calculate the values of the membership function of linguistic variable "Variation of rotation angle".

The movement of the joint around an axis has been described in the form of fuzzy temporal events. Since the events are located one after another on the time axis, the motion can be represented as a fuzzy sequential temporal sentence (Bernshtein et al. 2009). For example, the variation of the angle of rotation around the axis X for the joint "right foot" in the interval [t_4; t_{12}] shown in Fig. 9.6 can be described as the following series of fuzzy temporal statements: "For the right foot there is a very slow decreasing the angle of very short duration. This is followed by stabilization of the angle of zero duration. This is followed by a very slow increasing the angle of very short duration".

The above fuzzy sequential temporal sentence can be written formally as follows:

$$W = \left(B_{-1}\ rtf\ D_1\right) rtsn \left(B_0 rtf\ D_0\right) rtsn \left(B_{+1}\ rtf\ D_1\right),$$

where rtf is a fuzzy temporal relationship; rtsn is a temporal relationship of the direct sequence; B_0 is the term 'Stabilization', B_{-1} is the term 'Very slow decreasing', B_{+1} is the term 'Very slow increasing' of the linguistic variable "Variation of rotation angle"; D_0 is the term 'Zero', D_1 is the term 'Very short' of the fuzzy temporal variable "Duration of event".

9.6 Evaluation of Similarity Between the Identified and Etalon Movements

In the model of fuzzy sequential temporal sentence, an adequacy of the analyzed fragment δ_q of a dynamic process and the corresponding attribute q are determined by the validity criterion J, which is represented as follows:

$$J(q/\delta_q) = F_q(\delta_q)\,\&\,\mu_{Lq}(\delta_q).$$

Here $F_q(\delta_q)$ is the characteristic function that establishes a semantic relationship between fuzzy values of the secondary attributes of a dynamic process and values of the primary attributes determining them; $\mu_{Lq}(\delta_q)$ is the membership function of the term L_q of the linguistic variable L.

The validity criterion of fuzzy sequential temporal sentence W with respect to any dynamic process S is written as

$$J(W/S) = max_{I \in V}(J(W/S)_I),$$

where V is the set of all possible interpretations I. For instance, the validity criterion of fuzzy sequential temporal sentence W with respect to any dynamic process S for a set of fuzzy temporal events, which is expressed through successive attributes *a, b, c,* is described by the formula

$$\begin{aligned} &\mathrm{J}(\mathrm{W/S})_{\mathrm{I}} = \mathrm{J}(\mathrm{a}/\delta_{\mathrm{a}})\,\&\,\mathrm{J}(\mathrm{b}/\delta_{\mathrm{b}})\,\&\,\mathrm{J}(\mathrm{c}/\delta_{\mathrm{c}}) = \\ &(\mathrm{F_a}(\delta_{\mathrm{a}})\,\&\,\mu_{\mathrm{La}}(\delta_{\mathrm{a}}))\,\&\,(\mathrm{F_b}(\delta_{\mathrm{b}})\,\&\,\mu_{\mathrm{Lb}}(\delta_{\mathrm{b}}))\,\&\,(\mathrm{F_c}(\delta_{\mathrm{c}})\,\&\,\mu_{\mathrm{Lc}}(\delta_{\mathrm{c}})). \end{aligned}$$

In our case, the analyzed dynamic process is a sequence of frames in the skeleton vector model, which characterizes the rotation of one of the skeleton nodes around the axis X, Y or Z at a certain angle, and the criterion of validity is the criterion of similarity between the identified and etalon movements. So, the identified movements are considered as the well recognized with respect to the etalon movements if the value of criterion of similarity exceeds a predefined threshold.

For example, calculate the criterion of similarity between the identified and etalon movements describing a rotation of the node “right ankle”. The etalon movements are presented by fuzzy temporal event, which is written as follows: “For the right ankle there is a very slow decreasing the angle of zero duration.”

Let the initial data are the following time series: at the time moment t_0 the rotation angle $\rho_0 = 10.00°$; at the time moment t_2 the rotation angle $\rho_2 = 6.13°$. So, the duration of event is equal to 2 frames. Then by the graph of membership function $\mu_{D0}(\delta_t)$ of the term D_0 ‘Zero’ of the fuzzy temporal variable “Duration of event” presented in Fig. 9.3, we find the value $\mu_{D0}(\delta_t) = 0.70$ for $\delta_t = t_2 - t_0 = 2$ frames. By the graph of membership function $\mu_{B-1}(\delta_\rho)$ of the term B_{-1} ‘Very slow decreasing’ of the linguistic variable “Variation of rotation angle” presented in Fig. 9.4, we find the value $\mu_{B-1}(\delta_\rho) = 0.92$ for $\delta_\rho = \rho_2 - \rho_0 = 6.13 - 10.00 = -3.87$ degrees. Thus, the criterion of similarity $J(W/S) = 0.92$. If the threshold is equal to 0.80, then the identified rotation of the node “right ankle” is similar to the etalon movements.

9.7 Definition Contours of Human Hands

At the first stage gesture recognition of human hands, we slot image, to find the area of interest—hand. For this, use a combined approach based on analysis of data from the sensor depth and determining a person's skin color. To find the person we use the method Viola-Jones, based on cascades Haar (Dorofeev et al. 2013). The method is one of the best ratio of detection performance/speed. After finding faces in the image is analyzed information about the color of human skin. Based on the value tone complexion a histogram is built, in which each column is one of the possible values tone. The detector is based on the probability of belonging to the image to human skin. Calculating the probability is based on two models: an adaptive model based on histograms and models based on the mixture of Gaussian. The result of the application of these models is segmented image, which contains only the objects with the color of human skin. Then peel frame from all other items beyond the face of the user. This can be done by applying a depth map, obtained from a sensor Microsoft Kinect.

Assuming that hands are closer to the camera than face we find them using threshold values. That corresponds to the principle of communication in sign language.

Next, you need to use the method for tracking objects in the frame. This is the algorithm CAMShift. The algorithm is designed to monitor one object, and in sign language involved both hands, we propose to parallel algorithm CAMShift. After finding areas of interest with hands on the image we analyze data, to obtain contour hands of the area of interest. To highlight the path in the image is applied detector borders Kenny. For finding fingers we apply the method of k-bending on the convex hull of the path. Thus, we get the outline of the man's hands and point pointing fingers coordinates. In practice proven that these data are enough for training recognition system of gestures and their further definition.

9.8 Use For Teaching Children With Hearing Disabilities

We use information about emotional reactions to control the education of children with hearing disabilities. Briefly describe another developed by us system. The system is aimed for recognition and translation in real time gestures of the Russian language of the deaf in the text and the text in gestures. The system is intended for training of children with hearing disabilities and adults who need to learn sign language. It will be used in a test mode in school for children with limited hearing. But already now receives positive reviews.

Problem use Kinect to recognize the small gestures of hands is still unresolved, despite the successful application of Kinect to recognizing faces and tracking of the human body. The main reason for this low resolution depth map sensor.

In sign languages in communication, information is transmitted via several channels: directly through hand gestures, facial expressions, lip shape, position of the body and head. Hand gestures described via hand position, direction of movement,

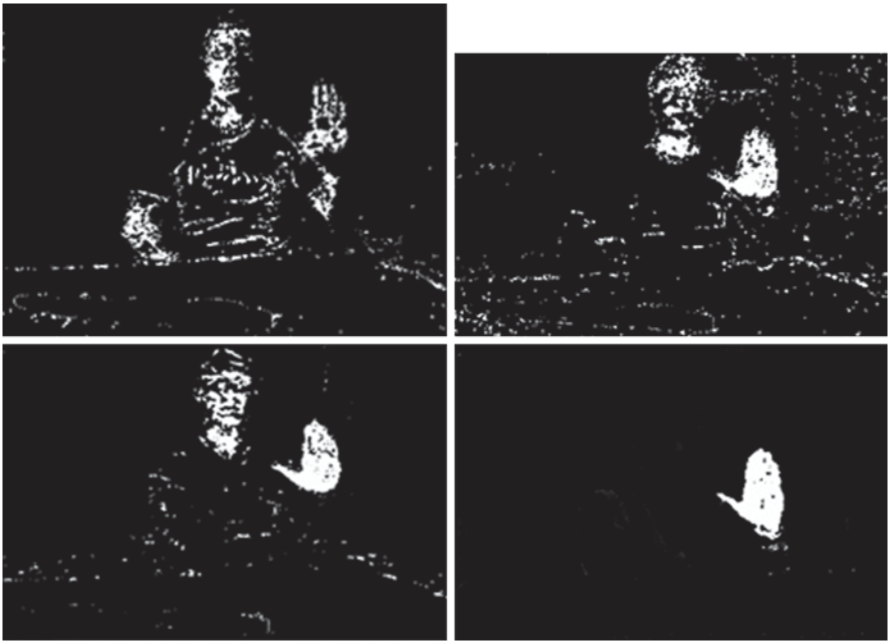


Fig. 9.7 Finding hands on the image

Fig. 9.8 Finding of hand gestures on the image

shape and direction of hands. The first stage of recognition is a segmentation of the image received from Kinect to find the hand or both hands. Development of a method for finding the hand in the picture is one of the most complicated problems in the process of creating a system of recognition of gestures. An example of the recognition the user's hand is shown in Fig. 9.7 and Fig. 9.8.

There are several signs that can be used to detect the object on the image: the appearance, shape, color, distance to the subject and context. When detecting faces in the image, a good sign is the appearance, as the eyes, nose and mouth are always about the same proportions. Therefore, to find hands, we first find the face of a man, define its color and highlight the closest object. Accept his hands. Next we apply the developed method for finding the hands and define user gesture.

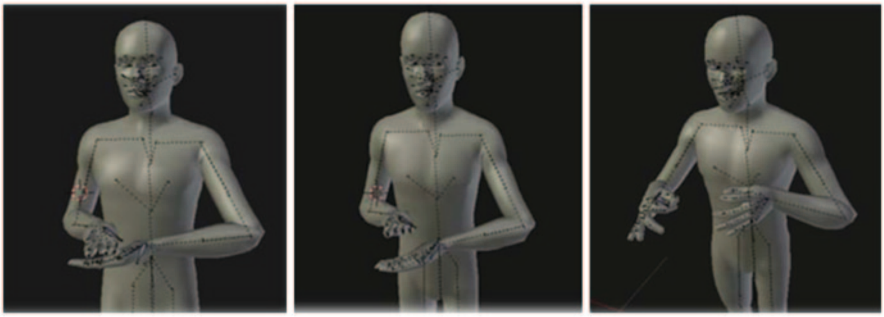


Fig. 9.9 Animated demonstration gestures

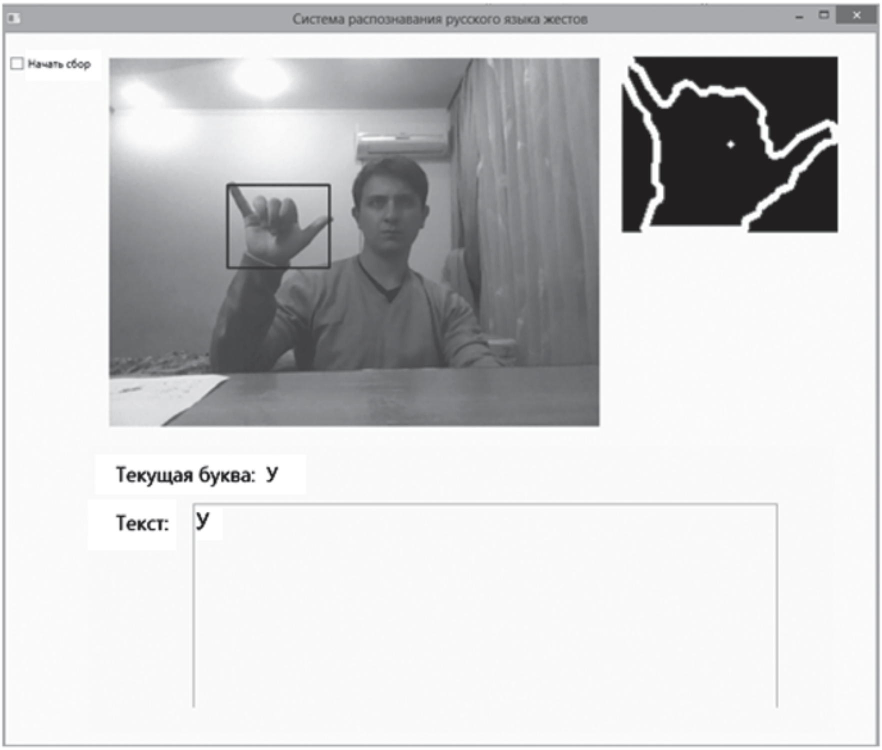


Fig. 9.10 Show gesture language of the deaf

The system works as follows. The user enters text. The system displays an animated image of the gesture. A sample output of the animated gesture is shown in Fig. 9.9.

User-child repeats movement. Example showing the user gesture is shown in Fig. 9.10.

The movement is recognized and checked for correctness. If not correct, the movement is shown again. If correct, then enter the new text. If the user starts to receive a closed posture characteristic of anger, resentment, it is informing the administrator and learning process can be stopped.

9.9 Conclusion

The identification of human emotional states is related to the problem of understanding normal human behavior. However, the variety of normal behavior is great. As a result, it is difficult to draw a line between acceptable and unacceptable behavior. The automation of the human emotion recognition can help to solve many problems of relationships between people as well as between people and machines and avoid possible misunderstandings.

Automated systems for human emotion identification by gestures and movements can be useful and are necessary in areas such as communication with the deaf people, in realizing personalized education/learning, in supporting emergency services, in monitoring emotional states of pilots, drivers, and operators of complex technical system, and so on.

In the future, we intend to use this approach to determine emotional responses based on handwritten text and to animate human gestures and motions as described in a limited natural language.

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Chapter 10
Student-Driven Classroom Technologies: Transmedia Navigation and Tranformative Communications

Leila A. Mills, Jenny S. Wakefield and Gerald A. Knezek

10.1 Introduction

The wide range of technology tools that support communications and information access options for learning may warrant a redefinition of the traditional concept of classroom technology integration. The research, design, and practice loop in education has been out-paced by the rapid advances in technology tools. Many practitioners remain skeptical and uncertain of the best methods for integration of technologies within educational contexts that will harness the power of the wide array of technologies—such as laptops, tablets, the Internet, search engines, email, chat, messaging, serious games, wikis, global positioning systems (GPS), location sharing and community building tools, audio, video, smartphones, and augmented reality—that are blurring the line between formal and informal learning (Mills et al. 2014).

There continue to be concerns that, in many schools, little progress is being made towards leveraging the affordances of classroom information and communications technology (ICT) to support innovation in teaching and learning (Halverson and Smith 2009; Bauer and Kenton 2005; Fishman et al.2004). Renowned technology expert, computer scientist, and educator Seymour Papert envisioned the transformative power of a new kind of system for education, one comprised of a student and a computer (Papert and Harel 1991). Papert and Harel (1991) recognized that

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technology-related change in education would face an uphill battle. The dream of Papert has yet to be actualized in the majority of schools. That is, "although technology enthusiasts expected a revolution to result from technologies for school learners, what schools experienced was a revolution in technologies for measuring and guiding learning" (Halverson and Smith 2009, p. 53).

Beyond the rapid advance of new technology tools, other factors are linked to the lack of effective integration of learning technologies in schools. Fishman et al. (2004) contend that most cognitively oriented technology innovations (innovations employing technology based on learning sciences research), are not in widespread use in classrooms due to a serious omission in design-based research—the failure to address real-world contexts and school-related issues of usability, scalability, and sustainability for innovative technology integration. Fishman et al. (2004) posited that these issues must be addressed in the larger context of school systems and classrooms before we can expect to see the widespread, innovative use of classroom technologies implemented to foster deep thinking and learning (Fishman et al. 2004).

Spector's (2001) overview of progress and problems in educational technology relates the unrealized promise of technology-supported improvements in learning and instruction to instructional design issues that have prevented instruction from keeping pace with advances in technology. These issues center on the complexity of designing to create a match between instructional methods, subject matter, and learner characteristics.

Beyond Cuban's (2001) concern that school instruction has changed little in the last 20, 50, or even 100 years, are concerns that schools are falling further and further behind in incorporating classroom innovations, such as new technologies, to meet the needs of a new generation of learners (Prenksy 2007) who may think differently that previous generations (Prenksy and Berry 2001). Bauer and Kenton (2005) conducted a study of 30 teachers who were considered to be technology savvy and reported that even among this group, technology tools were not regularly integrated into classroom teaching and learning due to a lack of time, hardware issues, lack of software, technical problems, and deficient student skill levels. It is not surprising that, all too often, new technologies continue to be under-used in classrooms, even as an updated mode for traditional content delivery, and are rarely utilized to create new forms of learning interaction to widen educational opportunities (Bauer and Kenton 2005). Under-use of classroom technologies is not surprising in light of the fact that popular instructional design often assumes that teachers will add technology integration to a long list of tasks and responsibilities. Perhaps we cannot expect the majority of teachers to be successful in advancing classroom technology integration in a classroom context that includes responsibility for diverse classroom activities to include facilitating a content-based assignment or project, fostering collaboration, employing instructional technology, helping students use technology, and conducting appropriate assessments—among other things.

Spector points out that new technologies offer options for the creation of new learning contexts that include a shift away from the instructor-led classroom model towards a model that includes a combination of technology-mediated and traditional classroom events (Spector 2001). Prensky (2007) suggested a movement toward classroom interaction that capitalizes on the fact that many students know more about, and can learn, use, and manipulate new technologies faster than teachers. Prensky further suggested that students should be allowed to employ skills and abilities to use classroom technologies, without dependence on the classroom teacher to teach how-to. It seems logical that if teachers are comfortable with relinquishing the role of the expert in classroom technologies, students will implement available technology media required for lessons as they would traditional media, based on their individual capabilities. Students and teachers will all learn to use technology tools together in a learning context that supports innovative technology integration. Freire (1996) envisioned a different learning context where "The teacher is no longer merely the one-who-knows, but one who is himself taught in dialogue with the students, who in turn while being taught also teach. They become jointly responsible for a process in which all grow." (p. 61). Such a learning context may fit well with transmedia navigation for technology implementation and innovation in the twenty-first century classroom. Prensky (2007), for instance, proposed:

> There are strategies for teaching with technology that can make both students and teachers comfortable, while allowing the students to go as far as they can with the technologies that characterise their age and that they love to use, and that prepare them for their twenty-first century future as well (p. 40).

The teaching side of this strategy is that being freed of teaching technology how-to (and directing whole class technology use) will allow teachers to focus on how technology use can best be used to enrich learning, achieve learning objectives, and on *why* the technology is being used (Prensky 2007).

The authors contend that instruction created within the design-based research paradigm with student-driven transmedia navigation can circumvent many problems and constraints associated with classroom technology integration for learning and support new learning contexts that encompass innovative uses of classroom technologies. Issues such as lack of time, lack of complete classroom sets of devices, and varying skill levels—the common obstacles to innovative classroom technology integration in the more traditional classroom setting—can be side-stepped if the classroom environment supports a learning context where student technology use is not dependent on the teacher being the technology expert who directs all students in the use of uniform digital media. Transmedia navigation and student choice in selection of mode and media for learning discourse can assist in supporting innovation and cognitively oriented technology use while providing avenues for sustainable, student-driven use of classroom technologies.

This research is based on a sample of $n=63$ middle school students who attend public schools in Texas, USA. Self-reported student data are examined to report students' observed trends in their attitudes towards school, learning, and classroom media. Student preferences for traditional classroom media, such as books, newspapers, and magazines are examined, along with their attitudes towards student and teacher use of classroom technology.

10.2 Conceptual Rationale

10.2.1 A Design-Based Research and Methodology

Design-based research is a systematic yet flexible methodology set in place to improve practice through an iterative process of analysis, design, development, implementation, and re-redesign. Theory, research, and design often advance without an accompanying concurrent advance in fields of practice. The design-based research paradigm can assist to advance practice with research and design (Wang and Hannafin 2005). This research and practice paradigm requires collaboration among researchers and practitioners and can lead to improved practice and revised theories (Van den Akker et al. 2006; Wang and Hannafin 2005). Brown (1992) warned that examination of separate processes, as isolated variables within laboratory or other impoverished contexts, will provide incomplete pictures of what is going on. Technology integration in instructional design often relies upon a design-based methodology (DBM) in order to allow processes, such as research and practice, to inform one another while also allowing researchers to refine theories and approaches to classroom practice with continual re-evaluation. The interaction between processes allows for testing and validation of theories through a series of adjustments during the application process. While DBM generally does not serve to replace other methodologies or methods used in quantitative or qualitative research (Orrill et al. 2003), it provides an approach for the adjustment of practice based on trials or experimentation that allows for a generation of new theories for learning in naturalistic contexts (Brown 1992; Collins 1992; Barab and Squire 2004). Barab and Squire (2004) recognized there are complexities and challenges for those (like teachers) who work within real-world contexts employing design-based research while serving in multiple research, design, and implementation roles. They hold that the true challenge and a major goal of design-based research is "pushing beyond that which can be designed to a greater appreciation of the constraints of those real-world contexts through which our contexts of implementation are nested" (Barab and Squire 2004, p. 12).

10.2.2 Transformative Communications

Slow if gradual progress is being made towards changes in educational practice to reflect Dewey's assertion, offered nearly 100 years ago, that knowledge and common understanding cannot be passed physically from person to person as can bricks, nor can they be shared among persons as could a sliced pie (Dewey 1985). Dewey, father of American pragmatism, believed it is fair to claim that any social arrangement that is vitally social, or vitally shared, is educative to those who participate in it, and further, that social interaction is identical to communication, while communication is the central process of education. Student-initiated communication of ideas, reactions, and content are potentially transformative catalysts for learning processes. Sharples (2005) identified a need for a conceptual framework that recognizes the essential role of communication for learning in the mobile age. Sharples et al. (2010) described learning as the conversation-driven development of knowing via continuous reconstruction of contexts. They base this definition on a central claim "that conversation is the driving process of learning. It is the means by which we negotiate differences, understand each other's experiences and form transiently stable interpretations of the world" (Sharples et al. 2010). Sherry and Wilson (1997) realized that the Internet adds new dimensions to traditional models of communications. They conceptualized a transformative, dynamic, two-way system of communication for education within the Web environment that combines elements of transmission and ritualistic views of communication.

Pea (1994) examined views of communication in educational computing, stating that neither of the contrasting and traditional views of communication-as-transmission or communication-as-ritual capture the entire truth about communication. Pea (1994) held that within the framework of transformative communications in multi-media learning, "A rich variety of media are needed for learning conversations, embodying symbol systems as diverse as photographs, animated scientific diagrams, maps, mathematical notations, graphs, texts, and films" (p. 290).

An emerging instructional theory that is centered on communications, learning, and teaching as communicative actions theory (LTCA) (Warren et al. 2010), supports instructional design for transformative classroom communications. LTCA discourse encompasses shared expression of identity and meaning making within a learning and teaching context visualized as four essential communicative actions, defined as normative, strategic, constative, and dramaturgical (Wakefield et al. 2011). The dramaturgical action (expressions of subjective understanding in the objective world), in particular, supports dynamic new models of classroom instruction that extend instruction beyond traditional classroom walls (Warren et al. 2013). Dramaturgical communicative actions are the result of individual understanding from interactions with content and ideas. The LTCA framework for learning has been used in Web environments utilizing tools such as Twitter (Wakefield et al. 2011), blogging (Warren and Wakefield 2012), in role-play within virtual worlds (Wakefield et al. 2012), and in transmedia storytelling (Warren et al. 2013).

10.2.3 Learning Technologies in Education

From the rise of the motion picture in the 1920s to the appearance of the computer in the mid-1970s, educators have been intrigued with the potential of technology to aid in the transformation of education and improvement of student learning (Hew and Brush 2007). Visionaries such as Papert and Harel (1991) predicted computers would be more than powerful classroom tools that allow learners to construct and test complex hypotheses. The computer and a new generation of technology tools provide new rationale for an examination of tools that may be used to improve intellectual effectiveness. Engelbart (2001) conducted a systematic study of the nature of a system comprised of an individual and the tools, concepts, and methods that match capabilities of the person to the problem at hand, based on the belief that "One of the tools that shows the greatest immediate promise is the computer, when it can be harnessed for direct on-line assistance, integrated with new concepts and methods" (p. ii).

While it has been shown that appropriate application of information technology can enhance student learning (Voogt and Knezek 2008), school technology implementations typically have not been in the direction of student use of technology tools as media for interaction with curricular content within schools (Halverson and Smith 2009). The promise of personal computers as tools with power to support new systems connecting learners, instructors, and digital information for learning interaction and knowledge construction continues to be mostly unfulfilled (Halverson and Smith 2009; Bauer and Kenton 2005; Fishman et al. 2004).

10.2.4 Classroom Activities: Transmedia and Learning

To learn, Ritchhart et al. (2011) noted we must think and engage with content. There is, however, concern among educators that trends toward accountability-driven instruction have limited learning opportunities for students (Ravitch 2010), decreasing instances of critical discourse, problem solving, and collaboration within the classroom. Fishman et al. (2004) reported that while many think of technology as being commonplace in K-12 education, cognitively oriented technology innovations, derived from constructivist theories and learning science research, "have not found their way to widespread classroom use" (p. 44).

One option for the introduction of engaging instruction in the twenty-first century classroom is interactive instruction implementing transmedia. Transmedia navigation, as noted by Jenkins et al. (2006) is the ability to conduct research and follow topics, stories, and ideas "across multiple modalities" (p. 4) or media. Transmedia navigation can serve as an important component of a technology-mediated learning paradigm known as the New Media Literacy (NML) framework (Jenkins et al. 2006). Correctly designed, a transmedia lesson that offers students a choice from a variety of media, to include ICT tools for interaction with contents, can function as a blend of student-directed and instructor-mediated research, discourse, and expression that can provoke student thinking. A very simple implementation of transmedia navigation for a middle school classroom would include students reading in class using paperback books, the Kindle, or iPads; topic-related discourse would include classroom discussion and posts to shared blogs; and final presentation choices would include classroom presentations with visuals, student-generated video, or enacted dramatic skits (Warren et al. 2013). As noted by Wakefield et al. (2013), "learning through digital tools, actively seeking content, weaving together storyline, sharing, communicating, and expressing individual understanding—arguing, defending, and critiquing—may provide a way for cognitive learning in a community" (p. 1612) and will additionally provide opportunities for the development of NML skills for collaboration, problem-solving, and knowledge construction.

10.3 Student Attitudes Towards Learning With Technology

Student attitudes can be measured with reliable, validated survey instruments, such as the Computer Attitude Questionnaire (CAQ), which includes five parts that build subscales to gauge: computer attitudes (comfort with computers and learning with computers), empathy, creative tendencies, motivation, study habits, self concept, and attitudes toward school. The CAQ has foundations in an instrument designed for the youngest school-age children: the Young Children's Computer Inventory (YCCI). Research and development of the YCCI was supported by many sources, including the Fulbright Foundation of Washington DC, the Japan Society for the Promotion of Science, and the Texas Center for Educational Technology. The CAQ, developed on the YCCI, was formalized as a validated measurement tool in 1995 and was extensively used in research studies (Knezek and Christensen 1995, 1996, 2000) before being released for public use in 2000. It was then revalidated in 2011 (Mills et al. 2011). The CAQ is comprised of 52 Likert-type statements with a five-point response scale ranging from 1 = strongly disagree to 5 = strongly agree. Cronbach's Alpha internal consistency reliability for the CAQ subscale Learning with Computers (alpha = 0.83) and Creative Tendencies (alpha = 0.88) were found to be very good, according to guidelines by DeVellis (1991) for the subjects of this study. One new prototype item was added to the Learning with Computers subscale for the purpose of this study: *The more often I use a computer at school the more I enjoy school*.

Selected items from the Student Attitudes Inventory (SAI) were also examined during this study. The SAI instrument gauges students' school-related dispositions. The SAI was developed for studies at the Hawaii State Department of Education (Dunn-Rankin et al. 1971). This instrument was designed to gauge a wide spectrum of school-related attitudes. The scales examined from the SAI for the sample of middle school students who participated in that study: all items School Attitude Inventory full scale (alpha = 0.85), SAI Good_student (alpha = 0.87), and SAI Hate_school (alpha = 0.92). These are all "very good" reliabilities according to guidelines by DeVellis (1991; Mills et al. 2013).

10.4 Study Participants

Survey subjects were students enrolled in one of two middle schools in a public school district in north Texas. The sixty-three (63) students completed a survey battery to report their attitudes towards school, technology, and learning during the spring semester of 2012. Survey participants were 48 % boys ($n = 30$) and 52 % girls ($n = 33$).

10.5 Findings

Student survey data, as reported on the CAQ and SAI, were analyzed for Pearson product-moment correlations in order to examine possible trends in students' attitudes towards learning, school, traditional classroom learning media, and classroom use of computers by teachers and students.

Significant positive correlations were identified between student perceptions that computers give them opportunities to learn many new things and:

- The more often the teacher uses computers the more I will enjoy school ($r = .33$, $p = 0.009$).
- The more often I use a computer at school the more I enjoy school ($r = 0.46$, $p < .0005$).
- I find learning new things interesting ($r = 0.40$, $p = 0.001$).

These responses indicated that students who rated higher on the perception that *computers give me opportunites to learn many new things* also reported (1) higher perceptions of enjoyment of school when teachers teach with computers, (2) higher perceptions of enjoying school when students use computers at school and,(3) a higher tendency to be interested in learning new things.

Significant positive correlations were also identified between students' perception that *I would work harder if I could use computers more often* and:

- Computers give me opportunities to learn many new things ($r = 0.50$, $p < 0.0005$)
- I find learning new things interesting ($r = 0.36$, $p = 0.004$)
- The more often the teacher uses computers the more I will enjoy school ($r = 0.40$, $p = 0.001$)
- The more often I use a computer at school the more I enjoy school ($r = 0.48$, $p < 0.0005$)

These responses indicated that, for the students in this study, there was an alignment between feeling motivated to work harder when using computers and perceived opportunity for, and interest in, learning new things. These data also indicated a relationship between feeling motivated to work harder when using computers and feeling that school computer use made school more enjoyable.

A positive significant relationship was identified between the two items *I enjoy books, newspapers, magazines* and *I really like school* ($r = 0.36$, $p = 0.004$). These correlations indicated that students who reported a higher preference for learning with traditional learning media also tended to report a more positive attitude towards liking school. Further examination of students' perceptions of traditional learning media reveals an association between students' preceptions that they do not enjoy books, magazines, newspapers and the subscale Hate_school ($r = 0.42$, p

$=0.001$) of the School Attitude Inventory. This finding indicated that students who had a less positive attitude towards traditional media, such as books, had a tendency towards hating school.

A negative significant relationship was found between the two items *I enjoy books, newspapers, magazines* and *The more often I use a computer at school the more I enjoy school* ($r=0.28$, $p=0.024$). This would indicate that students who reported higher attitudes towards traditional media also reported lower attitude towards computers making school more enjoyable, conversely indicating that students who had a less positive attitude towards traditional media had a more positive attitude regarding computer use making school more enjoyable.

Additional findings from the subscales of the CAQ were that Creative Tendencies and preferences for Learning with Computers were positively related ($r=0.51$, $p<0.0005$), indicating that classroom use of computer technology aligned with students' feelings of creativity or that students who tended to have higher regard for learning with computers reported higher perceptions of having creative tendencies.

The magnitudes of the findings reported, Pearson product-moment correlations, range from medium to large ((where large ($r=0.5$), medium ($r=0.3$), and small ($r=0.1$)), according to the guidelines by Cohen (1988).

10.6 Discussion and Conclusions

The promise of personal computers and ICT as a powerful force for school innovation, change, and improved student learning remains largely unfulfilled in many classrooms even while the advent of personal computers and Internet-based ICT tools are forcing a re-conception of teaching and learning. This study of student attitudes towards learning with technology reveals that students who report a dislike of traditional learning media (such as books, newspapers, and magazines) tended to have a negative attitude towards school and a perception that school is more enjoyable when they have opportunities to use computers in the classroom. The authors suggest that student enjoyment of school is an important consideration for improved educational outcomes and that additional research is needed to determine the extent to which students who report not liking books or traditional media might benefit from alternative access to information, such as that provided by transmedia navigation and the use of all available school media—traditional and technology-based—for learning interactions.

Transmedia navigation within the classroom (allowing students to choose from a wide range of electronic and traditional media for interaction with curricular content) is recommended to support new learning contexts. Student-driven use of classroom technologies may be key to harnessing the power of communications and technology tools to provide engaging options for the seeking and sharing of information within the school context. Allowing students to develop and display media literacy skills and choice in selection of learning media may assist to provide students with opportunities to think, problem-solve, and engage in critical discourse and transformative communications. The authors contend that a design-based research paradigm—continual re-evaluation of classroom practice based on theory-guided experience—can inform adjustments towards classroom technology integration that will relieve teachers of the burden of implementing and teaching large group technology how-to and allow students to seek and employ a choice of media for learning interactions. Additional research is needed to determine if instruction incorporating student-driven technology implementation within new teaching and learning contexts will result in better integration of learning technologies in classrooms while motivating students to engage in cognitively oriented learning activities.

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Part III
Learner Communities Through E-Learning Implementations

Chapter 11
ICT Support for Collaborative Learning—A Tale of Two Cities

Teresa Consiglio and Gerrit C. van der Veer

11.1 Introduction

Our research on ELE is performed in practice, during teaching and working with students. The only type of research possible in this circumstance is action research: we analyse problems, we consider relevant literature as well as the results of our own previous design, we plan improvements in our concepts of ELE and we apply them. Consequently, we assess our actions and start a new cycle.

The current report is an account of another cycle regarding the support of blended learning in the domain of Service Design. Previously (Consiglio and van der Veer 2011) we discussed the intersection between technological innovations and adoption in society for the purpose of adult learning. Our aim was to develop an e-learning environment, to be available both as a standalone-learning marketplace and as support for classroom-based learning. Our intention was to use the open source process to improve the quality of learning anytime and anywhere and make it as flexible as possible towards the culture, learning style and age of the learners. Van der Veer et al. (2011) showed how to adopt features in the ELE starting from the students' goals, in order to support them (and the other stakeholders in the learning process) to work in a real life context. These studies were a first attempt where the development of an ELE took place in a single context, a class of 26 bachelor students in a Curriculum of Architecture and Design of an Italian University in the city of Alghero (Sardinia).

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We took the chance to continue our action research approach by teaching the same course in a new context with an unknown cultural component: a group of ten master students in a university in China in the city of Dalian, starting from the same ELE concept and the same learning resources. Our intention was to explore whether one can design a flexible ELE suitable for teaching in different educational cultures. We discuss our experiences with both cases where the same teacher adopts this technological resource to teach Service Design to Italian and Chinese students.

11.2 ICT and e-learning, Opportunities for Higher Education

Our focus is on University level education and adult learning. At this level, learners and students are able and willing to set their own learning goals (Jones et al. 1994). As far as they participate in a curriculum, the teacher and the educational institute will set learning goals as well. In well-designed education, all these learning goals will be consistent and motivating (Williams and Williams 2011). The type of e-learning that we consider is a learning process where the teacher, the school, and the student all agree on the main goals, and where the students have specific goals related to their personal interests and context.

The development of information society gave rise to dynamic changes in the different tools and technologies available for support of the learning process (Redecker et al. 2009). A couple of decades ago the idea of education provided through the Internet was only just in the beginning. Nowadays e-learning is a widespread practice. E-learning techniques allow delivering educational content through the Internet. For the user-learner this represents a flexible learning solution, highly customizable and easily accessible. For the user-content expert or the user-teacher this represents an equally flexible solution for collecting, formatting, structuring, updating, and maintaining learning resources. In this vision e-learning environments cover a wide range of resources, practice and training applications, and virtual classrooms (Sampson et al. 2002)

In rare cases it seems useful to replace traditional education by e-learning, e.g. when geographical distance or time-zone differences prohibit face-to-face teaching. In many cases it seems useful to complement traditional classroom teaching with e-learning, since it allows learners to (partly) work in their own pace, time, and context, to choose for individual or group learning, to decide on the amount of practice they need or the sequence of studying content. This combination is often labeled *blended learning* (Garrison and Kanuka 2004).

Developing e-learning requires the combination and interaction between learning activities and teaching activities through electronic media. An e-learning environment should provide up to date resources as well as technologies, have a high level of usability and, above all, be adapted to different modes of learning, like inquiry-based learning or collaborative learning.

Effective teaching and learning through e-learning depends on many factors. We will discuss the educational and management viewpoint and refer to the barriers and preferences related to time and location.

11.2.1 Educational Viewpoint

The development and implementation of the e-learning part of a blended course should consider at least three closely related fundamental aspects: course structure; didactic methodology; and planning of different learning activities

The teaching strategy should consider that each student is different both in terms of cognitive and experiential learning and in availability of personal learning time (Boettcher 2007). ICT-based interactivity may in fact accommodate the variable individual needs of teacher and student and the needs of communication and collaboration between teacher and student, as well as among students. It also may support flexible management of educational activities and flexibility in choosing place and time.

ICT allows a flexible combination of, and alternation between, synchronous and asynchronous communication, allowing all stakeholders to communicate with each other in real time through the use of tools such as chat or videoconference, as well as to participate individually at will any time using forums, blogs, wikis, or e-mail. Providing this multitude of opportunities for communication enhances participation, collaboration and involvement in the learning environment.

11.2.2 Management Viewpoint

E-learning allows extensive use of multimedia for the content to be delivered (audio, video, web pages, podcasts, etc.) and of environments suitable for learning management (LMS, Learning Management System) or content (LCMS, Learning Content Management System). In the case of adult learners like we teach, the actual management of the choice, order and pacing of learning activities is anyhow done by the individual learners based on their actual context of learning. The teacher or domain expert who develops and fills the learning environment should support this. Providing adequate concept maps will help the learning in this management task and, at the same time, allows the teacher to explain the structure of learning activities and content in a systematic way suggesting the intended semantic relations in the learning content.

11.2.3 Barriers and Preferences

To overcome barriers of time and place that prevent access to education, students can attend courses they need or like even in remote areas far from universities, or at time available for those with full time jobs or who live in remote time zones. E-learning also allows students to choose their own preferred moments (just-in-time learning) and their own pace, a valuable commodity in the case of students who must balance learning with work or family commitments: our students in Italy mostly are active in (small) design companies, our students in China sometimes have part time jobs in their University, in a Dutch university for distance learning where we teach other courses, most students are considerably older and have a partner or spouse and, sometimes, one or more children.

11.2.4 Opportunities

New technology provides opportunities for, and triggers, modification of the methodological approaches and of the roles of teachers and students within the educational process. We take a constructivist perspective according to which learning is a dynamic process, which takes place either through the active engagement of the student or through interaction with others (Bruner 1960). With e-learning opportunities the teacher's role increasingly develops into being a facilitator and learning tutor, an expert in communication, and a manager and monitor of knowledge acquisition, while at the same time fostering socialization and group dynamics. In this way, the teacher (or learning resource designer) helps students to build their personal knowledge and to contribute actively to the shared knowledge of the group. E-learning is effective when teacher-tutors, content experts, and students develop an interdependent creative and productive relationship.

11.2.5 Designing a Flexible Electronic Learning Environment

In a traditional learning environment good teachers are committed to planning their lessons every day in advance, producing and arranging the materials they will use with their students, or at least making decisions of intended teaching to get ready to do the lesson.

The current availability of internet for use in education, and the actual connectivity to electronic learning environments outside the classroom (at home, in public transport, via mobile telephone providers) allow for, and often require, modification of the teachers' approach and role as well as the roles that students can have in the educational process: Students may and will decide when to learn, for how long, and in which order, based on their current context (at home, traveling by bus). For the phases of learning outside the classroom, teachers will be unable to control the times actually devoted to learning, and the order in which learning resources are approached. Consequently, the teacher's task changes to include enabling and supporting unsupervised learning, providing structure that allows students to make sensible choices, and pointing to additional resources for cases where students might need this (e.g., communication with peers, and pointers to additional relevant internet locations).

From a constructivist perspective (Vygotsky 1962) learning is a dynamic process that takes place both through the active engagement of the student and through interaction with others in order to build personal knowledge as well as to contribute to knowledge of the group. The teacher's role is increasingly to be a facilitator, a communication expert who manages and monitors the acquisition of knowledge and who supports the dynamics of socialization within a learning group.

Effective e-learning is achieved when teacher, students and learning content enter into a relationship of active, creative and productive interdependence. Course delivered in e-learning provides students with the opportunity of choosing multiple beneficial activities paced according to the context and to their individual needs (just-in-time learning).

In an e-learning context new opportunities to improve the quality and variety of teaching and learning allow key innovations to enable students to learn better by being actively involved. E.g., for our courses in Service Design we provide our students pointers to a web-based repository of relevant tools (http://www.servicedesigntools.org) that allows them a variety of learning activities (browsing the tools; choosing tools related to certain types of stakeholders; identifying tools that fit certain phases in the design process; etc.). In addition, we challenge the students to select certain tools from this resource that each of them considers specially relevant, and to teach this to their peers.

In addition, educational activities can be carefully structured in a workflow that promotes more effective learning. A bonus of this approach is the possibility to keep the instructional design for continuous improvement, reuse, and future sharing.

Hypertext and hypermedia technology allow the use of concept maps as a navigable element to access the contents related to the conceptual nodes of the map and then navigate the information space of the map. In our course development the notion of a concept map and its potential applications has been used for planning of the design of two courses in Service Design delivered in blended learning.

Performing the role of content author for e-learning follows more or less the same steps as in organizing educational activities to be delivered face-to-face. The main difference is that for e-learning design the organization of the curriculum must be strictly and totally explicit. After content preparation follows the phase of preparation of the digital environment.

Multiple learning objects are implemented and learning activities are programmed implementing step by step a didactic path. This will often include to find additional materials besides the textbook and fitting it to the multiple modalities and flexible navigation structure of the environment. The variety of available resources such as software packages, links, tools for synchronous and asynchronous communication and the development of transparent interfaces to the Learning Management System require the teacher to combine good teaching skills with the use of state of the art ICT.

11.3 The Course Domain: Service Design

Services are different from products that can be sold. Services are being provided and at the same time being used. After the service is provided the client does not own it, even if the service has been paid for. Production of the service and making use of it occur at the same time.

Service Design means planning and organizing the different providers, the infrastructure, and the relevant communication. Relevant and appreciated services are often based on organizing multiple stakeholders who all contribute to the total service. A well-designed service will provide, both a needed and appreciated help for the clients of the service, and a positive experience of being helped in a way that fits the clients' context and actual needs.

The activity of designing service was originally considered part of the domain of marketing and management. Shostack (1982) proposed the integrated design of material components (products) and immaterial components (services). In 2004, the Service Design Network was launched (www.service-design-network.org) intended to point to the need to make this an explicit design approach, as well as to stress the task of political authorities in this field. Moritz (2005) elaborates the need for a systematic approach to Service Design in relation to the increasing implementation of information systems in this domain. In 2007 the British government published an official statement illustrating an official intention in this direction (Prime Minister's Strategy Unit 2007). From this we learn that Service Design can involve the design of artifacts (physical and non-physical) as well as the organisation of communication, of the situation and environment and of ways to provide and to use the service. Because the actual service exists (only) at the moment of provision and use, designers can not exactly specify them: Service Design only can suggest scripts to the stakeholders and users involved. Service Design requires: identification of the stakeholders, including users; definition of the requirements for the service and the organizational structure; description of service scenarios with roles for the stakeholders; and representation of the service to communicate to all stakeholders and to guide the provision and use during the actual service. In our courses on Service Design we explicitly illustrate this with examples, both from private services (like a tourist office, a driving school) and official government services (a medical help desk, a town market place administration). In these cases we challenge our students to identify the complex structure of required and possible service related activities, and the whole network of stakeholders, e.g. in the tourist office case: hotel management, tourist attraction operators, local public transport as well as private transport providers, business travellers, tourists, etc. (Van der Veer et al. 2011).

11.4 The Context: Two Cities

The first instance of our course in Service Design was taught in the spring semester of the year 2009/2010 to 30 bachelor students at the faculty of Architecture, University of Sassari (Italy), in the town of Alghero. In Alghero there is a tradition of guest students in the group, who manage by trying to communicate in Italian. English, spoken by guest professors, will be understood though speaking or writing in that language is somewhat problematic for part of the students. In our case the Dutch teacher was physically present 10 h (in two days) every fortnight during the semester long (250 h) course while in the remaining time students worked in teams of four or five, and submitted their homework by email. The University provided an Italian speaking tutor who attended all classroom meetings and was available for the students at scheduled times when the teacher was not in the country, to support the students in understanding the learning resources provided by the teacher and the slides of the lectures. Our course was structured along generally accepted approaches of user centred learning, adapted to the domain of Service Design, where collaboration with different types of stakeholders with varying goals, cultures, and professional visions is a main challenge. At all stages of the course, and all phases of the design process, we asked the student to consider and elaborate three aspects: (1) the context of current activities, including all relevant issues related to stakeholders; (2) the design space with all design question to be answered, all possible options, and all relevant criteria; and (3) creativity in considering ideas as well as combinations of ideas from all stakeholders concerned.

The general design method introduced by the teacher was based on DUTCH (Design for Users and Tasks from Concepts to Handles; Van der Veer and van Welie 2003). In this approach, the various stakeholders are in fact identified in the first phase of task analysis. In finalizing step of task design the different stakeholders are all involved in setting the requirements from their different points of view and (business of consumer) context. In the next phase of initial detail design the same stakeholders are all confronted with design sketches and rough prototypes of their part of the system to be developed. In the final phase of dialogue design they are all involved again in assessing the usability of their respective interfaces with the new system. We found this approach matches nicely (and can be offered to the learners as a systematic and design theory basis for) the temporal and stakeholder related structure and

During this course face-to-face meetings between teacher and student occurred at scheduled short time periods when the teacher was in town. Alternative communication was by email. In addition, some of the students could not always be present when others presented work in progress, and expressed the wish to be able to still view their peers' presentations. We identified several issues that required improvement, related to the fact that synchronous communication only was possible during a small part of the time officially devoted to the course: during the course period, the students repeatedly showed a need for a preview of the structure for the remainder of the course, as well as a need for reviewing parts that were discussed before. Also, the students told us it would be appreciated if all content, as well as pointers to additional resources, could be found at a single central location that would be accessible any time. Summarizing: the students hinted at a central website for both review and preview as well as for all additional resources and pointers.

11.4.1 A Pilot Electronic Learning Environment

In the next iteration of the same course (academic year 2011/2012) 25 students were involved in a blended course. Based on the first empirical results we developed practical guidelines for the ELE, for the interaction of teachers and instructional designers with the ELE, as well as for the structure and format of learning resources in it:

- Videos are big and bulky by nature. An average course's recordings may add up to 60 videos of 200 MB, which will stress servers in the infrastructure of the learning environment. For the task of streaming videos to the learners, specialized services are required.
- Lengthy videos are hard to distribute and, even worse, these lose attention of the audience. An inviting educational video is about 10 min.
- Putting the video lectures in a public space like YouTube creates more exposure and possibilities for peers to get involved in use and co-development.
- Public services also offer possibilities for streaming to mobile devices, allowing learners to see the lectures any time, anywhere.
- When introducing an environment that is build up from multiple services, it is best to use the same styling as much as possible to avoid confusion for the users.
- PowerPoint slides should have a strong contrast between foreground and background to guarantee clear readability of text and images in the video.
- The slides should not contain too much text in order to keep these readable even when the video is replayed on a mobile device.

11.4.2 Providing Structure—A Concept Map

In order to support students to find their way in the ELE, a concept map was used to structure the digital environment, based on the lesson plan used in the previous year face-to-face course, see Fig. 11.1.

The characteristic of concept maps is that the concepts are represented hierarchically, with the more general concepts at the top. When developing a concept map one must reflect on the knowledge to be represented, and correlate ideas on learn-

Fig. 11.1 Concept map of the ELE that reflects the structure of the course

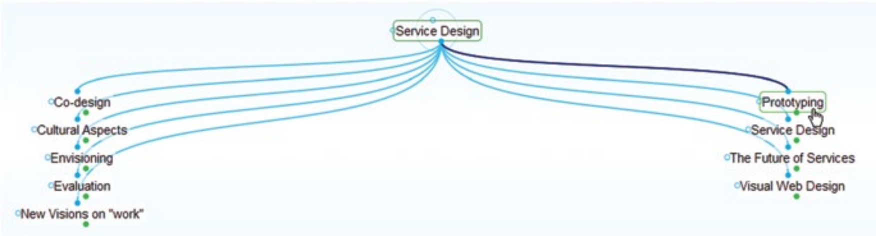

Fig. 11.2 Sub-concept prototyping is selected by mouse over and can now be chosen by a click event

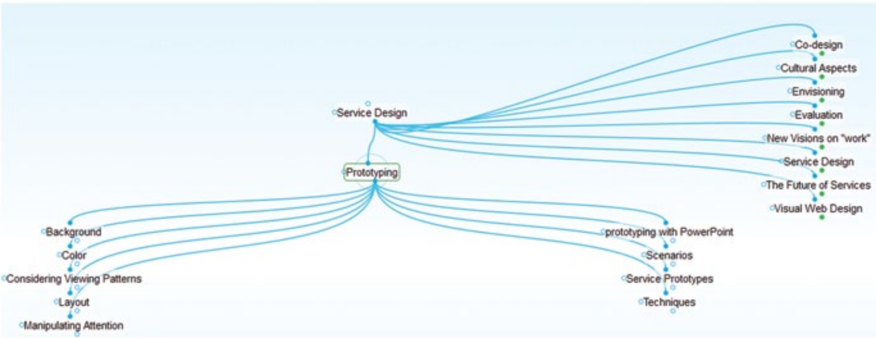

Fig. 11.3 Concept map is restructured by focusing on the element 'Prototyping'

ing and learning content (Novak and Gowin 1984; Novak 1999; Novak and Cañas 2008). For the second and third edition of the Service Design course a dynamic concept map has been developed that is a particular kind of knowledge representation, available only in digital format. Each node can be focused by locating the mouse there, which results in a visual and logical restructuring of the map and the perspective from where it is seen.

When one of the parts of the concept map is chosen (see Fig. 11.2) the map expands around the selected element (Fig. 11.3), which does allow a new selection to re-structure the domain map around another concept (Fig. 11.4, leading to Fig. 11.5). In this way both a teacher and a student are able to explore the structure of the course, to decide on navigation, and to evaluate their current activities in relation to their plan.

11.4.3 Organizing the Course for Different Locations

During the phases of planning and organization of the three editions of the course examined in this paper, concept maps played the role of an organizer, and the instructional design strategies based on mapping have been effective both in a traditional

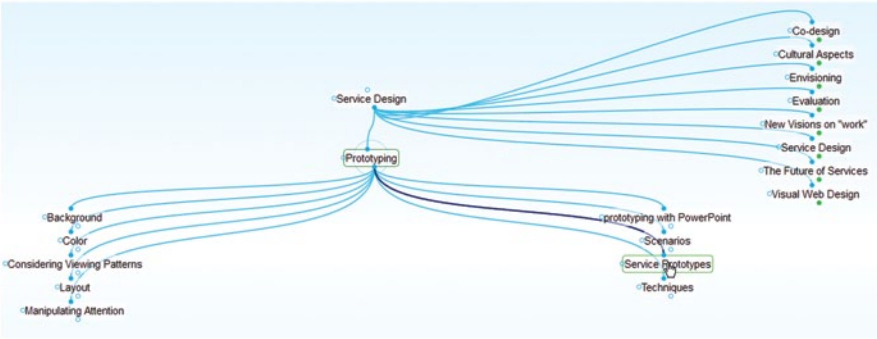

Fig. 11.4 Selection of an item of the sub-domain 'Prototyping' will trigger another re-configuration, where the concept 'Service Prototypes' is core

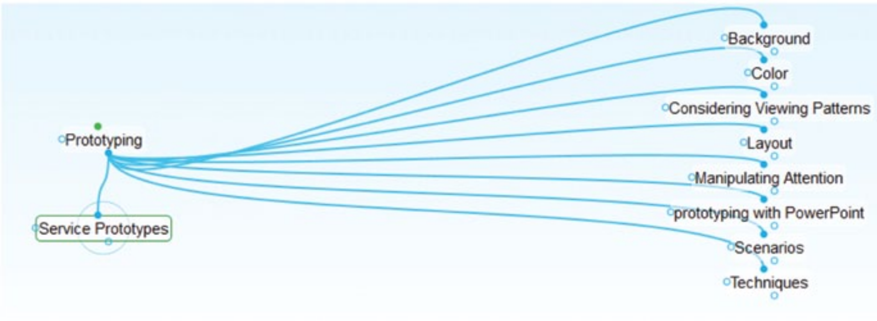

Fig. 11.5 Concept 'Service Prototypes' is now core, and in this case shows there are no sub-parts

educational setting in an e-learning environment (Consiglio and van der Veer 2011). The process of orchestrating the learning process was mapped in such a way that the step-by-step process towards the learning goals was actually executed in the learning environment; promoting the documentation from theoretical justification to every-day help for learners and teachers.

The structure of meetings with the teacher, teamwork, and availability of a tutor was identical to the previous version. The videos of the classroom meetings were uploaded to the ELE immediately after they had been captured see Fig. 11.6. The alternating classroom meetings, team meetings, and the (individual as well as team based) use of the learning environment resulted as an opportunity for blended learning.

Another instance with roughly the same version of the course on Service Design was taught in China, at a group of ten master students at the Dalian Maritime University, in October 2012. One of the students was not Chinese, there was a history of international guest professors, and all were used to speak English in the group

Fig. 11.6 Lecture videos were available immediately at the ELE

and during lectures. In this case, the teacher was available during seven consecutive days (including weekend days) for periods of 2 h while the students were supposed to (and actually did) work for about 8 h or more (60 h in total). The ELE was improved based on or analysis of the previous version in Italy. There was no tutor available, and the students were completely happy to deal with the language issues involved.

11.5 The Current Version of the Elecronic Learning Environment

11.5.1 Global Approach

Like in the first version of the course (not supported by an electronic learning environment), the teacher left most of the teaching to the students. In fact he only explained a small number of Service Design techniques and tools giving pointers to resources, and each student got the task to find the best description of the other tools and techniques the teacher pointed to and to teach to the other students why and how to use these, the benefits, issues and problems, and the conditions for application, The students' presentations were put on a dedicated YouTube channel as a resource during the rest of the course. In order to stimulate the students to improve their mutual teaching, some *excellent* student presentations were identified, and the students got the assignment to review these and to analyze why this examples of teaching made sense to them, both from the content point of view and from the presentation (i.e., knowledge sharing) point of view.

11.5.2 The Actual Design

In both blended courses the use of concept maps for knowledge representation, planning and teaching formed the basis for implementing the sequence of activities. This in effect made that they were transformed into an executable learning process, thereby promoting a concrete realization of the training documentation.

We designed the supporting ELE to inform, inspire and facilitate the students in their classroom-based learning, in collaborative learning and in free individual learning. The content structure and format are intended to provide a holistic learning experience.

Our system was structured based on the lesson plan used in the previous year for a fully classroom-based learning process. It was expanded with additional opportunities for exploration, communication within teams and between multiple teams and teacher. We provided additional resources like online exercises and multiple different modalities of presentation of knowledge. E.g., we developed mini lectures (10 min long teaching of a single technique like Cognitive Walkthrough, Moodboard, Persona) made available in different modalities: (a) full text with pictorial illustrations; (b) video recordings of actual teaching and (c) slide shows with voice-over.

The alternating classroom meetings, team meetings, and the (individual as well as team-based) use of the learning environment supported integration with online learning activities, resulting in opportunities for a blended learning process. Activities to build the learning service were diverse, requiring a variety of skills of the people involved. A close collaboration between teacher and instructional designer is needed particularly during the development phase. They need to match the instructional design of the classroom-based sessions with the online learning activities. E.g., during a classroom session students asked for opportunities to elaborate certain concepts in student teams outside the actual class meeting, to upload their findings on the ELO, and to be allowed to comment on each other's findings before a next class meeting. The teacher did not foresee this but immediately understood the benefit of allowing it. Happily the instructional designer was stand by to adapt the ELO in this case. For a future instance of the course this can now be arranged beforehand.

During the course all lectures of the teacher were recorded on video and published embedded in the learning environment in addition to the presentation slides, to complement the notes that the students made during the lectures. This was especially important in this course because the lectures and class discussions were in English while the native language of the students was Italian or Chinese (in some cases another language like Spanish or Finnish). The recordings were additionally published on a YouTube dedicated channel to make them available on devices like smart phones. Special attention was paid to the way to structure the slides, the readability of text, and the visibility of face and gestures of the teacher in the video version.

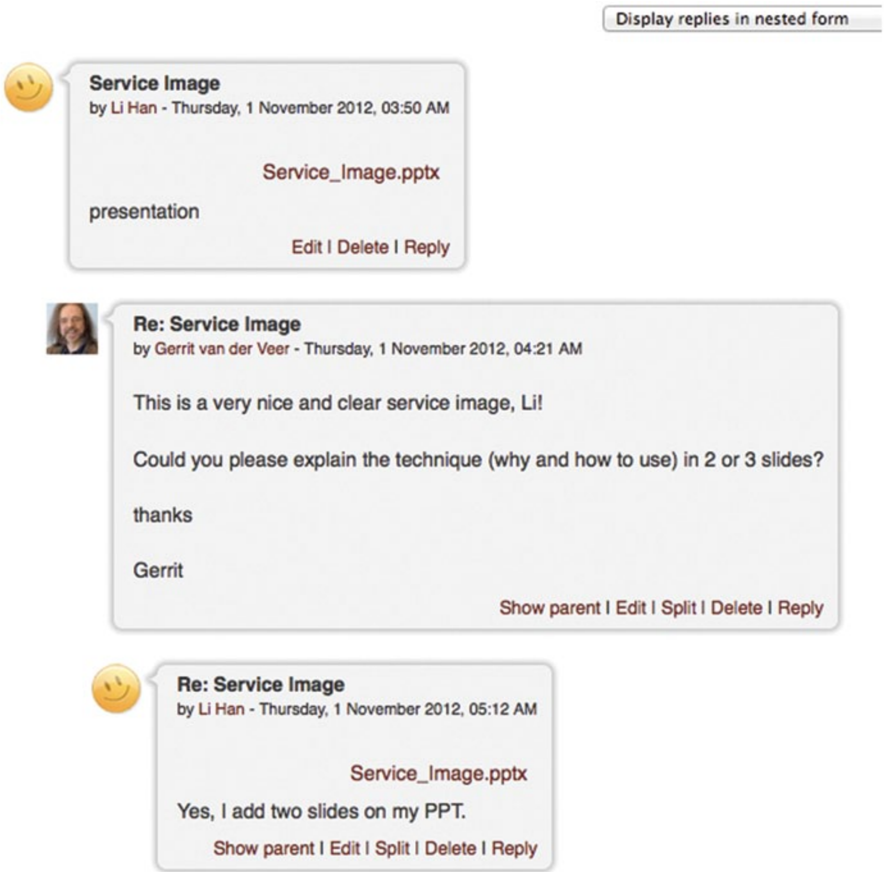

Fig. 11.7 Forum in the ELE on student request, allowing discussion prior to a student presentation

In the case of the Dalian course we made slight adjustments to publish movies because YouTube is not available. Therefore we uploaded the video lectures on a private server and deliver the movies embedded in standard web pages (Fig. 11.7).

11.5.3 Adaptation to Each Individual Class is Needed

The way to prepare, to present, and to discuss sources for the learning environment requires special attention: classroom communication as well as on-line resources featuring in an actual individual course may have to be re-used later (life lectures turn out to survive as YouTube clips, short PDF files, voice-over presentations, citations in student generated learning resources, etc.) but other resources have to be personalized basing on needs of the classroom. Chinese students asked to be allowed to upload their presentation before the lecture, in a plenary forum where their peers and the teacher could discuss beforehand (see Fig. 11.3) while for Italian students it was more suitable to have a dedicated space where they submitted their work individually as a design group to the teacher only, before discussing it in the class.

Consistent with our constructivist perspective on learning, and based on request from some Italian students who could not attend classes where they were supposed to present, we decided to allow them to submit a home recorded video presentation of their mini lecture to the ELE.

11.5.4 Student Opinions on the ELE

At the end of both courses on Service Design that used the ELE we asked the students to answer a questionnaire. For the Italian students, we translated this questionnaire in Italian, the Chinese students were happy to answer English questions. The number of students that participated in the questionnaire ten Chinese students and 13 Italian students) is too small to allow any statistical tests that would allow generalizations beyond the students in the two courses that we actually observed. However, the results certainly provide us with an interesting picture. Table 11.1 provides the answers that the students gave to our list of questions.

Our Chinese group was more positive overall on the help that the ELE provided (question a). This may be related to their educational level (this where master students in their final year) as well as to their fluency in English. It may also be caused to improvements in the course website (we obviously continued to structure the ELE based on our experience with the previous course in Italy). Regarding the specific types of use (question b) we only identified one difference, the Chinese students in our group were less interested to review the teacher's presentation video. Our group of Chinese students was more eager than the Italians to find additional resources (question c), possibly related to their educational level as suggested above in relation to question a. Our group of Italians systematically watched their peers' presentations again (question d), probably because we asked them to do this in our attempt to have them reconsider their presentation performances. For the Chinese group we did not do this, since in fact we did not find too many good examples among the group to start with. In fact we provided some examples ourselves, telling them how we acted in presentation and why ("make sure you look at the audience, that helps make them pay attention, like I just am showing you now"). Because we made a special effort of making the Italian students aware of the presentation skills of some (in fact the best) of their peers, we asked our Italian students what they did learn from the other students' video presentations (question e). It seems only part of the students felt they learned something from their peers' examples. However, both authors, as well as the Italian tutor at this course, were convinced the presentations improved significantly for the large majority of the students in this group. Since in both student groups smart phones seemed to be a natural extension to the students'

Table 11.1 Survey answers for two course groups

Course group:	China (#10)	Italy(#13)
a. ELE did help during course?		
Yes	9	6
A little	1	6
No	0	1
b. ELE useful for		
Finding teacher's slides?	10	8
Viewing teacher's presentation videos?	3	8
Finding URs for extra information?	8	7
c. Wish further resources in the ELE?	9	7
d. Did you watch video presentations:		
Of other students?	5	12
your own?	6	10
e. What did you learn from watching peer presentations		
To make readable slides	Not applicable	6
To speak to an audience		2
To structure the presentation		6
f. ELE feasible for smart phones in the future	6	9

hands we asked them if they would like to use smart phones for courses in the future (question f). Both groups showed a majority who thought this might be expected.

As stated at the start of this section, we would not dare to generalize. But surveys like this help us to find what worked in our current cases and helps us understand what the effect of our effort is. And we consider that the difference between the Italian and the Chinese context did not seem a major source of different student behavior. Based on that we make our plans for a next instantiation of our ELE. That is the essence of action research.

11.6 Conclusion

Our constructivist view on learning in higher education and our action research approach towards iterative design and assessment of an ELE shows how new ICT may be applied to provide blended learning, adapted and adaptable to cultural as well as to individual context and learning needs. We illustrated out approach with the design and application of an ELE for blended learning courses on Service Design in Universities in Italy and in China. The design of the course was structured with the help of concept maps.

We were able to show how we continue to learn from each instance of the course, and we provided a snapshot of one cycle in our approach.

We discovered that a flexible ELE is feasible for teaching in different educational cultures, and we developed some understanding of differences between the two situations.

Service Design was just an example, and in fact we are applying the same approach to other learning domains like Task Analysis, Visual Design, and the Design for Cultural Heritage Support. For these courses, like Service Design, we have the opportunity to develop a "Chinese" version after the current Italian (which are each taught several times with cyclic development of the ELO), we intend to take the opportunity to develop a generic design method for ELOs that, we hope, shows how to cope with cultural differences between the learners and their context.

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Chapter 12
The Investigation of Pre-Service Teachers' Concerns About Web 2.0 Technologies in Education

Yungwei Hao and Kathryn S. Lee

12.1 Introduction

Web 2.0 technologies have been strongly advocated for use in teaching, learning, and industry over the past several years (Altamimi 2014; Hew and Cheung 2013; Wirtz et al. 2010). Their high availability, ease of use, learning affordances, and low cost make them ideal tools for enhancing curriculum and instruction to promote student engagement and learning (Bower et al. 2010; Kapatamoyo 2010; Yen-Ting and Jou 2013). Studies have indicated that the social aspects of Web 2.0 technologies can facilitate learning by connecting school education with informal learning (Cakir 2013; Churchill 2009; Ravenscroft et al. 2012). Furthermore, Web 2.0 tools support collaborative learning and co-construction of knowledge (Bower et al. 2010; Brodahl et al. 2011; Hazari et al. 2009; Krajka 2012).

As Bower et al. (2010) explain, popular categories of web 2.0 tools for teaching and learning include social bookmarking, wikis, shared document creation, blogs, microblogging, presentation tools, image creation and editing, podcasting and the use of audio, video editing and sharing, screen recording, mindmapping, and digital storytelling. Furthermore, Web 2.0 tools may be categorized according to a framework that the authors developed:

> The approach conceptualises Web 2.0 learning design by relating Anderson and Krathwohl's Taxonomy of Learning, Teaching and Assessing, and different types of constructive and negotiated pedagogies to a range of contemporary Web 2.0-based learning technologies. The learning design process can then be based upon the extent to which different Web 2.0 technologies support the content, pedagogical, modality and synchronicity requirements

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> of the learning tasks. The model is resilient to the emergence of new Web 2.0 tools, as it views technology as only a mediator of pedagogy and content with attributes to fulfill the needs of the learning episode (p. 177).

Even though numerous technology integration resources such as Bower et al. (2010) Web 2.0 design framework exist and continue to be developed, using technology as tools in teaching and learning continues to meet resistance and barriers to its use. Integration of new ideas and practices (innovation) is destined to generate concerns among those affected because of its innovative characteristics (Dunn and Rakes 2010; Fuller 1969). When instructional innovation takes places within the context of education, teachers often have concern that may either facilitate or hinder their future implementation of the innovation (Hall and Hord 1987). Fuller (1969) first identified teacher concerns in an organized approach and defined concerns as teachers' feelings related to the introduction of new ideas or methods. Fuller studied small groups of student teachers and proposed that their concerns were developmental in their progression and that those concerns may change and mature as they progress through their teacher education program. The concerns were further categorized in to 3 classifications based on the focus of the concern: self, task, and impact on *students,* within the context of educational settings. According to Fuller, early teacher concerns about implementing innovations were often internal and related to self. For example, early concerns often focused on questioning one's individual competency and ability to implement the innovation. Conversely, stages of concern tended to mature with the succession of the stages in the implementation and often shifted from internal to external concerns, such as task implementation and impact on student learning. The Stages of Concern questionnaire was used to assess pre-service teachers' concern related to technology integration (innovation) in teaching and learning.

In this study, Web 2.0 technology integration in teaching and learning was considered the "innovation." The study defined Web 2.0 technology as those web-based technologies that allow learners to collaborate synchronously or asynchronously. Examples include wikis, concept mapping software, and presentation software. To help pre-service teachers effectively employ the innovation in their future classrooms, it is essential to examine the patterns of their concerns regarding technology integration. The aim of this study was to understand pre-service teachers' concerns related to technology integration so as to illuminate the design of teacher education programs in developing appropriate supporting resources to address the concerns. Adequately addressing their concerns may increase their readiness to learn and integrate the technologies. Therefore, this study investigated the trend of pre-service teachers' concerns in order to inform teacher educators and preparation programs.

12.2 Web 2.0 Technologies and Pre-Service Teacher Concern

Web 2.0 technologies permeate our lives, including educational settings. These collaborative technologies can support the process of collaborative learning and create easy-access online environments for learners to participate (Hazari et al. 2009; Krajka 2012; Magnuson 2013). Therefore, effective teachers integrate these economical technologies into instruction to meet the learning needs of their students as well as prepare them for working in our competitive global economy (Martinovic and Zhang 2012; Moteleb and Durrant 2009).

Teacher education programs are encouraged to equip pre-service teachers with the technological pedagogical knowledge and skills to effectively integrate technology tools in teaching and learning (International Society for Technology in Education 2008) as explained by V. N. Morphew (2012):

> Effective teachers model and apply the National Educational Technology Standards for Students (NETS•S) as they design, implement, and assess learning experiences to engage students and improve learning; enrich professional practice; and provide positive models for students, colleagues, and the community. (p. 4)

To successfully promote the integration of technology into teaching and learning in order to prepare our youth to live, learn, and work in our digital society, requires a commitment from all stakeholders. It seems illogical to expect pre-service teachers to embrace the adoption of technology into instruction unless they have been taught its value and experienced its value in their own teacher preparation learning experiences. Professional development related to the added value of technology integration in teaching and learning is necessary. Professional development that acknowledges participants' resistance and facilitates the de-construction of the participants' pedagogical beliefs may promote adoption of the innovation. For example, Willis et al. (2013) proposed a strategy for decreasing resistance to the adoption of technology implementation in teaching and learning:

> The objective is to decrease the resistance of those academics that may not yet have embraced some of the more modern teaching technologies. This is done by demonstrating that if integrated into existing teaching practices in a systematic manner, any short-term increase in workload can be offset by longer-term efficiencies, along with potential improvements to student understanding and satisfaction. (p. 109)

In line with Willis et al. (2013) systematic strategy in promoting the use of technology in teaching and learning, Archambault et al. (2010) studied the efficacy of a professional development workshop specifically designed for teacher educators. The workshop topics included

- An overview of twenty first century learners and the workplace environment
- An overview of Web 2.0 tools and participant outcomes and products
- Demonstration of curricular uses of Web 2.0 tools
- Time to plan curriculum; select a tool or tools; discuss the roles of teacher and students; and connect curriculum, tools, and twenty first century skills

- Time to plan for action research on the implementation
- Time to share curriculum plans on the project wiki. (p. 5)

Archambault et al. (2010) found that the workshop was effective in facilitating the teacher educators' re-design of an instructional unit that incorporated social networking tools. Furthermore, a significant finding was that through the professional development experience 42 % of the teacher educators shifted their perception related to their role in teaching. According to Archambault et al. (2010), "Role has been changed such that it is less 'teacher led' and is now more student-centered. Students have taken a more active role in their learning, and less emphasis has been placed on direct instruction" (p. 9). As one can infer from the workshop topics, promoting technology integration is not a simple or straightforward phenomenon. Facilitating the process of change is often a complex undertaking.

Leadership and support at various levels is imperative in order to successfully implement innovative practices that require change. As Thomas et al. (2013) assert, numerous levels of support are required to successfully implement the process required to adequately prepare teacher candidates with the knowledge and skills required for technology integration. For example, the investigators emphasize that "national level supports are needed, professional development resources are needed, and college-level, context-specific products and processes are needed" (p. 58). Efforts at various levels are required to promote the change process.

Studies into pre-service teachers' concerns related to Web 2.0 technology integration, such as this one, are helpful in providing insights that may be used by teacher educators, teacher education programs, and professional development designers in expediting the process of change required for adoption. In addition to designing more studies similar to this one, in which valuable insights may be discovered, longitudinal investigations that assess and measure pre-service teachers' technology integration concerns over time may also be beneficial. Studying pre-service teachers' concerns from the beginning of their teacher preparation program to the first several years of their teaching practice may further illuminate the technology integration change process.

Skilled educators employ technological pedagogical content knowledge skills (Mishra and Koehler 2006) in order to design and facilitate engaging and authentic instruction for their students. The use of technology tools in teaching and learning prepares students for today's workforce (International Society for Technology in Education 2008); therefore, pre-service teachers require training in the use of technology in teaching and learning. Koehler and Mishra (2009) explain the complexity of this challenge:

> Faced with these challenges, how can teachers integrate technology into their teaching? An approach is needed that treats teaching as an interaction between what teachers know and how they apply what they know in the unique circumstances or contexts within their classrooms. There is no "one best way" to integrate technology into curriculum. Rather, *integration efforts should be creatively designed or structured for particular subject matter ideas in specific classroom contexts*. Honoring the idea that teaching with technology is a complex, ill-structured task, we propose that understanding approaches to successful technology integration requires educators to develop new ways of comprehending and accommodating this complexity. (p. 62)

To further complicate the challenge, especially related to teacher education, many practicing teachers and teacher educators earned their degrees before educational technology was considered a viable tool for teaching and learning and have little or no experience with using technology in their own learning. Furthermore, they may "not consider themselves sufficiently prepared to use technology in the classroom and often do not appreciate its value or relevance to teaching and learning" (Koehler and Mishra 2009, p. 62). It is no wonder that concern arises when considering the implementation of technology into teaching and instruction. What concerns do pre-service teachers have regarding the task of technology integration? The answer is unclear, and the lack of research related to the pre-service teachers' inner state of concerns warrants investigation.

Various studies have indicated that when teachers are required to change their teaching practice, they tend to have concern (Al-Rawajfih et al. 2010; Bellah and Dyer 2007; Sadaf et al. 2012). Changes to instruction may be initiated by introducing innovative practices or new instructional technologies. Both practicing and pre-service teachers may experience concern related to using technology in teaching and learning, and unaddressed concerns may impede the adoption of the promoted practice. Studies have shown that if teachers' concerns are effectively addressed, lower-level concerns often mature and transform into higher-level concerns, which eventually may dissolve resulting in teachers having less barriers to carrying out the innovative practice (Sanders and Ngxola 2009; Shoulders and Myers 2011).

Fuller (1969) was the first to study the concept of teacher concern. Other researchers followed, and elaborated on her work. For example, Hall et al. (1977) proposed the Stages of Concern Questionnaire (SoCQ) to assess concern about innovation. They conceptualized the model having seven stages of concern. With the model as the framework, Hall and Hord (1987) suggested a Concern-Based Adoption Model (CBAM) to represent the seven stages of concern within four categories. The seven stages addressed in this study are Stage 0 (awareness), Stage 1 (informational), Stage 2 (personal), Stage 3 (management), Stage 4 (consequence), Stage 5 (collaboration) and Stage 6 (refocusing). The four categories of stages include *unrelated* (Stage 0), *self* (Stage 1, Stage 2), *task* (Stage 3), and *impact* (Stage 4, Stage 5, and Stage 6) concerns. The intensity of every stage ranges from lower internal (stages 0–2) (early-stage concerns) to higher external concerns (stage 3–6) (later-stage concerns). The nature of the stages may overlap with each other. The details of each stage are as follows.

In Stage 0 (awareness), teachers may demonstrate little interest in the innovation and are concerned about other things. This stage is categorized as "unrelated concerns." In Stage 1 (informational), teachers lack information about the innovation and its implementation. In Stage 2 (personal), teachers are concerned about how the innovation may influence them personally and worry if they have the ability to implement the innovative practice. Stages 1 and 2 are categorized as self-concerns. In Stage 3 (management), teachers are concerned about how to manage the innovation. The focus is on how to implement the innovation effectively. Stage 3 is categorized as "task concerns." In Stage 4 (consequence), teachers are worried about the impact that implementation may have on their students. In Stage 5 (collaboration),

Table 12.1 Summary of stages and categories

Stage	Name	Category
0	Awareness	Unrelated concerns
1	Informational	Self concerns
2	Personal	Self concerns
3	Management	Task concerns
4	Consequence	Impact concerns
5	Collaborative	Impact concerns
6	Refocusing	Impact concerns

teachers are concerned about how to work effectively with the various stakeholders (e.g., colleagues, parents, administrators). In Stage 6 (refocusing), teachers' concerns center on searching for more efficient ways to modify or replace the existing innovation. Stages 4, 5, and 6 are categorized as impact concerns. Table 12.1 summarizes the sequence of stages and their corresponding categories.

The purpose of this study was to investigate pre-service teachers' concerns on Web 2.0 technology integration. The research questions were as follows:

1. What are the patterns of the pre-service teachers' concern regarding integration Web 2.0 technology into instruction?
2. What are pre-service teachers' specific concerns?

12.3 Methodology

12.3.1 Participants

Data were gathered from 350 pre-service teachers who were moderate users of Web 2.0 technologies attending a teacher education university in north Taiwan during the spring semester of 2012. Of the population 38.5% were male students and 61.5% female, which is fairly representative of the population of pre-service teachers. The pre-service teachers were invited for research participation during their class meetings. Those who agreed to participate were given the consent form and the web site address of the 35-item web-based survey. The participation rate was 90%. Within the survey, they were invited to further participate by agreeing to face-to-face interviews. Eight pre-service teachers provided their emails for participation in the interviews. All participation was voluntary and anonymous, and the participants could withdraw from the study at any time.

12.3.2 Data Collection

This study employed the Stages of Concerns Questionnaire (SoCQ) that identifies the intensity of seven stages of concern related to an individual's concern regarding an innovation. As previously explained, the SoCQ was designed to measure concerns that an individual may have when experiencing an innovative practice (Hall 1979). Each stage of concern is assessed through five test items for a total of 35 items listed in a mixed order. Responses are measured using an 8-point Likert scale varying from "not true of me now" (0) to "very true of me" (7). The higher the number of the stage, the higher is the concern. The SoCQ has been shown to have sufficient validity and reliability (George et al. 2006). Validity of the instrument had been examined in other studies, and the Cronbach alpha coefficients ranged from 0.64 to 0.83 for the seven stages (George et al. 2006). The SoCQ has been used with both in-service and pre-service teachers over the last 2 decades (Al-Rawajfih et al. 2010).

The qualitative data in this study were collected through interviews with pre-service teacher participants who responded in the web-based survey that they were willing to further participate through a face-to-face interview. The interviews were conducted individually, and each participant spent about 1 hour answering the questions. The interview questions included "What are your concerns about integrating Web 2.0 technologies into instruction?" and "Why do you have the concerns?"

12.3.3 Data Analysis

The survey data was coded and analyzed with SPSS 20. Descriptive statistics were used to present the data gathered from the SoCQ. Raw scores for each sub-scale in the SoCQ were tallied and converted to normed percentiles. Descriptive statistics were used in this study to numerically report the pre-service teachers' scores within each of the stages of concern. The benefit of reporting the scores within each of the stages of concern was to identify the pre-service teachers' highest concerns in order to acknowledge and address them in teacher training programs. The qualitative data were collected through interviews and used to complement the quantitative survey data to gain insights into the pre-service teachers' concerns. After transcribing the interview data, the researchers coded the qualitative data and categorized the codes.

12.4 Results

Table 12.2 shows the percentiles for scores for each of the seven stages of concern. Figure 12.1 is a line chart representing the average percentiles for the pre-service teachers and the concern profile. As shown in Table 12.2 and Fig. 12.1, the mean percentiles for the seven stages were between 37 and 66. Table 12.2 shows that the

Table 12.2 Descriptive statistics for stages of concern for the total participants (N=346)

Stage	Mean±SD	Minimum	Maximum
0 (awareness)	37.06±12.57	11.43	82.86
1 (informational)	66.66±16.17	20.00	100.00
2 (personal)	59.97±15.86	0.00	100.00
3 (management)	50.11±16.91	0.00	100.00
4 (consequence)	53.34±13.60	0.00	88.57
5 (collaboration)	58.43±17.43	0.00	100.00
6 (refocusing)	46.86±14.31	0.00	88.57

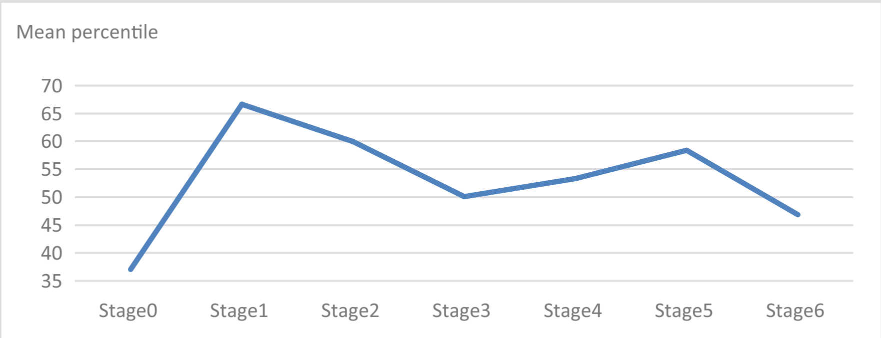

Fig. 12.1. Stages of concern for the total participants

teachers had the most intense concern mean percentile in Stage 1 (information, close to 70%), Stage 2 (personal, 59.97%), and Stage 5 (collaboration, 58.43%). The least intense concern level was in Stage 0 (awareness) (37.06%).

Figure 12.1 shows that generally pre-service teachers focused on their concerns in Stage 1 (information), next in Stage 2 (personal) and then Stage 5 (collaboration). Their levels of concerns dropped in Stage 3 (management) and Stage 4 (consequence), peaked again in Stage 5 (collaboration) and dropped again in Stage 6 (refocusing).

Interviewing the pre-service teachers provided some insights related to the levels of concern that were assessed in the questionnaire. As shown in Fig. 12.2, the pre-service teachers voiced concerns related to three main categories. The categories included concern about how technology integration would impact (a) their students; (b) colleagues and school; and (c) parents.

Several pre-service teachers expressed concern about how the technology integration might impact their students. For example, several reported that they were concerned about their students having equal access to technologies and access to the infrastructure required for Internet connectivity. Several reported concern about the benefits of technology integration on student learning. For example, they were concerned that integrating technology in their classrooms may be distracting to their

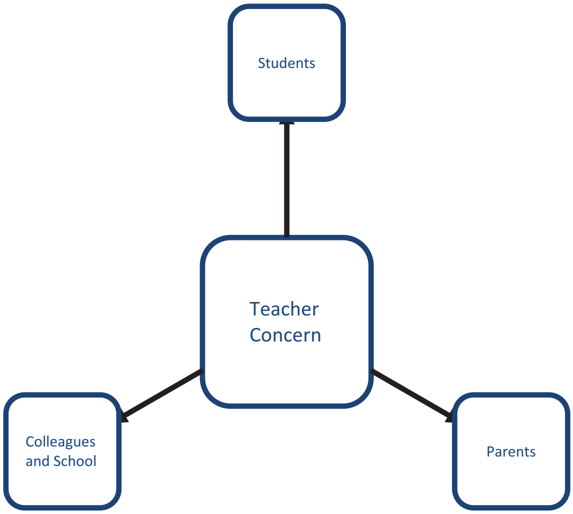

Fig. 12.2 : The macro view of teacher concern

students and may actually have a negative effect on learning achievement. In addition to concerns related to the impact of technology integration on their future students, several respondents reported concerns about how technology integration would affect their colleagues (other teachers) and school.

As for their concerns related to colleagues and school, some of the pre-service teacher interviewees indicated that they would expect financial incentives to integrate technology into their classrooms. One interviewee said, "If I am paid the same amount of salary as teachers who don't integrate technologies, why should I bother to spend extra time on technology integration?" Additionally, several interviewees reported other potential barriers to successful integration related to the school, such as slow Internet speed and bans on social media web sites.

Several participants expressed concern related to how they would explain the benefits of technology in learning to parents of their students. Many reported that most of their students' parents would likely hold traditional beliefs about their views of teaching and learning and would tend to regard Web 2.0 technologies as playful media. They feared the parents would object to the use of social media for learning. They questioned their ability to defend the learning affordances of Web 2.0 tools in teaching and learning.

12.5 Discussion

As illustrated in Fig. 12.1, the mean percentile scores identified the intensity of pre-service teachers' concerns related to Web 2.0 technology integration. Their concerns peaked at Stages 1 and 2, and then dropped gradually until Stage 5 when the concern level peaked again. This implies that most of the pre-service teachers had some general awareness of the innovation, Web 2.0 technologies, and that they had interest in learning the general characteristics related to Web 2.0 integration in teaching and learning. According to George et al. (2006), at the informational stage, teachers usually are not concerned about their personal ability regarding implementing the innovation. They are more interested in learning about the general aspects of the innovation and are less concerned about how the innovation may impact them personally.

The high scores in Stage 2 may imply that most of the pre-service teachers had little knowledge of the use of Web 2.0 technologies in education. Providing pre-service teachers with information about the use of Web 2.0 tools in learning and instruction and providing them resources through workshops or teacher preparation courses may help to alleviate much of this concern. Learning about the general features of Web 2.0, the effects of technology tools on learning, as well as the time, skills and equipment required for the technology integration may likely reduce their Stage 1 concern and help them progress to the next higher-level stages of concern. Furthermore, concern levels that are higher at the personal stage implies that the pre-service teachers' concerns focus on how they will be influenced by the requirements of the Web 2.0 technology integration, and how capable they are to implement the integration effectively. In other words, their concerns center on the impact of the innovation on themselves and their roles in the implementation. Therefore, after providing the pre-service teachers with sufficient information and resources on Web 2.0 integration, teacher education programs may develop these future teachers' self-efficacy by requiring teacher educators to appropriately embed the technologies into their regular instructional activities and create opportunities for the pre-service teachers to learn with the technologies themselves and eventually design technology-enhanced instruction for their future students.

Another peak that the concern profile displayed was Stage 5 (collaboration). That implies that the pre-service teachers have another concern focus, which is on how to work with others, such as their administration, colleagues, parents, and other stakeholders. To alleviate these concerns related to collaborative efforts required for integration, teacher education programs can provide case studies for the pre-service teachers for reference and discussion, and may require teacher educators to model collaborative learning strategies by designing collaborative projects or activities for the pre-service teachers to experience in their own learning. Having technology integration modeled by teacher educators and experiencing the use of technology tools in their own learning will likely help pre-service teachers become more comfortable with technology in learning and help to alleviate many of their concerns. Professional development for teachers and teacher educators that includes the facilitation of dialogue among the participants may be beneficial. De-constructing their beliefs surrounding the innovation may promote participants' insights into their beliefs that may hinder or advance the adoption of the innovation (Orr and Mrazek 2009).

Namely, the pre-service teachers had the most intensity of concern within the informational and personal stages, which corresponded with some of Liu and Huang's (2005) findings in their study of in-service teachers. Liu and Hang found that their in-service teacher participants expressed most intense concerns in information, personal, and refocusing stages. As found in their study and Rakes and Casey's (2002), teachers' concerns tend to be highest in Stages 0–2 during the early phases of an innovation. Unlike our study, Liu & Huang's participants reported high concern scores in Stage 6, refocusing. This difference may be related to their participants being practicing teachers who routinely think about the most effective ways to address their students' academic needs. Another difference between this study and Liu & Huang's is that in our study the pre-service teacher participants held high concern levels in Stage 5 (collaboration). This difference may be related to the culture within the research context. Perhaps the practicing teachers had more experience and comfort with collaboration due to their professional experience that requires collaborating with others as a routine part of their profession. Whereas, in our study, the pre-service teachers may have had little or limited experience with collaborating with others in their education or in their work prior to enrolling in the teacher education program. This may explain their high scores in the Stage 5 collaborative concern level.

Based on the interviews, a few findings emerged. Most of the pre-service teachers who were interviewed acknowledged the significance of Web 2.0 integration in instruction. This supports the low Stage 0 (awareness) scores. All of the pre-service teachers who were interviewed reported that they were familiar with several popular social networking Web 2.0 tools. They reported familiarity with blog tools, such as Google's Blogger, but limited familiarity with other Web 2.0 tools such as wikis, collaborative graphing or presentation software, which are considered more task-oriented. These types of Web 2.0 tools support productivity and the co-construction of knowledge (Bower et al. 2010). A few of the interviewees, who had reported that they personally use some of the Web 2.0 technologies, reported that they had no idea of how to effectively integrate those same tools into teaching and learning. They reported having little or no experience in learning with technology themselves. They also reported that they had not had any formal training in pedagogy related to using technology tools to enhance learning and teaching in their preparation program. Namely, they reported a lack of confidence and ill preparedness to undertake the task of technology integration in the classroom. The pre-service teacher interviewees' reported lack of self-efficacy might explain why the overall concern levels in Stage 1 (informational) and Stage 2 (personal) were highest among the 7 concern levels. Their low levels of management concerns (Stage 3), those associated with the operation and management of the technical aspects of integration, may be due to the reported familiarity and technical experience with using social networking tools in their personal lives. The pre-service teacher interviewees voiced other concerns related to integration of technology tools in their future classrooms as well.

Some of the interviewees voiced concerns about their future students' access to technology. They expressed an awareness of how economic inequities related to computer ownership and the infrastructure required for access to the Internet might impact their students' access, ability, and willingness to use Web 2.0 technologies in learning. They also disclosed that they were worried about their students' parental resistance to the use of technologies for learning. They felt unprepared and apprehensive about responding to parents' questions and concerns about the impact of technology-enhanced instruction on student learning. They also communicated that they were concerned about the level of administrative support in the schools and support from their colleagues, other teachers. Several of the interviewees divulged that they were anxious about how the effectiveness of technology integration would be evaluated. Their concerns related to the evaluation may explain the high concern percentile scores in the impact-concern stages.

The significance behind the study lies in the findings about pre-service teachers' concerns on Web 2.0 technologies, which can illuminate the concern theories on teachers and can provide practical direction for teacher educators and teacher education programs to improve the quality of teacher education. Several implications may be drawn from this study. The Stages of Concern scores and interviewee comments clearly indicated that these pre-service teachers felt unprepared to adequately integrate Web 2.0 technologies in teaching and learning. The pre-service teacher interviewees reported a lack of first-hand experience with using technology in learning themselves and lack of modeling technology use in teaching and learning in their teacher education program. Some reported that although they had learned some pedagogical skills in their training, they lacked competency in their ability to apply those pedagogical skills in relation to new contexts.

A few of the pre-service teacher interviewees raised concerns related to the effectiveness of the innovation in enhancing student learning. In order to address these concerns, teacher education programs committed to promoting the use of Web 2.0 tools in teaching and learning may strengthen their curriculum by including the study of the empirical research base related to the implementation of technology tools in learning. Furthermore, teacher educators may address the pre-service teachers' concerns related to their competency and ability to effectively use the tools in their classrooms by providing the pre-service teachers instruction in pedagogical reasoning required for designing meaningful technology-enhanced instruction. The concerns that a few interviewees raised about wanting financial incentives to motivate their technology integration in relation to other teachers who do not employ technology that are paid the same salary may be linked to the belief that integrating technology into instruction requires more planning, time, and effort than is required of other teachers who do not. Perhaps barriers to technology may be linked to individual personality characteristics. Investigating the phenomena related to individual characteristics or types who are resistant to change as compared to those individuals who embrace change and are constantly striving for ways to improve their teaching to impact student learning would be worthy of future study.

Like all studies, this one has limitations. First, the findings came from a limited sample size and specific population of pre-service teachers in an East Asian country, so the results may not be generalized into other contexts. It is suggested future study be conducted in other cultural contexts. Second, although the results indicated different intensity and types of concerns, the study did not investigate the relationship of the concerns with the personal characteristics of the participants. Future study is encouraged to include the participants' individual differences into investigation. Third, although self-reported data from surveys and interviews may provide rich insights into the phenomenon being studied, self-reported data also has its limitations. Self-reported information, by its nature, is inherently biased and subjective and threatens the validity of a study. Future study is suggested to include analysis of individual discourse, such as analysis of learning journals in which participants document their individual experiences. This would allow a direct examination of the participants' individual concerns.

12.6 Conclusion

Even though change in educational practices and beliefs is often challenging and slow to implement (Hargreaves 2005), as teacher educators, we can act as agents of change and promote practices that positively impact student engagement and learning achievement. A significant component of that change process is understanding and addressing pre-service teachers' concerns related to the innovation of integrating Web 2.0 tools in teaching and learning. Acknowledging and explicitly addressing pre-service teachers' concerns inform and enrich the teacher education knowledge base. Teacher educators, teacher education programs, professional development designers, and other stakeholders may use these insights into pre-service teachers' concerns to more effectively promote Web 2.0 technology integration into teaching and learning. Equipping pre-service teachers with necessary pedagogical skills and requiring them to use technology as tools to enhance their own learning will likely facilitate their adoption of the innovation. Understanding pre-service teachers' concerns may also inform teacher educators and teacher education programs as to changes they may need to implement in their teacher preparation curriculum and teaching practices. After all, we educators all share in our commitment to effectively prepare our youth so that they are able to learn and work productively in our ever-changing world and competitive global economy.

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Chapter 13
Teacher Training Using Interactive Technologies: Performance and Assessment in Second Life and Simschool

Julia Meritt, David Gibson, Rhonda Christensen and Gerald Knezek

13.1 Introduction

In spite of efforts to better prepare teachers and support their induction into the profession, the high attrition rate of teachers, where half a million U.S. teachers either move or leave the profession each year (Alliance for Excellent Education 2014), suggests persistent problems. Many of these problems concern classroom management skills. This article introduces two highly interactive technologies aimed at giving pre-service and new teachers improved classroom management training situated in virtual classrooms. Both technologies involve simulations that address the challenge of providing pre-service teachers with ample experiences interacting with the wide variety of student behaviors they will encounter in the real world of teaching. One approach involves a Second Life environment in which pre-service teachers play the role of a classroom teacher or students in a classroom. Afterwards, the class debriefs and discusses the behaviors and teacher responses, and makes suggestions for alternative actions. The second approach involves simSchool, a flight simulator for teaching that uses a computational model of teaching and learning. SimSchool supports practice and reflection on a variety of teaching challenges, including classroom management, classroom activity design, student personality attributes, and

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the psychology of learning. Each technology—role playing and computational modeling—will be introduced in its own section, followed by comparisons and contrasts between the two. The discussion section will first summarize implementation considerations and then focus on assessment issues arising when comparing the two.

13.2 Conceptual Rationale

To be productive and thrive, educators are tasked with developing a deep understanding of the complexities of the interactions between teachers and students that lead to the engaged, productive learning they strive for daily. Teachers with a positive sense of efficacy with regards to classroom management are likely to remain in the profession longer (Glickman and Tamashiro 1980). Virtual spaces can provide a means to mediate efficacious identity construction in educators as well as to inform our understanding of how pre-service teachers go about learning to teach.

Bowers et al. (2009) claim, "Constructivist applications of technology promote student-centered learning with real-world relevance by offering unique opportunities for interactivity, collaboration, critical thinking, problem-solving" (p. 95). In realistic and immersive ways, pre-service teachers either role-play teachers in Second Life, or choose from a variety of teaching acts in response to diverse pupils in the classroom using simSchool. In both cases, teacher education students learned about teaching when they played the role of teachers in virtual spaces because they were offered concrete entry points for negotiating an understanding of the complex phenomena (Ackermann 2004) of effective classroom management.

Learning breaks down and reconstructs itself in micro worlds such as those described in this chapter. Whether pretending to be a pupil or a teacher or observing others in similar play, students' progressively internalize teaching acts. Learning is fragile Papert (1980), and, while immersed in virtual worlds, actors have opportunities to play with alternative strategies in safe spaces (Ackermann 2004) to sharpen and make explicit their fragile understanding of effective teaching. Students may gain realistic insight into their classroom management skills as actors (avatars) because they can be the role they are playing and also retain a distance from that role. For example, simSchool allows students to integrate new understandings of teaching from the perspective of the teacher and in Second Life from the perspective of both the teacher and the pupil.

Digital simulations offer a promising new way to provide a practice environment for student teachers (Grossman 2010). Simulations provide a low-risk, high-touch, scalable and efficient method for microteaching and pedagogical experimentation by integrating the elements of fantasy and play with realistic dynamics and authentic actions into the pre-service classroom. The two methods presented here, a virtual world for role-playing and a computational model of learning embedded in a game-like interface, each have different affordances for virtual professional practice, introduced below.

Among the new affordances of simulation-based professional practice, new assessment opportunities stand out. In a virtual role-playing environment, students may feel liberated to experiment and take risks, and may experience heightened emotions while microteaching or observing others as they experiment. Using a grounded theoretical approach, the Second Life researcher observed actual micro teaching events, interactions with other virtual students in and after each event and discussions about those interactions. Furthermore, students' written reflections were coded to discern patterns whereby students revealed their thoughts regarding the implications of pedagogical decision-making observed or enacted during each event. In the case of interacting with a digital model such as simSchool, the assessment challenge includes how to make sense of what a user knows and can do based on an analysis of interaction log files. The log files are typically time-stamped records that provide a high-resolution view of the user's performance over time. These files can become quite large in comparison to typical educational measurements, often comprising thousands of records for a single virtual performance interaction, compared with dozens or perhaps a hundred responses from a 30-min multiple-choice "test." Several recently edited books have begun to bring together findings from researchers who are grappling with the issues of time, sequence, action relevancy, big-data pattern recognition, grain size and resolution, overlapping patterns, levels of meaning and other intriguing challenges (Ifenthaler et al. 2012; Mayrath et al. 2011).

Today, a person responding to assessment prompts embedded in a digital game or simulation, or anyone working with digital media and tools in an online space, can perform a wide range of actions, can do so continuously over extended periods of time, and can leave behind traces of decision-making, intentions, and even emotions (Dede et al. 2004; Gibson 2011). These new ways of performing introduce a need for new psychometric considerations for methods of data capture, analysis and display. Digital performance-based data also raise the possibility that learners, teachers, psychometricians and others may be able to assess and evaluate new kinds of assessment targets best exhibited through complex tasks and artifacts, targets such as critical thinking, collaboration, creativity, and communication as well as physical performances that demonstrate these skills. New reports from exploratory research such as the two profiled here can offer additional insight and help lead to ideas that may prove useful for a synthesis of methods that are emerging to deal with the data from interactive digital learning applications.

13.3 Simulated Learning Environments

13.3.1 Classroom Management in Second Life

For a course entitled "Classroom Management and Teacher Student Relationships," four university colleagues launched a virtual third grade classroom. These four included: (1) and (2) A project manager and a Second Life expert from the university

Instructional Technology Support Team, (3) the Instructional Technology Coordinator, also a Second Life expert, and (4) the course instructor and Subject Matter Expert (SME). Together this team created a prototype to ascertain whether the virtual reality tool, Second Life, would be a viable means to help pre-service teachers practice classroom management skills in a relatively risk-free environment.

Students practiced managing a series of mildly challenging student behaviors virtually. Class debriefings held after each of four simulation scenario enactments, whole class discussions and detailed reflective papers allowed students to construct emerging identities as classroom managers both interpersonally and on an intrapersonal level. Flores and Day (2006) describe the "notion of identities as an ongoing and dynamic process that entails the making sense of, and reinterpretation of, one's own values and experiences. They identified three main shaping forces: (a) prior influences, (b) initial teacher training, and (c) school contexts" (Schaefer 2012, p. 12). Potentially all three of these forces come to bare in shaping students construction of identities as educators as they participated in the activity.

Though many students found working in a virtual environment for the first time challenging, they unanimously agreed that the process informed their teaching practice. This section will describe the process of creating four scenarios used in Second Life, the actual scenario enactments, and student interns' responses to the experience as a whole.

13.3.2 Constructing Knowledge in Second Life

Second Life provided a virtual space for students to construct a deeper understanding of some of the technical aspects of teaching, specifically classroom management. The instructor facilitated the learning process (Dewey 1938) in a virtual Zone of Proximal Development (Vygotsky 1978) in which students practiced management skills in concert with their peers and with the scaffolding of their instructor. Students co-constructed knowledge of individual teaching acts within the virtual environment, during peer-led debriefings held immediately after role-playing, and finally through personal reflections.

When used as a tool to augment and enhance the quality of instruction for college faculty, virtual reality can pose some challenges. Faculty may not have adequate knowledge or university support to do so effectively. However, given the expertise of programmers and a supportive instructional technology department, it was possible to create an intriguing and provocative assignment that both forced and allowed students to become immersed in the required curricula.

It is interesting to note that, for the team, this project afforded opportunities for learning on two levels. Firstly, while conceiving and constructing the prototype the team negotiated a shared understanding of the complexities of classroom teaching as well as the limitations and possibilities for play in virtual spaces. The Instructional Technology [IT] team had to learn the instructor's vision for students to have life like virtual classroom experiences. Moreover, the faculty member learned that, while virtual spaces are quite life-like on many levels some of the subtleties of human behavior and, thus in this case, interactions between a teacher and his/her third graders do not always translate into a virtual classroom as well as s/he might have expected.

Bi-weekly meetings facilitated a shared understanding of virtual space programming and fairly typical classroom exchanges between third graders and their teachers. Many discussions were necessary in order to make the avatars as life-like as possible within the scope of Second Life and to design scenarios that were practical, but still as authentic to real classroom life as possible. In the end, the programmers created an inviting virtual classroom, and the course instructor fashioned scenarios that translated into a workable virtual classroom in which student interns might begin to become more confident classroom managers.

The IT Coordinator was single-minded in her ability to sharpen the focus of the project throughout, never losing sight of whether or not the project would retain its usefulness for student interns. The efforts ensured student buy-in enabling them to describe and analyze their virtual actions and tangible learning. The activities resulted in an assignment, which invited students to participate as either a virtual student or teacher, construct new points of view collectively and reflect deeply.

Secondly, the multilayered task required students to engage with the topic at hand in diverse ways. All students pretended to be the third graders who populated the virtual classroom, and some were randomly chosen to role-play the virtual teacher in selected scenarios. Further, students were asked to partially disengage from their role-playing to debrief interpersonally with peers and the faculty member. And finally, students examined the entire process on an intrapersonal level by explicating describing what they learned in carefully guided reflective papers. In all, the process, including training and acclimation to Second Life, four scenario enactments of about 15 min each and debriefing after each scenario for about 15 min took 1 full instructional day spent at the computer lab in the IT department.

13.3.3 Scenario Enactments

To get started, the team's programmers who were experienced at orienting undergraduates to Second Life provided students with written directions explaining how to create personal avatars requiring students to create their avatars prior to meeting in a technology laboratory on campus. This forced students to gain at least a rudimentary understanding of virtual spaces in the event that they might be new to Second Life. The next step was to spend time orienting students to the university island and how to navigate it. Students were given time to practice walking, flying, using headsets and learning from orientation stations created to help them navigate the virtual world and to troubleshoot technical issues on the morning of the simulations. Students' laughter and jokes illustrated the success of the orientation that ended with a group picture of our Second Life class (Fig. 13.1).

Fig. 13.1 Student avatars during orientation

Each of 16 students was assigned the role of a pupil (third grade avatars). Four or five selected pupils were to be the 'stars of the show' for each scenario. As such, they were cued to misbehave in prescribed ways. Individuals randomly selected to be the simulated teacher left the lab to manage the class from a dedicated space in another room where she was given an overview of the scenario and minimal instructions for setting the scenario in motion.

Though not designed as such, the first scenario became a practice run. The teacher of that scenario reported being disoriented having never used Second Life before and the students as avatars simply acted like children might without supervision (Fig. 13.2). The following scenarios B, C and D functioned much more as the scripts directed. Each teacher dealt with typical classroom situations described briefly in each scenario. From managing a class that took place on a holiday to managing one with small group or peer interaction directives, students enacted roles as teachers in situations that were very familiar because they were also interning with a classroom teacher 1 day a week in a public elementary school near their university campus.

After each scenario enactment, students were provided with 10 min to make notes about what they observed in a prescribed framework. For example, in Scenario A the notes sheet read as follows: Discipline is a process, not an event. How did the teacher in this scenario appear to demonstrate that she believes it is her role to teach students how to behave appropriately in the classroom? Did she provide structure and choices that helped students behave properly? Select at least three below to make notes on: Connections, New Understanding, Analysis, Questions, and Self-Criticism

Whole-class debriefings followed each scenario enactment. This important part of the process brought the guidance of the instructor as well as the comments and feedback of colleagues to bear on their understanding of the process.

Fig. 13.2 Teacher and third grade avatars during a scenario enactment

13.3.4 Student Intern Responses

At this juncture in their studies student interns were particularly invested in learning how to manage a classroom effectively because they spent 1 full school day a week in the field observing/ practicing in an elementary school. Further, they concurrently took a classroom management course focusing on theories and models covering a broad spectrum of values and educational philosophy. In particular, students were expected to examine personal philosophies, beliefs, and style of teaching as they relate to the various methods of classroom management, student discipline and teacher-student relationships. Following this course, student interns enter student teaching. This next step in their development makes it vital to them that they learn exactly how to manage a classroom effectively. Students are genuinely concerned with being both effective and kind. They want their own future pupils to learn, enjoy the experience of learning and to feel safe in their care.

Emergent themes collected from analysis of student reflections revealed pre-service teachers considered student perspectives, mentors as models, course readings and deeply held beliefs about how classrooms should work when reflecting upon how they might manage their own classrooms in the future.

Themes include: virtual teacher moves versus perceptions of correct moves, plan to try some effective techniques in the future, pupils' perspectives, acknowledgement of complex variables regarding effective class management techniques including: rules/consequences, procedures/preparedness, student choice, timeout/punishment, positivity/firmness, mentors' models of teacher behavior, and course content relevance to the 'real' classroom.

13.4 Virtual Pedagogical Practice in Simschool

A major challenge facing beginning teachers is how to juggle teaching and learning parameters in an often-overwhelming context of a new classroom. The classroom simulator, simSchool, has been established, improved and researched for its role in contributing to teacher development to help address this challenge. In this brief overview, we provide the rationale for using a computational model as the engine for a teaching simulation, describe in broad terms how the model works, and share the results of research on simSchool.

The use of digital games and simulations to help prepare teachers is inspired by the dramatic rise and growing appreciation of the potential for games and simulation-based learning in professional training (Aldrich 2004; Foreman et al. 2004; Prensky 2001). Research and development of teacher education games and simulations is in its infancy. The new field has the twin goals of producing better teachers and building operational models of physical, emotional, cognitive, social and organizational theories involved in teaching and learning (Gibson 2007, 2008, 2009). These considerations are situated in the broader arena of the role of technology in field experiences for pre-service teachers, since the goal of the simulation as construed here is to provide learning and training opportunities that can transfer to the real classroom and if possible, improve teacher preparation.

13.4.1 Computational Representations of Teaching and Learning

In brief, simSchool uses a dynamic modeling approach in which the user is a teacher who is an independent actor that chooses tasks and talking interactions, which in turn act as attractors for automated simStudents. The artificial intelligence driving each simulated student is based in part on a hill-climbing algorithm; each student attempts to reach equilibrium by attaining the goals of a given task if the task and setting do not impose too many barriers and the system is not perturbed by any other user actions. The time it takes simStudents to reach equilibrium with a task is determined by how their personality variables (three physical, five emotional and two cognitive variables) interact with the requirements of the tasks and the teacher's talking choices. The game-like goal of simSchool is for the player to influence positive learning differences for all students during a teaching session.

SimSchool promotes pedagogical expertise by re-creating the complexities of classroom decisions through mathematical representations of how people learn and what teachers do when teaching. The model includes research-based psychological, sensory and cognitive domains similar to Bloom's Taxonomy of Educational Objectives (Bloom et al. 1964). Extending that theory, in simSchool these domains are defined with underlying subcategory factors that reflect modern psychological, cognitive science and neuroscience concepts. For example, the Five-Factor Model of psychology (McCrae and Costa 1987, 1996) serves as the foundation of the student personality spectrum. This model includes the following characteristics: extroversion, agreeableness, persistence, emotional stability, and intellectual openness to new experiences. For each of these five factors a continuum from negative one to positive one is used to situate the learner's specific emotional processing propensities, which can shift as the context of the classroom changes. A simplified sensory model with auditory, visual and kinesthetic perceptual preferences comprises the physical domain. For each of these physical factors, a scale from zero to one represents the simulated student's strength and preference in a unified model (e.g. a setting of zero means that the simStudent both cannot see and has no preference for visual information and a setting of one indicates that the student can both see and has a high preference for visual information). A flexible single factor is used to represent a specific academic domain. Together the physical, emotional and academic factors are used to represent salient elements of classroom teaching and learning (Gibson 2007).

Aspiring teachers interact with this cognitive model over several sessions spanning several weeks, with micro-teaching interactions lasting from 10–30 min; and attempt to negotiate the simulated classroom environment while adapting their teaching to the diversity of students they face. Additional details concerning how simSchool works—how the simulated students respond to tasks and teacher talk—can be found in previous publications (Christensen et al. 2011; Zibit et al. 2006; Zibit and Gibson 2005).

The simSchool game mechanic ensures that the difference between any starting condition and any current or ending condition of the game is a result of the decisions made by the player. If a simStudent has learned or failed to learn, it is directly traceable to the user's decisions. While it oversimplifies the complex art of teaching practices, this arrangement actually allows a wide variety of performances by simSchool users, with potential for a number of inferences that can be made based on the digital record as well as by pre- and post-assessments and concurrent observations of the users.

13.4.2 Indications from simSchool Research

Results spanning several years of study Knezek et al. (2012) suggest that simulations such as simSchool can play an important role in preparing tomorrow's teachers. Pre-Post data gathered at three points in time across 5 years indicates that simSchool in a pre-service teacher candidate environment measurably increases Instructional Self-Efficacy (confidence in one's competence), Learner Locus of Control (the teacher's sense of responsibility for learning results), and Self-Estimates of Teaching Skills, Experience and Confidence. Which of these areas is most greatly impacted appears to depend on intertwined factors such as (a) the purpose of the course in which simSchool is utilized (and hence which aspect of simSchool is featured), (b) the level of development of the teacher preparation candidate, (c) the extent of prior experience with teaching, and (d) time on task in the simulator.

Research on simSchool indicates that it provides pre-service teachers with a safe environment for experimenting and practicing techniques, especially methods of addressing different learning characteristics, and wide variations in academic and behavioral performance of students. Replicated findings reported since 2006 indicate that similar outcomes can be expected if produced and tested in products such as simSchool, as simulations expand into wider use in teacher education (Christensen et al. 2012). Findings in this 2012 review of research on simSchool illustrate that the simulation is capable of modeling a wide range of student learning, and can be envisioned as having significant impacts on improvements in teaching. For example, for a treatment group, Teaching Skills (ES =1.0, p <0.001) and Instructional Self-Efficacy (ES =0.95, p <0.001) exhibited large gains. Learning Locus of Control (ES =0.25, NS) changed from a belief that a teacher is "very limited in what he/she can achieve because a student's home environment is a large influence on his/her achievement" toward the belief that the teacher can make a difference in the child's life.

Avenues by which this can happen are also becoming clear. For example, as pre-service teachers learn how to read the student descriptions and learning characteristics indicators in complex representations of teaching, and how to make appropriate adjustments in task sequence and complexity, simulations can help them see better results and gain confidence in their abilities. The strongest findings from matched treatment versus comparison analyses for general preparation pre-service educators using simSchool in the 2012 review of research were found in the area of Instructional Self Efficacy, a kind of resilience against "giving up" when a strategy or activity attempted by a teacher does not succeed in the classroom. The pre-post gain in this area for the treatment classroom (Pre-Post ES = 0.96) was sufficiently greater than the gain for the comparison group (Pre-Post ES = 0.40).

Hopper (2014) showed that Instructional Self-Efficacy increases with simSchool use as pre-service teachers may be overconfident before extensive classroom experience, and simSchool experience brings their expectations more in balance. Pedagogical balance is a new measure created by the simSchool research team through grants awarded by the U.S. Dept. of Education Fund for the Improvement of Postsecondary Education (FIPSE), the Gates/EDUCAUSE Foundation, and the National Science Foundation to assess alignment of perceived confidence and experience. Pedagogical balance is defined as the difference between a person's average confidence rating for teaching and average experience rating for teaching. The lowest rating on the 16-item Survey of Teaching Skills used for examining pedagogical balance is 1.0 for each measure, while the highest is 5.0, so the greatest possible difference between confidence and experience is 4.0. The idea implied by the concepts underlying pedagogical balance is a difference score equal to 0.0 indicates that the confidence of a pre-service teacher is aligned with his/her experience. Experience has been found to increase after simSchool training. Pedagogical balance has shown improvement as pre-service teachers' experience increases and becomes more in balance with confidence.

In the end, there is growing confidence that users of simSchool become measurably better teachers. The findings of different gains in treatment versus comparison group indicators can be interpreted as evidence that the instruments work and that the simulator is useful. Further research is needed to verify long-term impacts of simSchool on teacher quality and K-12 student learning. Similar outcomes can be expected if produced and tested in products such as simSchool, as simulations expand into wider use in teacher education. Findings reported to date illustrate that simulations are capable of modeling a wide range of student learning, and can be envisioned as having significant impacts on improvements in teaching.

13.5 Similarities and Differences

This section will compare features of the two simulated teaching environments that have the same end goal—to prepare teachers to be more effective in the classroom.

13.5.1 Similarities

SimSchool and Second Life enactments of teacher actions have multiple similarities. In both models, students interact with virtual students as the teacher. Both technologies support gains in confidence and self-efficacy through realistic instructional decision-making without risk of harm to real children. Practice in these role-playing environments leads to teacher competence. An incompetent teacher can derail a student's learning so much that they may never recover. "Regardless of socioeconomic status or family background, students succeed if they have a series of several good teachers" (Indiana's Education Roundtable n.d.).

Researchers studying teacher effectiveness found that students in the classroom of a high quality teacher may gain 1 full year more learning than students in an ineffective teacher's classroom (Prince et al. (nd)). Other researchers have found that students who were placed in a classroom with a highly effective teacher for 3 consecutive years were likely to score up to 50 percentile points higher in mathematics than students in the classroom of an ineffective teacher for 3 consecutive years (Sanders and Rivers 1996). Student interns are very much aware that, "a high quality teacher may be the single most significant factor in student success" (Hoglund and McClung 2012).

Students' intrinsic motivation to win at the game of teaching is present whether they are using simSchool or Second Life. In both environments, either the instructor or other students can create new scenarios and the simulations can then evolve as users interact in the scenario. In simSchool the progression of the scenarios are repeatable within close but flexible bounds, allowing for single player experimentation and private asynchronous practice. In Second Life, the scenarios are socially constructed and are experienced in a live group setting leading to rich, socially constructed learning.

13.5.2 Differences

The primary difference between the two models lies in how knowledge is constructed while students are in situ. In the virtual environment created in Second Life, students are both the actors and the acted upon in concert with an audience of their peers. Students construct their understanding of effective teaching socially before, during and after the experience. In simSchool the pre-service students can create virtual students with particular psychological and cognitive characteristics, build a virtual classroom with targeted performance and social characteristic student profiles, and during "run time" make instructional decisions, which cause surprising emergent pupil responses that differ subtly as the context changes. A replay capability allows students to experiment to find better moves to assist the virtual pupils by adjusting tasks, task sequences, and personal interactions. Thus a major difference is the socially constructed knowledge of teaching practice in Second Life compared to private experimentation with a computational model of teaching and learning in simSchool.

Flexible emergence of themes of teacher perception of autonomy, effectiveness and satisfaction in Second Life are compared to concrete measures, including demonstrable and causal linkages to actions as indicators of teacher effectiveness in simSchool.

13.6 Discussion

13.6.1 Implementation Issues

The delivery environments for Second Life versus simSchool differ somewhat. Both require user registration and may require payment of fees for access. Second Life is a very large system serving multiple functions and numerous islands, while simSchool is a single-purpose environment. Instructors need the support of an IT team to create a virtual environment in Second Life. Most do not have the technological expertise or time to create a realistic classroom environment including avatars to populate a virtual classroom. Additionally, orientation to Second Life is a must if students are going to utilize it free of concerns of acclimation to virtual reality to focus on the problem at hand, effective classroom management. Attention should be given to students' actual and perceived notions of effective management skills prior to immersion in the virtual classroom. Finally, instructors must consider reflective follow-up to such work. They must ask themselves what should come after a simulation such as this to prevent it becoming no more than a virtual field trip. In simSchool, an individual pre-service student or faculty member can self-register and experiment for free with little technical support. However, the complexity of the modeling framework and its openness for flexible purposes entails building up experience in applied educational psychology and cognitive science as well as teaching methods, which provide benefits for effectively creating scenarios and making sense of the data produced by the simulation. Data is captured every 10 sec of simulation on 10 variables per virtual student, leading to a “big data” challenge in analyzing and interpreting the data for some purposes. Automated analytics ease the burden, but for particular research goals, new exploratory data methods may be needed, utilizing techniques from data mining and machine learning, and this can be daunting for some implementations.

13.6.2 Assessment Challenges and Opportunities

New assessment challenges and opportunities abound in both the role-playing virtual worlds and digital simulations contexts. While many of the ensuing questions are common (e.g. to what extent these experience have an impact on one’s preparation to teach, cause valuable conceptual changes, and improve one’s knowledge, skills and attitudes as a teacher) the approaches differ for addressing them, leading to new methods of inquiry and analysis.

13.6.2.1 Assessment Considerations for Role-Playing Models

Role-playing as a teacher in Second Life when combined with face-to-face instruction invites the researcher to consider the long-term behavior effects on pre-service teachers’ future teaching practice. Virtual reality allows the learner be immersed in the environment with a high degree of authenticity. By combining real-life problems of great intrinsic value to the learner with a dedicated space designed for the learner to solve those problems with cooperative support of their peers and instructor, learners are required to analyze their choices and those of others. The question becomes whether any of this results in deepened conceptual understanding and behavior change resulting in effective teaching practices.

Furthermore, students’ perceptions of a classroom management task before grappling with it, whether virtually or in reality should be examined. Analysis of those perceptions could be coded for themes to ascertain the alignment with current understanding of effective practice and potential for success in the classroom. Students are already required to reflect in writing often about such as a regular part of classroom management coursework in most colleges. Discussions are often held in seminars around problematic issues such as persistent behavior problems, organization, procedural issues, etc. These might be examined with a lens toward student intern perceptions, as well.

Examination of the constructed nature of learning when established criteria such as intrinsic motivation, socially mediated problem-posing and problem-solving tasks, an immersive and authentic virtual environment and active learning is needed. Assessment of learning outcomes should focus on performance in a real world context. It stands to reason that students must be assessed in real world classrooms against measures of effectiveness. Data could be mined from student teaching performance assessments on students according to the themes that have emerged during preliminary data analysis of student classroom management moves in Second Life and on measures of performance already collected as a regular part of student teaching.

Comparison groups could be created. It would make sense to compare two groups of interns: a control group-those who do not complete the Second Life Simulation Assignment prior to student teaching and an experimental group-those who complete the assignment prior to student teaching. It might be possible to discern whether immersion in a virtual environment, which allows students to make management decisions without risk of harm to real-life pupils, has any effect on future instructional decision-making when faced with real-life pupils while student teaching.

Finally, satisfaction and feelings of preparedness for teaching should be measured. Attrition rates of teachers are abysmal and are directly related to fears of a lack of ability. Beginning teachers value support focusing on problems of practice (Gehrke and McCoy 2007). One wonders whether or not virtually, immersive experiences in the classroom allowing students to pretend to be teachers in realistic ways followed by collegial discussions meaningfully situated in shared practice would translate into a greater sense of autonomy and satisfaction with teaching. This might be measured in a longitudinal study of teachers beginning when they are student interns, continuing through student teaching and ending after their first 5 years of teaching.

13.6.2.2 Assessment Considerations for Computational Models

Digital games and simulations based in computational models provide learning experiences in a dynamic new performance space with implications for assessment (Mayrath et al. 2011; Tobias and Fletcher 2011). The interactions of a game-playing test-taker for example, unfold as performances in time and cover a multivariate space of possible actions. Similar in some ways to the representation of knowledge called a problem space (Fikes and Nilsson 1971), the new digital performance space is a domain-independent representation of the possible ways one can show what one knows and can do. Performance tasks in a digital-media learning environment often have relatively unconstrained parameters such as interactions with the mouse, keyboard and screen, storyline choices, open-ended text responses, recorded speech, drawing, use of digital tools (including simulations of real-world tools). In addition, the assessment record can contain historical traces from problem solving decisions, and biometric information such as facial expressions, skin responses and brain states (Brave and Hass 2003; Park et al. 2008; Parunak et al. 2006).

However, unlike a problem space, the digital performance space is not primarily a mental model. Instead, it contains both intangible (e.g. value, meaning, sensory qualities, and emotions) and tangible assets (e.g. media, materials, time and space) that a performer utilizes to communicate a response, bounded by constraints and affordances of the tangible assets, and imagination and intent among the intangibles. Modern approaches to virtual performance assessment (Clarke-Midura et al. 2012) are attempting to grapple with a range of new, relatively untapped performance capabilities in the new interactive digital space. Both processes and products are of interest in this new world, but processes in particular are now much more amenable to documentation and analysis than ever before, because events in a digital space can be documented at the micro-second level, producing high-resolution data for visualization and analysis.

Data mining and machine learning in a context of data science applied to educational measurement are approaches and theory needed to address the new challenges of assessment (Gibson and Knezek 2011). Within each area are a multitude of techniques and algorithms for finding patterns, discovering production rules, exploring solutions, and constructing models. Exotic-sounding phrases such as "nonlinear state space reconstruction," "weakly coupled variables, " and finding the "underlying manifold governing the dynamics" need to be explored and integrated into the analytic frameworks of educational assessment. These new methods suggest that educators need to partner with computer scientists to develop a working knowledge of the field. In addition, new exploratory tools are becoming widely available and should begin to replace the monopoly held by statistical packages. For example, the WEKA project of Waikato University in New Zealand and the Eureqa project of Cornell University provide a wealth of readily available tools.

A number of projects are underway in the U.S. exploring the new psychometrics of digital learning. A recent book (Mayrath et al. 2011) contains reports from some of them. For example Debbie Denise Reese, in the Selene project, has discovered the performance signature of the "ah-ha" moment when users learn how to utilize the game mechanic to cause planets to form. Jody Clarke-Midura of Harvard and Gibson are working together to analyze performance data concerning scientific reasoning by middle school students who played a game requiring them to collect and utilize evidence to build a scientific argument. A pilot project by the Educational Testing Service is creating a suite of tools to diagnose and identify the learning needs of English Language learners, then instruct them and determine when they should exit special services. Integral to the planned assessment suite are new psychometric measures of language performance that take advantage of the affordances of the digital performance space; new conceptions of tasks, test prompts, and test taker responses are evolving. As these projects mature, the new science of psychometrics will also evolve.

13.7 Summary and Conclusions

Two alternative technologies forming the basis of computer-mediated teacher preparation systems have been compared and contrasted regarding implementation, operation, and assessment considerations. The role playing system in Second Life is shown to have the unique characteristic of developing shared, constructed pedagogical knowledge, while the flight simulator metaphor of simSchool encourages rapid, stepwise refinement of pedagogical expertise. Each has cost and traveling distance advantages over face-to-face traditional meetings, as well as shortcomings. Ultimately, the largest assessment issue for both is how to measure learning inside a simulator or a social media space. Further research is needed in this area.

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Chapter 14
A Study on Improving Information Processing Abilities Based on PBL

Du Gyu Kim and Jaemu Lee

14.1 Introduction

Because of the development of information engineering, the twenty-first century is being called the Knowledge-Based Society. The lifespan of information and technology is shortened, and it becomes difficult to use information that we learned in school; therefore, the ability to choose appropriate knowledge and re-compose it is needed in authentic problem situations (Evensen and Hmelo 2000; Jonassen 2000). Educators find new teaching methods by reflecting on existing school-based teaching methods to meet the demands of the times. One of these new teaching methods is the Problem Based Learning (PBL).

To put it concretely, PBL uses authentic problems drawn from the learners' life experiences. It increases the interrelationships of learning materials and allows students to develop a higher degree of thinking ability using in-depth interaction, concrete experience, and clue-compared traditional learning methods used in the course (Barrows 1994). Learners are motivated toward the achievement of learning by the removal of humdrum memorization and are inspired to learn in a spontaneous manner (Aspy et al. 1993). In addition, PBL develops interpersonal and teamwork skills as it cements group members and invigorates interaction and teamwork in the process of problem solving. It is an improvement on existing traditional teaching methods.

PBL has developed and is changing with development of ICT and PBL, web-based study (Richards 2001; Zumbach et al. 2004). PBL is student-centered. It emphasizes cooperative learning with other people and solves authentic, complex, and ill-structured problems in a web-based environment (Koschmann et al. 1996).

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PBL based on ‘blending’ makes it possible to search and share various pieces of information. It develops new forms as members of the community interact in various ways and learning atmospheres change. It uses e-mail, online boards, synchronous and asynchronous conferences. Learner-learner and learner-instructor interaction becomes active and extends the lesson beyond the classroom because cooperation and communication are needed to solve problems. It becomes more effective because of the need to develop a process for information searching, for the analysis and solution of the problem and problem solution plan, for verification, arrangement, synthesis and presentation.

There is an abundance of information on the Internet. Students can improve their creativity and problem solving abilities by selecting suitable material, analyzing, synthesizing, and remaking it into new information. We believe that learners expand their thoughts beyond limited learning by using ICT to transcend time and place (Korea Education & Research Information Service 2004). It is more useful to select knowledge and information by personal individuality or thought than to simply memorize what is provided to them. Students should have more than simply a quantity of knowledge; that is, ‘How much you know?’ Instead, information processing abilities—that is, ‘Can you make new knowledge using information?’—are what we should be developing. The difficulty is that computer classes are taught as extracurricular activities, and ICT education isn’t taught in every school. In this situation, ICT education does not provide concrete examples and ways to improve ‘Information Processing Abilities’ because it is taught in literacy training classes.

The purpose of this study is to improve information processing abilities through the solving of problems concerned with students’ situations using the computer. To improve information processing abilities, the PBL model is applied and combined tasks are presented. Students use computers to solve tasks and improve their information processing abilities in the process of PBL-concerned tasks. There are various teaching method to improve information processing abilities, but this study will provide what is effective teaching method for improving information processing abilities.

14.2 Background Theory

14.2.1 Information Processing Abilities

The Information Processing Abilities are based on the ‘Standard ICT skills of elementary-middle school students’ as defined by the Korea Education & Research Information Service (Korea Education & Research Information Service 2004).

Many suggestions are provided. Considering the test group, elementary school students, we define ‘Information processes ability’ as the ability of the students to discover a problem about subject by themselves; and then research and study the problem as they solve it. In other words, the students set the learning objective, find information by themselves (with the assistance of the teacher), and solve the problem. All of this involves the ability to collect, create, remake information, and internalize it.

14.2.2 Examination of the Literature

Problem based learning is an instructional method in which problems are the focal part of the learning process. Problems are the instructional materials presented to students to trigger their learning process. Problems are typically descriptions of real-life situations or phenomena which students are required to explain or resolve (Hmelo-Silver 2004). This educational method allows the student to acquire case-specific problem-solving skills and the ability to apply their own previous knowledge and gain new information while solving these problems using critical thinking skills (Gurpinar et al. 2013). Problems are often presented in text format, sometimes with pictures and computer simulations. They are also sometimes knowns as "triggers", "cases", or "scenarios" in the PBL literature.

Gallagher et al. (1992) found that the problem-finding abilities of students who attended PBL increased in their study concerning the effects of PBL on problem solving. In addition, they indicated that structured problems are not needed in the process of problem solving and problem finding. They suggest that PBL is a way to solve ill-structured problems through compared consideration of structured problems and ill-structured problems.

Sage (1996) said that PBL is an education approach for a constructed curriculum and classes on life problems. It is helpful to learners in that it improves critical thinking and cooperation in research and shows the characteristics and the effects of PBL on the learning activities of students as a development and teaching strategy. Most research applied ill-structured problems and target adult learners, so Sage (1996) wishes to discover if ill-structured problems are also suitable for young learners. He has been suggesting follow-up research about how the problems are developed.

A PBL assessment questionnaire was developed by the author. A comprehensive review of literature was done to investigate the available tools to examine student's performance in a PLB session (Taylor and Miflin 2008).

Achilles and Hoover (1996a) said that students do not have sufficient socialistic ability and time to solve problems through cooperative learning in a study conducted to discover the possibility of PBL as an education innovation in one high school and two middle schools. According to their study, PBL is not an innovation strategy for school education in general, but it is flexible and helps students respect each other and does improve their ability to think through cooperative learning.

The Students' role in PBL is transformed from passive to active, enhancing their communication skills, independent responsibility for learning, and abilisty to work in a team (Hartling et al. 2010; Azer 2011).

Achilles and Hoover (1996b) suggest that the education standards of elementary and middle schools is improved as a result of applying PBL in elementary and middle schools. With PBL, the curriculum is integrated, alternative assessment methods are suggested, teaching methods are improved, and active and cooperative learning is enhanced. Their study, however, suggests that students have difficulties solving in groups when they practiced PBL; it suggests that students need training before PBL is applied.

Richards (2001) insists, on the other hand, that PBL classes are very useful as an approach to the integration curriculum using the Web. In particular, he emphasizes that students can do reflection learning and learn overall aspects with respect to the leaning objective. Zumbach et al. (2004) suggests that there are on-going attempts to integrate the Web and PBL, and to provided PBL (distributed Problem-Based Learning) courses which integrate PBL, LBD (Learning by Design), and Web-assisted CSCL (Computer Supported Collaboration Learning) on the Web.

The literature suggests that, with respect to learning, a new education paradigm is needed. Long-term and continuous PBL instruction is needed in order to develop positive effects and an improvement in information processing abilities. In the process of their study, learners can improve their information processing abilities and find relationships in information; they can structuralize and schematize it.

Thus, this study is concerned with real life problems of elementary students and presents various discussion subjects. It focuses on information processing abilities that create new information and development the ability to express relationships in information using the computer.

14.3 Study Method

14.3.1 Participants and Period of the Study

This study performed with twenty-three fifth grade elementary school students over the course of 8 months from March 2012 to October 2012, and presented PBL problems eleven times. In addition, an 'e-PBL board' was created and used for this study.

14.3.2 Assessment Method

The prototype for an assessment method to measure 'information processing abilities' based on the 'Standard ICT skills of elementary and middle school students' was made by the Korea Education & Research Information Service (Korea Education & Research Information Service 2004). Two computer education experts and one education evaluation expert examined the content validity to assure the validity of the assessment method and suggest any necessary modifications. Afterward, this study developed an 'Information processing ability assessment table' and used it according to Table 14.2.

14.3.3 Design of the Study

This study focused on experimental research which compared the abilities of the students through pre- and post-tests.

The subjects are the test group. This research analyzed the information processing abilities of students before they study. It also analyzed through pre- and post-tests after the students practiced tasks using the PBL process of seven steps based on the PBL model. This study process was: first, reports of learners before applying PBL are analyzed itemizing the information processing abilities and the actual condition as researched. Second, the class homepage for the Web-based PBL was opened and managed. Third, the students were given ICT literacy training on how to solve problems using the computer. Fourth, PBL was performed in order to improve the students' information processing abilities. Fifth, after applying the PBL, the reports of the learners were assessed using the Information Processing Ability Assessment Table and changes in abilities from the pretest to the post-test were ascertained.

14.3.4 Apply PBL Process for Information Processing Abilities

The PBL was based on the most well-known model of Barrows and Myers (1993). This study teaches seven steps for the PBL process in eleven tasks, and then analyses and observes the results to continually instruct insufficient parts of the Information Processing Abilities. All participants performed below Table 14.1 eleven PBL Tasks for 8 months.

Step 1: Provides a task related to life concerning time through website as shown in Table 14.1. There are eleven tasks over 8 months.

Step 2: Each team creates a 'plan for task performance'.

Step 3: Team members divide the task into personal tasks based on the 'plan for task performance'.

Step 4: Students are taught how to collect the information that they need by themselves, how to write up sources to ensure reliability, and how to check for the information's validity in solving the problem.

Step 5: Students are presented with personal tasks in active time and complete the team task through discussion. Students learn to remake the information that they found through classification, analysis, and comparison in order to solve the problem. They then upload the result to the website and an analysis of their Information Processing Abilities is itemized. A steady improvement in the students Information Processing Abilities was observed.

Step 6: Students listen to the various opinions of other teams at presentation time.

Step 7: At the end of the team activity, the students make a reflection journal. It is used as a good way for the students to reflect on their work, to check what they have learned, and what they think about their study.

Table 14.1 PBL task

Task	Task based on the web	Relation of life
Task 1	The causes and effects of yellow dust on daily life and a solution	Korea issued a yellow dust watch because of the yellow dust
Task 2	Ownership declaration of Dokdo by Japan	Japan declared ownership of Dokdo
Task 3	Korea-USA FTA	Signing of the Korea-USA FTA
Task 4	The oil tanker called the Sea Prince sank off Yeo-su	Visit affiliated sister- school in Yeo-suKum-o island in June
Task 5	Are there any ways to overcome the destruction caused by typhoons and heavy rains every year?	Destruction caused by typhoons in Korea
Task 6	What is the problem with North Korea having nuclear weapons?	The nuclear weapons of North Korea issue
Task 7	What is the problem with the Screen Quarter System?	The Screen Quarter System issue because it has disappeared
Task 8	Overcoming the IMF problem	The IMF issue is taught in socials classes
Task 9	Netiquette	Netiquette education is required because a problem of netiquette was happening on the school homepage
Task 10	Family trip plan to Geojedo	There was a family trip planned to Geojedo around holiday on the 5th of the month
Task 11	Volcano	The nature of volcanoes is taught in science class

14.4 Research Results

This study applied PBL model to students in order to improve their Information Processing Abilities. It compared pre- and post-test to ascertain the difference of information processing abilities using an ‘information processing abilities assessment table’. This study assigned tasks to students and recommended their using an e-PBL board for learning. It shows the efficacy of learning using an e-PBL board for research on actual conditions and provides an academic atmosphere for this study. It shows the learning process of an authentically applied PBL model and verifies the effect on applying it by measurements before and afterward. Table 14.2 shows a comparison of the Information Processing Abilities of the students before and after applying PBL.

Table 14.2 Comparison of information processing abilities based PBL before and after

Items	Assessment point of view	Pre-tests results $N=23$, %=100						Post-test results $N=22$, %=100					
ICT knowledge	Do students remake the collected content as they want and edit using word processors and so on??		5	4	3	2	1		5	4	3	2	1
		N	4	8	2	0	9	N	12	6	3	1	0
		%	17	35	9	0	39	%	55	27	14	4	0
	Do students insert photos and pictures properly to help with understanding?	N	2	0	0	4	17	N	17	2	0	2	1
		%	9	0	0	17	74	%	77	9	0	9	4
	Do students arrange the report using tables and charts that aid in easy understanding?	N	0	0	0	0	23	N	15	3	1	2	1
		%	0	0	0	0	100	%	68	14	4	9	4
	Do students upload document as attached files to the board of the class homepage?	N	4	8	0	4	7	N	20	0	2	0	0
		%	17	35	0	17	31	%	91	0	9	0	0

Table 14.2 (continued)

Items	Assessment point of view	Pre-tests results $N = 23$, % = 100						Post-test results $N = 22$, % = 100					
Information processing abilities	Do students find information and material which they need using the Internet? [Information collection]	N	2	13	2	6	0	N	9	9	3	1	0
		%	9	56	9	26	0	%	41	41	14	4	0
	Do students not select unnecessary information while searching the Internet, but only what they need? [Information selection]	N	3	8	4	8	0	N	9	9	4	0	0
		%	13	35	17	35	0	%	41	41	18	0	0
	Is the selected content information appropriate for the task? [Information reliability]	N	2	13	8	0	0	N	9	9	2	2	0
		%	9	57	35	0	0	%	41	41	9	9	0
	Do students write sources for the information collected? [Information reliability]	N	1	2	0	4	16	N	15	1	3	2	1
		%	5	9	0	17	69	%	68	4	14	9	4
	Do students do information classification, comparison, and analysis as they work? [Information classification, comparison, analysis]	N	2	7	3	6	5	N	3	12	7	0	0
		%	9	30	13	26	22	%	14	55	27	4	0
	Do students collect valid information for problem solving? [Information validity]	N	1	13	6	3	0	N	2	14	6	0	0
		%	5	57	26	12	0	%	9	64	23	4	0
	Do students synthesize and remake the information through classification, analysis, and comparison? [Information synthesis and remake]	N	2	7	2	8	4	N	6	5	8	1	0
		%	9	30	9	35	17	%	27	23	36	4	0
	Do students present their thoughts based on the collected information using valid statements? [Information internalization]	N	1	1	0	3	18	N	2	12	5	2	1
		%	5	5	0	13	78	%	9	55	23	9	4
	Do the results of the problem solving achieve the goalof authentic problem solving to some extent? [Information completion]	N	1	7	5	7	3	N	8	10	4	0	0
		%	5	30	22	30	13	%	36	45	18	0	0

Likert scale-*5 points* very good, *4 points* good, *3 points* normal, *2 points* needs instruction, *1 point* needs much instruction

14.4.1 Research on the Actual Condition of Information Processing Ability Before Applying PBL

This consisted of a profile as in Table 14.2 and an analysis of the actual condition of the Information Processing Abilities of the students. It itemized and analyzed the student subjects before applying the PBL. We, first, focused on their Information Processing Abilities before applying the PBL.

- About 40 % of students used content from websites without editing. We therefore needed to teach the students about the editing process using a word processor to produce the content that they needed.
- Ninety-one percent of the students did not use materials such as photos, pictures, charts, graphs, and so on to help in understanding the content.
- Thirty percent of the students could not upload their report to the board of class homepage.
- In particular, 86 % of the students did not indicate an interest in reliability; that is, what information was reliable or what was the basis of information that they collected. It was necessary to check for the reliability of the information and develop a proper attitude toward written sources considering the fact that there is an explosive increase in knowledge and a great deal of unreliable information.
- Ninety percent of the students could arrange information downloaded from the Internet; however, they were unable to express their opinions using the information, or use it as clues. They therefore needed to be instructed with respect to how to express opinions with the information found through a search of the Internet and how to use the information as clues.
- Sixty-five percent of the students knew how to select information from what they collected, but 35 % of the students needed instruction.
- Forty-three percent of the students were not able to accomplish the PBL tasks because they were too unskilled to classify, compare, analyze, synthesize, or remake. There is an obvious need, therefore, for the students to have Information Processing Instruction with respect to classification, comparison, analysis, synthesis, and so on.

The results indicate the following for consideration.

- There are some students who cannot make tables and presentations to compare information through ICT abilities. In addition, some students cannot append files when they upload information to a site for sharing. ICT Literacy Training, therefore, should be taught to improve students' Information Processing Abilities.
- There are many students who simply copy the content of web page without any editing. It is necessary, therefore, to teach students the process of editing using a Word Processor.
- Many students produce a problem-solving report in a form that is difficult to understand. They need to be taught how to use photos, pictures, and tables to aid in understanding.

- Most of the submitted reports did not show the sources of the content which made them unreliable. Students need to be taught how to write content sources to ensure reliability and validity.

Many students just copy and arrange the contents without classification, comparison, or analysis. They need to learn how to process information. Students need to be taught how to collect information, classify it, compare it, analyze it, and synthesize it. This is needed so that students can re-create information.

14.4.2 Comparing Information Processing Abilities After Applying PBL

We analyzed the pre- and post-tests after the students had practiced with eleven tasks using the PBL process of seven steps based on the PBL model. We compared changes in their abilities using an itemized list from the 'Information Processing Abilities' of Table 14.2.

- Forty percent of the students used content without any editing from search engine. Afterward, over 95 % of the students remade the information as they wished using a Word Processor and so on.
- Over 90 % of the students did not insert photos, pictures, tables, graphs, and so on which could have helped in the understanding of the content of the report. Afterward, over 86 % of students inserted photos, pictures, tables, graphs, and so on to support their reports.
- Thirty percent of students couldn't upload attached file to the board of the classroom homepage. After applying PBL based on Web, all of them could do that.
- Fifty-two percent of the students used information that had been classified, analyzed, and compared. Afterward, 96 % of the students could use information with these methodologies in the post-test.
- In pre-test, 14 % of the students were interested in reliability; they checked to see if their information was reliable and what the source of information was. Afterward, 86 % of the students provided the source of their information to check its reliability.
- With respect to the internalization of the information, only 10 % of the students used searched information as clues. Afterward, in post-test, 87 % of the students could use information as clues to support their thoughts after their classification, analysis, comparison.
- Forty-eight percent of students knew how to select information that they needed and 35 % of the students used the information without any selection. Afterward, however, 82 % of the students were able to select information properly. There were no students who simply provided information without any selection process.
- At the beginning, 35 % of the students succeeded in completely solving the problem through selection, classification, analysis, comparison, synthesis and re-production. Afterward, 81 % of the students' completed the task very well.

14.5 Conclusion

This research used a PBL model to improve the information processing abilities of a group of elementary students.

Let us look at the results of the pre-test in an analysis of the information processing abilities of the students before applying PBL model. First, About 40 % of the students used content from websites without editing. Second, 91 % of the students did not use any materials such as photos, pictures, charts, graphs, and so on to help in the understanding of their reports. Third, 30 % of the students could not upload their report as an attached file to the board of the class homepage. Fourth, over 75 % of the students were accustomed to collecting information, but did not have sufficient ability to classify, compare, and analyze the collected information. Fifth, and not significantly, 86 % of the students had no interest in the reliability of their sources or what was the basis of the information that they had collected. Sixth, 90 % of the students could arrange information from Internet, but they were unable to express their opinions using the information as support. Seventh, 65 % of the students knew how to select information that they wanted to collect, but 35 % of the students needed instruction. Eighth, 43 % of students were not able to complete the PBL tasks because they were unable to classify, compare, analyze, synthesize, and remake.

These are the results of this study. First, there were very significant improvements in the students' abilities. The percentage of 'information selection' abilities increased from 48 % to 82 %. 'Checking of information reliability' increased from 14 % to 86 %. 'Information classification, analysis, and comparison' and 'internalization of information' abilities increased from 52 % to 96 %. The abilities involved in 'information collecting' and 'checking for information validity' increased only slightly from 88 % to 96 %, and from 74 % to 96 %, respectively; probably because the learners had these skills to some degree before the PBL model was applied. Second, the number of students who inserted photos, pictures, tables, and graphs in their reports to help in its understanding increased from 9 % to 86 %. Forty percent of students used content from websites without any editing; but, after the application of the PBL model, over 95 % of the students remade the information as they wanted using a Word Processor of some kind. Third, their information processing abilities improved because this was not cramming method of teaching; but, instead, the process of solving a problem and making a 'task plan' based PBL. It is a teaching-learning method that improves information processing abilities.

There are some implications from this study. First, it is helpful to apply the PBL model to improve information processing abilities; therefore, program research and development to improve information processing abilities using various teaching-learning models (Goal Base Scenarios, Action Learning, etc.) based on learning by doing in addition to PBL should be continued. Second, ICT literacy training should precede PBL work if information processing abilities is to improve. The '2012 Revised Curriculum' being applied in Korea at this time does not allow enough time for ICT literacy training. Each school, therefore, should provide ICT literacy training time as part of the national curriculum in order to improve the students' information processing abilities and make them suitable for the information age.

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Part IV
Collaborative and Student-Centered E-Learning Design

Chapter 15
Constructivism vs Constructionism: Implications for Minecraft and Classroom Implementation

Catherine C. Schifter and Maria Cipollone

15.1 Introduction

The sheer proliferation and vast commercial success of video games have led scholars to investigate the cognitive benefits (Bavelier et al. 2012) and drawbacks (Anderson and Dill 2000) of the medium. In terms of learning, many scholars claim that video games give players the opportunity to experiment with knowledge in meaningful contexts (Gee 2007; McGonigal 2008; Shaffer 2006; Squire 2005).

While interest in the academic potential of video games and learning is almost as old as video games themselves (Malone and Lepper 1987), it is only recently that scholars have acknowledged that the certain popular video games implicate a different set of learning outcomes than those designed specifically for educational purposes (Bruckman 1999; Gee 2007; Ito 2008; Salen 2008). Bruckman (1999) aptly pointed out the behaviorialist principles which guide the design of educational games take learning out of context, and rely on instructor-centered style of teaching, which keep them from really engaging their target audience (p. 74).

Similarly, Ito (2008) explains that many educational video games are, "[F]ocused on curricular content, rather than innovative game play" (2008, p. 93). She provides a more in-depth justification for the market success of the "academic" (i.e., educational) video game, explaining that this software was marketed toward parents who were interested in advancing their children in the academic "rat race" (2008, p. 94).

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In the following analysis, we use our observations of *Minecraft* game play in a high school classroom to conduct a Piagetian analysis of three student made *machinima*, or films made in the game environment. We claim that *Minecraft* is an environment that assists in helping students think about a range of possibilities related to the abstract concepts of characterization and plot, and this evidences Piaget and Inhelder's (1969) description of the formal operational phase. We use Seymour Papert's (1980, 1993) discussion of constructionism to show how *Minecraft* is a pedagogical tool with roots in Piaget's constructivist theories of cognitive development. Next, we discuss our observations of the instructor in this study, and how his approach to teaching differs from traditional instruction-centered methods. Finally, we discuss the trajectory of technology integration and its relationship with instruction, as well as the effect that the organizational culture of schools has had on the implementation of constructionist tools like *Minecraft*.

The next section describes the development and success of *Minecraft*, and details the rich community of practice that has constructivist roots. This leads into a discussion of our study and our interest in using *Minecraft* as a learning environment.

15.2 Minecraft

Marckus "Notch" Persson, the game designer, created *Minecraft* to be intentionally simple and open so users could interact with environments normally impenetrable in most other online video games. Duncan's words best explain the draw of the game: "What makes Minecraft 'work' is a fascinating mix of the game's aesthetic sensibility, its mechanics, its development history, and the creative activities of its players" (Duncan 2011, p. 2). Unlike more structured game worlds, such as *World of Warcraft*, *Minecraft* presents players with an environment where successes are based on their creative and collaborative efforts. The *Minecraft* environment encourages interaction with the system in both graphical and technical forms, and the community of players use these elements to create vast modifications and new layers to the game. As a learning environment, playing the game allows teachers to give students opportunities to show how creative they can be, while also working collaboratively with others in their classes.

Minecraft shares characteristics with sandbox game worlds (such as *The Sims*) that are driven by the creative efforts of its players, rather than games that encourage a more structured narrative and set of competencies (e.g., first-person shooter games like *Call of Duty*).

15.2.1 Constructionism in the Context of Minecraft

Both Bruckman (1999) and Ito (2008) discuss the value of the construction or creative genre of video games, in which learning comes from creation and exploration.

Bruckman (1999) directly cites these games as descendants of the constructivist notion of learning (p. 77). Both Bruckman (1999) and Ito (2008) link this genre to Seymour Papert, famous student of Piaget's and the creator of the LOGO programming language, who was one of the first proponents of using digital environments to have students explore and create. The observations from this case study work from the premise that the commercially popular video game, *Minecraft*, presents a constructivist notion of learning, and has roots in *constructionism*, which is the implementation of constructivist principals into classroom instruction.

In his work on the institutional culture of schools and technology integration, *The Children's Machine*, Papert claimed, "School would have parents…believe that children love [videogames] and dislike homework because the first is easy and the second hard. In reality, the reverse is more often true" (Papert 1993, p. 4). Early on, Papert himself identified the inherent learning principles in commercial video games, but he also recognized that institutions would not be quick to recognize video games as learning objects in their natural state, hence the educational genre of which Ito (2008) and Bruckman (1999) speak.

Others hold that *Minecraft* presents a dynamic space for learning via social constructivism, where collaborators demonstrate specific skills, but also give players the ability to "learn how to learn" (Banks and Potts 2010, p. 6).

Although the modifications evidence the highly collaborative aspects of the game and the game culture, our focus is on the highly *constructivist* and *constructionist* nature of the game itself. This aspect of the game is not the first of its kind—it draws on many predecessors and developmental traditions. Of the types of games she observes in her ethnographic work, Ito (2008) forecasts that construction games (that support the more constructivist style of learning and cognitive development) will most closely align with the economic and cultural needs of future learners, and has the potential to transform the traditional modes of K-12 learning. In her words: "If I were to place my bet on a genre of gaming that has the potential to transform the systemic conditions of childhood learning, I would pick the construction genre. With the spread of the Internet and low-cost digital authoring tools, kids have a broader social and technological palette through which to engage in self-authoring and digital media production (Ito 2008, p. 115)." Here, Ito sees the construction games as a space for experimentation for the types of meaningful practices players need both in the classroom and the world. Like Ito, we agree that construction games give players the space to tinker with these concepts. Her mention of the "systemic conditions of childhood learning" also implies the need for a shift from the heavy instruction-based practices that dominate childhood.

15.2.2 Piaget's Constructivist Theory of Cognitive Development

Jean Piaget's contribution to the understanding of cognitive development is vast and has exerted influence on a multitude of classroom and family practices. Although there is a multitude of work that detail his findings, our theoretical analysis is largely derived from his 1969 work with Bärbel Inhelder, *The Psychology of the Child*. In this work, Piaget and Inhelder spend a great deal of the text reinforcing the central tenets of their theories: that children progress through cognitive schemata, both by their biological readiness (represented by an age range), and their assimilation of new information that assists in their progression through cognitive development.

In the Piagetian notion, children must be given the tools and space to play with "reality" in order to challenge their current understandings of the logico-mathematical realities of space and time, and subsequently integrate this new knowledge into a more complex schema. A large portion of the text is dedicated to the earlier stages of *sensorimotor* (infantile) and *preoperational* (anywhere from a toddler to about 7 years old) of cognitive development. Little is discussed (both in this text and in other contexts) about the *formal operational stage*, the 'last' stage of development, where preadolescents progress to more abstract understanding of concepts, and can generalize to understand theories of behavior. Piaget and Inhelder describe this phase as, "[a] final fundamental decentering, which occurs at the end of childhood, prepares for adolescence, whose principal characteristic is a similar liberation from the concrete in favor of interest oriented toward the non-present and the future" (Piaget and Inhelder 1969, p. 134).

These observations demonstrate that individuals are accommodating their knowledge into a new schema known as the formal operational stage. In this stage, individuals can create theories and construct concepts that are removed from concrete props. Individuals in this group are able to hold those concrete experiences in their cognitive stores while also designing new possibilities that are not explicitly derived from the objects in front of them.

In all phases of his developmental model, children and adolescents come to understanding the function of reality through experimentation. For Piaget and Inhelder, knowledge is derived from action upon objects (Piaget and Inhelder 1969, p. 155). The knowledge gained from this tinkering is to extract their properties, and logico-mathematic knowledge of how the objects function in space. Piaget and Inhelder call this the "experimental spirit", which is the strongest in the formal operational stage (p. 149). It is this "experimental spirit" which is the crux of the Piagetian concept of constructivist knowledge building—that knowledge is assimilated through careful observation and testing via informal experimentation.

In this way, we see *Minecraft* as a tool that offers students (or players) the ability to garner knowledge through experimentation in the constructivist sense. As we have discussed, Piaget and Inhelder's (1969) theories of cognitive development are at the foundation of the constructivist view of cognitive development and learning. In our study, the students accommodate new knowledge in the formal operational stage via experimentation and expression in *Minecraft*. Although we discuss aspects the formal operational stage, we wish to emphasize the role of the *Minecraft* environment, which helped our participants experiment with new abstract concepts. Our primary interest is how the digital environment (and others like it) may help students in the knowledge production process.

15.2.3 Papert's Constructionism

For Papert, constructionism was the application of constructivist thought into classroom pedagogy (Kafai and Resnick 1996; Papert 1993). Papert's works (1980, 1993) serve as a bridge from Piaget's theory to pedagogical practice. His work strengthened the momentum of Piaget and Inhelder's (1969) theories, and serve as a rich translation of Piaget's intentions. Papert had very emphatic thoughts on the ways that Piaget's theories should be translated into practice. On more than one occasion, Papert (1980, 1993) wrote in frustration about the over-emphasis on Piaget and Inhelder's (1969) distinct stages of cognitive development and the obsession with incorrect assumptions children had about logico-mathematical relationships (e.g., conservation; 1980, p. 133). He felt that educators were too focused on correcting the erroneous assumptions that children had about the nature of reality. Thus, evidencing teachers' natural inclination to deliver the correct knowledge to children, instead of fostering an environment where learners might discover it. Papert asserted that the most valid pedagogical translation of Piaget's work was to position the child as a scientist, who is given space to fail and develop ways of knowing and thinking through experimentation. In his words, "Piaget has shown that children hold false theories as a necessary part of the process of learning to think. The unorthodox theories of young children are not deficiencies or cognitive gaps, they serve as ways of flexing cognitive muscles, of developing and working through the necessary skills needed for more orthodox theorizing" (Papert 1980, p. 133). The role of the educator is to provide the environment to explore these assumptions, and give space for children to "flex" their "cognitive muscles".

Papert placed the emphasis squarely on the importance of the conditions that would help children experiment, or think through ideas in concrete ways. This concrete experimentation was the prime difference between the constructionist style of instruction and the abstract knowledge delivery service style of instructionism (Papert 1993, p. 141). In the introduction of *Mindstorms* he discussed how his early understanding of the fixed and differential gear remained a structure through which he understood and excelled in mathematics (Papert 1980, p. vi). This was Papert's goal in creating the *LOGO* environment, and more importantly, Turtle, which was a digital representation of an object that children could manipulate using the *LOGO* language. Papert calls these metaphors that individuals use to understand other systems of knowledge "objects to think with" (1980, p. 11). As Papert used the differential and fixed gear metaphor as an "object to think" about mathematics, he created Turtle as a digital "object to think" about relational structures in computing (and ultimately, mathematics). Papert calls Turtle a "transitional" object which is "deliberately created as…Piagetian material, where [c]hildren relate to them, and they in turn relate to important intellectual structures" (Papert 1980, p. 187).

We claim that *Minecraft* is also a "transitional object", much like Turtle, and we see that the game environment is a valuable place for learners to relate to the environment, and intellectual structures of knowing. In the section below, we describe the study and then discuss our observations of student-made films in the game world (i.e., machinima). We believe that the themes demonstrated in these films evidence two related conclusions. First, that *Minecraft* can assist in helping adolescents experiment with literary concepts that are more complex and varied, thus resonating with the formal operational phase of development. Second, that *Minecraft* is a "transitional object" in the sense that Papert (1980) describes, but this conclusion implicates a style of teaching that is still not widely employed in the current educational environment.

The next section describes the case study we conducted with a high school instructor and 20 student participants, followed by analysis of their creative productions in the *Minecraft* gaming environment. Specific guiding research questions were: How would high school students in an English literature class use the game environment *Minecraft* to respond to a specific curricular prompt related to characterization and plot, as required by the Common Core Curriculum? And how would the high school English teacher scaffold the use of this game environment for the students?

15.3 Research Methods

This *in situ* study took place in early 2012 with the authors collaborating with a high school instructor in the New England area of the United States. The high-school instructor proposed to use the game *Minecraft* to explore the concepts of characterization and plot with a small sample of ninth and tenth ($n = 20$) grade students in his English literature course, and the university partners (i.e., the authors) would provide a communal server for all to use as a game space. The high school instructor was interested in finding new ways of achieving his curricular goals rather than having students individually write their own stories or having them read a work of literature. The researchers were interested in understanding the pedagogical value of using *Minecraft* as a classroom tool.

According to the instructor's informal survey of the class, only one male student was initially playing the game; thus, 19 out of 20 students were unfamiliar with the game and how it was played. After introducing them to the game environment, he then introduced the assignment. The desired outcome of this assignment was to produce an online video of a narrative work. This narrative would be produced and presented in a 3D film inside the game space. These 3D films are also known as *machinima*. The machinima would be developed by each group to demonstrate their understanding of the literary concepts.

The sample was a sample of convenience, which comprised two classes the high school English teacher taught, seven females and thirteen males. Students were divided into participating small groups based upon their preference for completing the related assignment. The high school instructor gave the students two options to achieve the assignment–they could use *Minecraft* to create their online video using game play captured using free software called Bandicam (Bandisoft 2013), or they could create a live-action narrative film using a camcorder. Four female students decided to not to use *Minecraft*. The instructor then randomly assigned the remaining 16 students who chose to develop their stories using *Minecraft* into four equal-sized groups (one of which didn't finish the final film). This chapter focuses on the instructor and the students who chose to use *Minecraft* as their development tool.

The instructor carved five class periods for the students to capture their narratives using either *Minecraft* or the video camera. Prior to the first of these five class periods, the students collaborated outside of class to start to develop their storyline. The instructor gave the students a prompt that they could use to assist their creativity. The assignment was as follows:

> Parents are out of town and kid is being pressured to host a party. He/she agrees and the party quickly gets out of hand.

Then, during these class periods, the students were given access to laptop computers in the classroom to practice their stories, capture pieces in online video to review, and then time to revise their stories. The all-female group was also given time to capture their storyline using the camcorder. When the *Minecraft* groups were capturing their online video within the game, we used participant-observation to understand how the teacher interacted with them to facilitate students' use of the game environment.

After completing the data collection process, we examined our field notes from participant observation described above, as well as the students' film productions, or machinima. We used Piaget's theories about the formal operational stage of cognitive development to drive an analysis of the students' narrative films; but also, we allowed relevant themes emerge organically from the data. Our analysis was to understand the use of *Minecraft* as an instructional tool with high school students. We reconsidered our initial inquiry into the use of *Minecraft*: How do high school students in an English class use the *Minecraft* environment to address the concepts of characterization and plot?

In their work on ethnography and virtual worlds, Boellstorf et al. (2012) impart the notion that the data analysis process in ethnography should be guided by critical discussions among the researchers. As students of learning theory and cognitive development, our discussions about the data began to touch upon the grand theories posited by Piaget and Inhelder. Boellstorf et al. (2012) state that relevant theories should be "responsive to the data and research interests" (p. 162). As researchers, our interest is to help scholars and practitioners see the value of technology in the context of pedagogy and cognitive development.

15.4 Results and Discussion

Rather than code the transcripts of the films, we relied on the plot and character development concepts in the film to indicate the students' understanding of their work. This study was highly exploratory in its nature. Our paper suggests that tools like

Minecraft promote an understanding of such concepts that incorporate a broader array of possibilities, while offering an understanding of the concepts through construction via the game mechanics. The older students in our study took a complete departure from the suggestion prompt, and developed their own story, "A Burning Passion". The story features Joseph, a young man who had the unfortunate experience of watching his parents burn in a fire when he was very young—a fire that he mysteriously caused. The first scene features him weeping by his parents' graves, and refusing to go and live with his uncle because if Joseph lives with him, his uncle will soon meet a similar fate. As Joseph warns his uncle, we see a lightning bolt ignite a fire in the distance. Here the students offer us their version of characterization by introducing a character with a tragic flaw—everyone he loves is doomed to burst into flames. Although their instructor could have easily had students read *Tom Sawyer* to identify a similar type of character and complexity, the interaction with *Minecraft* gives the students an opportunity to experiment with a range of characterizations, in order to develop formula that help them to understand how this variable functions in the context of a story's plot.

In their story, "The Hole", another group of ninth graders introduce us to another type of characterization via Roy, a delusional young man who is restrained by his family because he insists on digging holes. Roy digs holes because he is instructed to do so by a fun-loving bunny rabbit, that only he sees. Beneath his house, Roy constructed an entire world where he and his bunny friend can cause destruction. When Roy expresses his distaste for the rabbit's incessant chattering (about non-sensical things), he barks at the rabbit: "Who are you, anyway?" The rabbit answers: "But Roy, I am *you*!" This type of character development demonstrates a dynamic understanding of character and the range of possibilities that can be considered when formulating characterization. Here, the students create Roy, who is odd and anti-social, but who has control in his purpose (to create underworlds), even if his mind deviates from reality. The students have developed a character with multiple personalities, using the space of the game to explore a complex range of character traits. We see this as evidencing a dynamic understanding of the abstract concept of characterization.

Another group created a horrific tale called, "Flesh Eating Predator", where three friends are trying to find a party, but they seem to show up to an empty house with a creepy host (who is potentially the predator). Two of the friends, Anna and Caroline, are concerned with the appropriate social behavior (wanting to party), but their other friend, Kelly, seems intent on saying socially inappropriate things about her dog and her mom. In this video, we see the students experimenting with social norms for their age group. The character of Kelly, who says socially inappropriate things, might represent their fears about being socially outcast. Once again, we see the students experimenting with different types of characterization, not linked to any concrete prop, but representing an amalgam of real life and mediated experiences.

In both of the stories "The Hole" and "A Burning Passion", we witness students developing characters who struggle with character flaws. These flaws offer the promise of doom, but overcoming the flaws offer the promise of stability.

In the case of “A Burning Passion”, the plot centers on Joseph’s struggle to be intimate with others, because he fears that they will catch on fire (as do all the people who Joseph tends to love). The development of the plot in the students’ film gives them a chance to explore the concept of characterization from a multi-dimensional perspective, rather than the static identification of elements that are offered in traditional texts. We see this exploration through the lens’ of Piaget and Inhelder’s formal operational stage. Here, the game space offers the students the ability to play with various formulae related to the concept of character. The open nature of *Minecraft* gives the students (or players) the tools to construct characters and plots that, while archetypal in their nature, represent their own abstract understanding of characterization and character development, and are not tied to specific text. “A Burning Passion” demonstrates experimentation with a range of possibilities in terms of a story’s plot.

In “The Hole”, Roy, a delusional young man, also struggles with his character flaw, this time presented as a mental illness. In the final climax, Roy battles his alternate ego and destroys him in order to join the ranks of his more “normal” family. Again, the students experiment with plot lines to understand how characters resolve or succumb to their flaws. These archetypal stories demonstrate that the students have long observed these concepts in popular media and instructional material. In this case, however, *Minecraft* is a vehicle where they can experiment with those concepts in more abstract ways, ways we believe mark the maturation to more formal operational thinking.

“The Flesh-Eating Predator” narrative is less resolute. Kelly is murdered by the predator; and her friends meet a similar end. We felt that this data was not as rich in its display of characterization and plot, but we think it has less to do with the students’ understanding, and more to do with the technological scaffolding that is required to use *Minecraft*. Our analysis of *Minecraft* has mostly focused on the narratives that our participants produced within the game. However, underlying the more aesthetic elements were the technical production skills that were required to create such dynamic narratives. If the students did not master the technical skills of the game, either through the scaffolding of their instructor (or via collective networks on the Internet, such as YouTube), then their exhibition of the more abstract concepts were not as successful. For example, “Flesh-Eating Predator” is not as strongly developed as the other films. Although there are underdeveloped characters and unclear plot lines, one of the major flaws of “Flesh Eating Predator” was the students’ technical skill within the game. They used the same avatar for both a victim and a murderer, so it is unclear which character is which. Although all the students were amateurs, the weaker skill set in this group demonstrates the definitive link between technical skill within the online video game and the concept development.

The next section describes our observations of the style of teaching that the instructor implemented in this case study. As a part of our larger discussion, we see that this style is more hospitable to tools like *Minecraft*, but it is not the norm. We see that the more traditional instructor-centered style blocks the diffusion of technologies like *Minecraft* in the classroom. However, we do not place the blame on teachers, but suggest that there may need to be organizational shifts in the educational system as a whole.

15.4.1 The Next New Thing

The connection between games, teaching, and learning activities has been challenging even to the most experienced teachers. As noted before, game development, as with educational software in general, has not been in sync with curriculum development or needs. The experience for many teachers using any form of media (e.g., film, video, television, “educational” software) over approximately 75 years has been the same: the new technology solution was not designed with the curriculum in mind (Cuban 1986, 2001) Cuban (1986) noted that as each new technology was introduced as the new “panacea” for education, reality in the classroom showed just the opposite (e.g. film strips breaking, projector bulbs burning out, keyboards not working, and more). These problems make it more likely that teachers used technology only as a supplement, as opposed to infusing it into the teaching and learning process, exploring student’s excitement with media. “While games may provide interesting formats and add motivation to various activities, a missing critical piece is helping teachers learn how to think about games within teaching content” (Schifter 2014).

A decade ago, 100 % of all public schools in the U.S. had access to the Internet with 93 % of public school classrooms having Internet access. The ratio of students to computers with Internet access was 4.4–1. With the advent of new tablets and portable devices, and the Bring-Your-Own-Device initiative that have emerged in the last few years, this ratio has no doubt changed for the better. However, access to devices does not always translate into appropriate pedagogical use. If teachers are not prepared to use the new technology, whether software or hardware, the tendency is to not use it at all. In addition, in Schifter’s review of professional development (PD) for using technology in classrooms (2008), she noted that, while “authors continuously ‘recommend’ sustained PD that is rooted in classroom needs and practice”, the reality of most teacher PD around using technology solutions in their practice tends to be 1 day or one half-day sessions that may or may not directly relate to what they are trying to accomplish in their classroom. More likely than not, the PD is about the latest gadget that was acquired by the district, which the teacher may or may not have in their classroom.

The teacher who was the subject of this case study taught English in a high school. This is an anomaly to start with because typically the teachers who embrace the use of new technologies in their teaching are either the technology teacher, or early childhood teachers. This instructor had been exploring uses of *Minecraft* before he proposed using it as a medium for students to demonstrate their knowledge of characterization and plot. He had been collaborating with a community college teacher in California around how this new game environment might be used to explore Japanese internment camps from World War II. From his conversations with the teacher in California, this teacher decided he would explore how the game environment could support his honors students, to give them a different way to respond to the required content around characterization and plot. As noted, rather than take an established text and analyze for characterization and plot, he chose to have his students take on the task of developing a story line along with developing the characters who would be part of the story.

As this teacher said in an interview, “My colleagues thought I was wasting time with *Minecraft* project, asking why I did not just give them a short presentation on characterization and plot and be done with it in a day.” (Reeves, C., personal communication, April 23, 2012) While it would have been easier to do just that, this instructor chose to take the harder path which included introducing the students to the game environment since only one student had played the game before, and teaching them how to use the video editing tools required to create their *machinima*. The *Minecraft* project took approximately 5 weeks to complete. He also needed to support the one group of girls who chose not to use *Minecraft* in their project, but to use a traditional camcorder to record their video.

From observing the teacher within *Minecraft* working with his students, he was extremely familiar with the tools and able to help the students build and develop their characters. He stated in one interview that he showed one student how to change his avatar’s skin, and that student took it upon himself to teach all the others in the class. Students took it upon themselves to teach each other the skills they were developing as they explored how to function within the game environment. And perhaps that is one advantage of *Minecraft*, in that, with the free online version of the game, a user can explore and try out new techniques, after which they become the “expert” to teach others in the classroom.

Using the constructionist approach to demonstrating knowledge, this instructor allowed his students to explore a game environment in order to demonstrate their narratives which in turn reveal their fundamental understanding of characterization and plot development. As Papert suggested, exploration and construction through the game environment allowed two of the stories to exhibit a level of understanding that met the demands of the assignment (as demonstrated through Mr. Reeve’s grading using an evaluation rubric). While his colleagues were telling him to take the “easy way” and just read a story, this high school English teacher chose to give the students a challenge and to allow them to explore and construct their knowledge using an online game environment.

15.4.2 A Thousand Tiny Cuts

Papert wrote *The Children*’*s Machine* (1993) to reflect on his experiences trying to implement *LOGO* into classroom practices, and instructionism versus constructionism pedagogical practice. He addressed those claims that were similar to Cuban’s (1986, 2001), saying that the over emphasis on one particular digital tool or “transitional object” would be myopic, and couldn’t possibly affect a total sea change. Rather, reformers should think about the gradual shift, as digital tools become more popular and relevant in children's lives outside of school, they will fail to legitimize the traditional instructionist experience. He argued the overwhelming popularity of computing tools (which were infinitesimal in 1993 compared to today) would eventually forge a shift in education because students would find the instructional experience so unrelated to the learning experiences found in their everyday computing experiences. In his words, "To the extent which children reject School [sic] as out of touch with contemporary life, they become active agents in creating pressure for change. Like any other social structure, School [sic] needs to be accepted by its participants. It will not survive very long beyond the time when children can no longer be persuaded to accord it a degree of legitimization" (Papert 1993, pp. 5–6). Thus Papert claimed that the gradual influx and popularity of tools like *Minecraft* would draw power away from the instruction-based system.

This exploratory study of one high school English teacher demonstrates that there are teachers who see that the traditional, behaviorist approach to teaching does not work best for some students. Albeit, the students in this case study were honors students, which says they were already advanced in their abilities to demonstrate learning. However, the idea that technological tools, whether *Minecraft* or some other productivity tool or game environment, can support teaching boils down to whether the teacher is willing and able to take the chance. The educational environment in the United States in the early Twenty-First Century is one of testing and accountability. If introducing a game environment does not result in students doing better on the high stakes tests, teachers will not take that chance. Papert argued for students to be given the chance to explore and make mistakes, and to learn from those mistakes rather than merely memorize names, dates, and places. This teacher was willing to take that chance.

15.5 Conclusion

We see the popularity of experiences like *Minecraft* as evidencing the potential of this shift away from instructivism toward contructivism and construct*ion*ism. Our exploratory analysis revealed some of the possibilities *Minecraft* offers to learners who are exploring and experimenting with abstract concepts. Students repeatedly demonstrated an understanding of the concepts of characterization and plot that were much more dynamic than a simple identification exercise presented through a static text (e.g., *Tom Sawyer*). But more importantly, we chose to use *Minecraft* as an educational tool because it was not only so commercially popular, but had inherent learning experiences embedded in game-play.

Although our interest was to use Piaget and Inhelder's notion of the formal operational phase of development to understand the type of learning possible in

Minecraft, we believe these data evidence a growing trend in the twenty-first century classroom. We feel our analysis shows that twenty-first century technologies such as *Minecraft*, provide students with the opportunity to construct knowledge in meaningful ways and in situated environments that are highly impactful. In fact, many scholars, such as Gee and Hayes (2011, 2012) suggest that these preferred modes of learning are more salient and relevant for the current global marketplace.

The goal of any exploratory study is to understand the need for deeper inquiry, and we believe our data have evidenced the potential for *Minecraft* to provide meaningful learning scenarios of which others have discussed (Gee 2007; Shaffer 2006; Squire 2005). As we proceed, we are trying to balance the open-nature of game with the culture of standardized assessment that drives the current educational culture. We believe that a multi-modal approach is needed going forward, with quantitative analysis using structured task completion within the game, and qualitative interviews to understand the creative process within the game. Also, in future study, we will observe and evaluate the nature of the social constructivist learning that occurs in *Minecraft*. We didn't aptly capture this part of the gaming experience, and we acknowledge that it holds vast implication for how the game is experienced.

This paper reinforces the notion that there is a tension between the knowledge production that is characteristic of the game, and the instruction-based culture that dominates the contemporary classroom. As digital technologies shift the type of epistemology and modes of production that hold currency in the global market, it will be necessary to resolve these tensions in order to provide students with more valuable and meaningful skills in their professional lives. We see this small project as evidencing a much larger transformation at work.

This work is limited by the fact that the sample was a sample of convenience, limited to only one English high school teacher in one small rural district in a state in the New England part of the U.S., and limited to student participation in one spring semester only. While the teacher stated that he would have liked to have the same students use the game environment for an additional assignment, the end of the school year precluded this occurrence. Findings cannot be generalized to either other high school English classes or teachers, or other subjects taught in high school in the U.S. Additional research is needed to better understand how a virtual game environment, such as *Minecraft*, can be harnessed to support assessment of student understanding of content, as demonstrated through their activities and constructions within the game environment. Game-based learning has extensive literature (see Ferdig 2009), however, the use of virtual game environments for assessing knowledge has not been extensively explored. (Shelton et al. 2013; Schifter et al. 2010)

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Chapter 16
Student-Centered, e-Learning Design in a University Classroom

Melissa Roberts Becker, Pam Winn and Susan L. Erwin

16.1 Introduction

Resulting from an initiative to improve undergraduate instructional rigor, student satisfaction, and student retention, a regional state university solicited survey feedback from faculty members. Findings indicated faculty experienced frustration because students did not read assigned course materials prior to class meetings. Student classroom behavior necessitated constant reminders to disengage from non-course related digital devices. Furthermore, lack of student responsibility for pre-class preparation stymied thoughtful and productive participation in class discussions. In addition, faculty members voiced concerns about the increasing rates of course withdrawal and failure.

End of semester course evaluations by students cited their dissatisfaction with inconsistent use of the learning technology throughout their academic programs. In particular, students indicated the utilization of the learning course management system (Blackboard) varied by instructor and by class, adding to the complexity of coursework. Confusion and frustration were results of this practice (Institutional Research 2012). Students also noted course content often seemed irrelevant to their lives. They did not believe the information or content would help them in future learning or employment opportunities. The university maintained a tradition of student-focused learning and a core value of excellence. At this point in time, the two ideals appeared to be in dire conflict.

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To address noted issues affecting learning, university leadership invited faculty volunteers to redesign courses based on research and best practice in teaching. Research on contemporary instructional challenges was examined and effective techniques for adult learning explored. Technology use was reevaluated to identify applications that would drive student-centered instruction and collaboration to motivate twenty-first century adult learners. Systematic and intentional application of technology in the teaching and learning process was a focus of course redesigns. Evaluation of how instructors used the technology in the instructional process would be paired with the student use in the expression of their content understanding.

While several university courses were redesigned over a year-long process, this chapter examines the results of one junior-level education course. The results of the redesigned education course included pre-class instructional units which applied multimodal digital tools. The tools maximized and individualized initial learner content acquisition. As students entered class, they were all the time more prepared to engage collaboratively in student-centered learning events. The instructor was at hand to facilitate learning at critical points of instruction. Students acknowledged the relevant workplace skills as applied to real world scenarios in the reflective process which followed class. In summary, adult learners' engagement increased before, during, and after class.

16.2 Review of Literature

16.2.1 Contemporary Instructional Challenges

Although not clear whether students today are characteristically different from previous generations, no doubt they access more information faster than ever before. Furthermore, information they peruse is more likely to be digitally delivered, which differentiates them from earlier generations. Sprenger (2009) suggests contemporary learners, equipped with hyper-connected and multi-tasking digital brains, are unprepared to endure the slow pace of instructional practices developed more than a century ago. Consumer and entertainment oriented, today's students today intellectually disengage in non-digital environments (Taylor 2005). While some debate the existence of generational characteristics (Bennett and Maton 2010; Helsper and Eynon 2009; Trzeniewski and Donnellan 2010), many contend that contemporary students think, behave, and learn differently due to permeating exposure to technology (Prensky 2001; Tapscott 2009; Taylor 2005).

Digital learners fundamentally think and process information differently than their predecessors by using multi-tasking and parallel processing; they prefer graphics to text, random access (hyperlinks), networking, instant gratification, frequent rewards, and games rather than "serious" work (Prensky 2001; Castillo et al. 2013; Garcia 2007; Hayes 2010). Stimulation and adaptability enable the brain to constantly reorganize or rewire itself (Jensen 2005; Willis 2008). Physical evidence corroborates brain differences resulting from exposure to digital media in terms of how digital learners process, interact, and apply information (Juke 2006). Combining digital learner processing skills and learning preferences with brain research further justifies breaking from the current teaching/learning paradigm in which professors control content, delivery, and products in favor of authentic learner engagement. Institutions of higher learning that effectively communicate the value of classroom learning will attract and retain the adult student market (Gast 2013).

16.2.2 Instructional Engagement

Transforming passive content-consumers to active information-processors requires instructional engagement. Engaged learners work collaboratively, transforming understanding through creative problem solving (Jones et al. 1994). Taylor (2010) noted authentic engagement occurs when educators furnish students with the skills and tools to become self-motivated. Schlechty (2001) stresses students learn best in applied learning tasks, emphasizing engagement as an active and interactive process, and not synonymous with time on task. Engaged students learn more, retain more, and enjoy the learning activities more than unengaged students (Dowson and McInerney 2001; Hancock and Betts 2002; Lumsden 1994; Voke 2002). Instructional goals that create opportunities for authentic engagement, where students meet expectations and intended instructional outcomes responsive to learner interests and values, produce the most effective learning (Schlechty 2002; Trilling and Fadel 2009).

Carmean and Haefner (2002) suggest deeper learning principles are required to help engage digital learners meaningfully process content. Jensen (2005) posits students today require instruction based on problem solving, critical thinking, relevant projects, and complex activities that stimulate the brain and challenge learners. Jensen also encourages interactive feedback that is specific, timely, and learner-controlled while addressing multiple modalities. Instructional engagement is complex and instructors must apply in an intentional manner.

16.2.3 Rethinking Technology's Role

Technology empowers students to communicate and interact socially beyond the classroom through innovative interaction and exploration. No longer limited to physical space, an expanded classroom can accommodate community-driven, interdisciplinary, and virtual collaboration. An unprecedented opportunity exists for schools to reexamine current technological practices and redesign parameters of effective instruction (The Horizon Report 2010). Supporting educator effectiveness by expanding innovative learning models that utilize online and blended learning, high-access, technology-enriched learning environments, and personalized learning models should increase student learning (Bennett and Maton 2010).

Unfortunately, many published examples of currently implemented technology-driven, learner-centered instructional design fail to meet the new demands. Rather than technology innovation as an end in itself, educational technology should focus the means to deliver instructional goals. Needed are both deeper understanding and well designed instructional models to demonstrate the untapped power of learning in technology-rich environments. Puentedura (2008) identified four levels of technology use in class instruction: substitution, augmentation, modification, and redefinition (SAMR). Created to help teachers reflect and refine their use of technology in instruction, the first two levels of the SMAR model focus on instructional enhancement (technology as a tool substitute), but provides no functional change (testing on computer instead of paper). At the next level, technology still substitutes for a conventional tool, but with functional improvement (watching a video versus modeling the process). However, at the transformation level, technology significantly drives instruction. Puentedura suggests that technology used to drive instruction results in richer, more engaged and integrated learning at higher levels of thinking.

16.2.4 Instructional Innovation

Teaching digital learners requires that educators utilize technology to empower learners. Universities using technology to automate processes (testing, email) are moving toward informing processes to empower students to solve problems, access information and create relationships outside the classroom using digital tools (November 2010; Flumerfelt and Green 2013; Collopy and Green 1995). While university professors still require students to read textbook information, few utilize technological applications that help prepare students for class learning. Instructors with content competence and an arsenal of effective instructional strategies produce higher achievement outcomes among students (Coleman et al. 1966; Rowan et al. 2002; Whitehurst 2002). Ensuring transformation in educational processes requires creation of new instructional models by effective instructors; however, many university professors are reluctant to embrace this shift due to technology availability, cultural lag (change in universities happens more slowly), and instructional training (Chen 2007; Johnson 1997; Maddux 1997).

Nevertheless, Somekh (2000) found educational institutions that valued information and communication technology were more effective in transforming learning through integrated instruction. Furthermore, Cavanaugh et al. (2011) found significant changes resulting from technology-integrated instruction. Not only did direct instruction decrease, collaboration and project-based learning increased, and student motivation and engagement improved. The instructor used technology in the teaching process and students used technology to demonstrate their learning.

Strayer (2012) inverted (or flipped) his traditional statistics coursework in which textbook assignments and interactive lectures were replaced with tutorial software that introduced statistical concepts prerequisite for active learning in the classroom.

Results indicated the inverted class was more open to innovation and working cooperatively as compared to traditional class counterparts. Conversely, traditional class participants responded favorable to traditional class structure while the inverted class noted a fragmentation course structure when online content was not directly aligned with the active learning expected in class. A similar study used a hybridized inverted model (Talley and Scherer 2013). After psychology undergraduates viewed direct instruction lectures online, each created and submitted a video demonstrating understanding of course material. Websites, course blogs and a learning management system (Blackboard) provided online resources and communication while face to face class sessions included content review, practice exams, additional use of online related resources for deeper level understanding, and additional direct instruction as needed. Results included final course grades significantly higher than in previous semesters and students reported the direct instruction videos and student content explanation videos as most effective. When Findlay-Thompson and Mombourquette (2014) applied the inverted classroom concept to an undergraduate business course, final grades were no different than those in traditional course sections. Nevertheless, inverted class students believed they learned more and perceived more opportunity to ask questions of the professor and peers. The instructor's lack of formalized training in course design and absence of formalized procedures and expectations for the inverted class may have affected findings. Communication and clear expectations for student behavior was noted in the study as an essential component for success.

16.3 Methods

16.3.1 Rationale

To effectively redesign a junior level education class fraught with disengagement, the course instructor embraced Levine's (2010) assertion that education programs must transform traditional educational practices such as lecture, note-taking and dated textbooks. Students are accustomed to rapid pace of answers to questions and ponder briefly the questions where answers elude them. The instructor agreed with Pink (2006) that today's students can be engaged using technology for information acquisition, communication and collaboration projects. Furthermore, to actively engage students in meaningful learning, the instructor sought to include active, authentic, real-world experiences as recommended by Schlechty (2001) and supported by Jensen's (2005) contention that engaged students retain information longer and are more apt to apply the content in new situations.

Upon assessment of course instruction design, the instructor noted many suggested practices for twenty-first century adult students were missing from the junior level education course. Students did not actively participate in class discussion and products developed in small teams reflected limited basic content knowledge. While evidence indicated students learned content for the assignments, content knowledge did not appear to transfer to subsequent assignments or improve learning schema. Insufficient content transfer would jeopardize adequate pedagogy development in the future teachers. As the atmosphere of disinterest and low level learning continued, overall course grades fell. The instructor considered class performance unacceptable for students only three semesters away from teaching their own public school classes. The course assessment process conducted by the instructor was the linchpin for course redesign.

16.3.2 Course Redesign Training

Joining a cohort of faculty volunteers at a regional Southwestern United States university, the instructor of the junior level education course sought to re-structure the class to meet research-based, best practice instruction for adult twenty-first century learners. The faculty course redesign cohort trained 1 week in the summer followed by monthly meetings during the subsequent fall and spring semesters.

Based on best instructional practices (Turner and Carriveau 2010; Judson 2006; Rosen 2010), the instructor shared instructional resources with the faculty cohort, created digitally-driven learning objectives and content was aligned with active, student-centered learning experiences created for in-class engagement. To hold students accountable for basic content acquisition before classes met, the instructor developed an alternative content delivery method keeping in mind the transformed course must provide a cohesive structure through in-class expectations and out-of-class requirements as noted by Butt (2014). Technology was embedded in the learning processes to drive instruction as suggested by Strayer (2012), Hede (2002) and Wood (2009). Furthermore, the instructor provided essential communication with students regarding learning performance expectations as encouraged by Findlay-Thompson and Mombourquette (2014). Clear communication required formalized procedures that ensured students understood the rationale and process behind the course redesign: (1) prepare basic knowledge before class, (2) apply that knowledge in class, and (3) increase comprehensive understanding following class.

During the training, the instructor worked with faculty peers and developed several methods for raising class preparation expectations and accountability measures. When responsibility for initial learning shifted to students, time for facilitation of learning in the classroom was gained. For example, the student produced a completed a basic knowledge assignment as they entered the classroom. The completed assignment provided evidence the student read the material or viewed the content video before attending class. If the students did not have the evidence, he was not allowed to enter the class until the guide was finished. The student sat in the hall or in his/her desk and finished the guide while missing the interactive learning in the class. Faculty members anticipated few students would arrive to class unprepared more than one time.

Paired with a faculty fellow from the university's center for instructional design and working in small groups the instructor identified innovative digital solutions to drive the redesigned course. Access to instructional technology experts in the application of university-supported technology tools provided immeasurable benefits. Furthermore, required monthly progress reports to faculty cohort participants provided suggestions and feedback to help ensure the redesigned course was ready to launch at the end of the fall semester (6 months).

The course redesign simultaneously embraced students' digital connectivity and enhanced content acquisition. The components of course redesign included:

1. Acquisition of basic course content information prior to class attendance;
2. Evidence of basic content knowledge upon arrival to class;
3. Active participation in authentic learning experiences;
4. After class, reflection on lessons learned.

16.3.3 Redesign Components

Prior to each class meeting, a variety of learning objects were assigned and evidence of that pre-class preparation took several forms. Objects and associated accountability forms were accessed at the beginning of class or through the class learning management system (Blackboard). The learning objects varied through the course to maintain novelty and thus engagement for the student. For example, before class students might access a visual and auditory object (video, Captivate product) with an associated viewing guide to be completed as a ticket into class. The next week, the students would complete a media scavenger hunt to locate a supporting object that reinforced the assigned readings for the weekly class meeting. The student posted their learning object on the course blog for peers to view. Another example is the use of Twitter. A summary of the main points of the assigned pre-class content preparation, students posted a tweet (on course Twitter account) to summarize their new learning. Analog examples were also applied. Students could bring a question they wanted answered in class that day or a summary statement of the most important information gleaned from a learning object then share their statements with a peer in the class for the first five minutes of class. Initially, if the student arrived unprepared for class (i.e. the evidence was not provided to the instructor upon entering the classroom), the instructor directed the student to complete the assignment and then return prepared for class. The real world application assisted the student in making a transition from thinking and behaving like a student to thinking and acting as the professional he or she aspired to become. Only when the evidence of basic knowledge was produced to the instructor was the student permitted entry to class. Heightened class preparation expectations created a professional environment similar to the real-world workplace. Before long, students consistently arrived prepared for work in class or returned ready to contribute to the learning community the following day. The class expectations were clearly communicated and reinforced to all students.

As a result, during class, students actively engaged in authentic learning experiences deepening their content understanding. In contrast to traditional in-class content delivery, the instructor facilitated students applying basic content knowledge to higher level applications as they created new knowledge. When applying content, students make mistakes. In traditional instructional delivery, students applied content for homework, with no instructor support. In the redesigned class, the instructor was available to re-teach content as misconceptions arose or affirm accurate learning (Ferreri and O'Connor 2013). In the new course design, the instructor provided specific and immediate feedback, enhancing learning and scaffolding students to the next level of understanding.

In-class evidence of deepened learning was demonstrated in a wide range of forms. Authentic learning experiences completed individually or in teams, included real-world problems to solve. For example, students designed effective public school lesson plans to address various difficult learning outcomes. The challenges addressed in the lessons were genuine as students applied their field experiences to the lesson design. The lesson included anticipated lesson modifications and adaptations for all students in a diverse classroom (gifted students, English language learners, students with special needs, etc…). Students presented results to an authentic audience of local public school teachers who noted strong points and provided feedback for improvement on the lesson plan.

Applying basic content learned before class, students also individually evaluated current dilemmas in instruction by applying problem solving strategies. Facilitated by the instructor, students realized the importance course content as the information was juxtaposed with contemporary education issues (i.e. classroom management, applying contextual factors to learning and tutoring students in content areas in need of remediation). Students worked in teams to create digital posters (Glogster), brochures (lino sticky), Wordles (word clouds) or presentations (interviews with experts through Google hangout) applying best practices from the course content in education to answer typical questions asked by society today. Questions were randomly drawn and each team member had a specific role in the creation of the product/presentation. Each student was evaluated individually and received feedback from the instructor on demonstrations of deepened learning. Rubrics and checklists were used in the process.

While these future teachers had experience in working with children, most did not have experience tutoring public school students in content areas that were difficult and challenging. While they tutored the student, they had to maintain a measure of classroom management with that student in order to keep him or her on task. The job of teaching became real as they designed lessons for an actual classroom of students and applied course content to real world questions asked by the community.

After class, the future teachers reflected on lessons learned before class through the learning objects and during the interactive learning experiences in the class. The learning follow-up took the form of extended learning assignments which directed students to expand current understanding as suggested by Strayer (2012). For instance, students interviewed public school employees and used information gleaned to enhance application of course content through pod casts and YouTube postings.

Reflective digital journaling also deepened understanding of course content after class as they posted their reflections in the learning management system. Students used higher order thinking prompts to guide their reflections. Students applied the course content to project the impact of instructional practice on the future of education. After posting the reflective journal, each student received two peer feedback posts and feedback from the instructor. In order to ensure the students' understandings were effectively enhanced, specific instructions and examples for peer feedback were provided. Before posting feedback, students were directed to consider the initial post for at least five minutes. After pondering the post, students were to comment as to how this reflection was similar to their own experiences, ideas and beliefs (depending on the nature of the higher order thinking prompt). The students then explained how another person or the community as a whole might view the information differently. The students then offered either a new perspective on the original reflective journal entry or provided a specific best practice example which supports the original journal posting.

Learning objects were also applied in the final portion of the learning process. Several interactive review modules were created in Soft Chalk. The review modules were based on the course content and were not available to the students until after the class session. A routine was established early on for the release of learning objects and the intended purpose of the learning after class. While some learning objects were review of content, most challenged students to move beyond the explicit content requirements and interactive class learning. The learning objects were to function as a spring board for their individual learning as they applied their specific interest and vision for themselves as future teachers.

As a final reflection assignment in the junior education course, students created a visual demonstration with narrative (photostory product) to address unique instructional challenges faced by their public school tutee as experienced in the public school classroom during the semester. In this way, students used technology to demonstrate lessons learned during the semester. Students shared these products with a small team (usually four students in a team) and received direct feedback from their peers (rubric applied and guided discussion questions). After receiving the feedback and participating in the discussion, students were given time to alter their product before final submission to the instructor. The instructor was available as a facilitator during the peer feedback portion of the course.

The narrative product was one of two signature assignments of the course. The final assignment uses interactive peer editing and electronic portfolio submission. Students created a vision statement document explaining how they see themselves as teacher candidates. In this document, they explained what they believed about the teaching profession and exactly why they wanted to teach. Students referenced specific course learning and field experience examples to authenticate the document. Students brought their vision statement to class and received peer-feedback (applying a rubric) and class discussions ensued. The vision statements were displayed on individual computers in a lab. Students rotated through the lab and provided suggestions for edits to the documents using the comment function in Word. Students referred to the scoring rubric which would be used by the instructor to assess the final product. Students had the opportunity to revise the vision statement before final submission. The vision statement and Photostory product were uploaded to the students' digital portfolio. At the time of graduation, the digital portfolio would be available to prospective employers of the teacher candidate's choice. The portfolios are referenced by the potential employers as part of the interview and selection process. The digital portfolio provides potential employers evidence of the teacher candidate's ability to demonstrate the understanding of education's professional field and the student's potential for growth in local education systems. The portfolio also serves as an authentic product for the students as they see the potential use of the portfolio, even as a junior education major.

16.4 Results

16.4.1 Data

A concise comparison of the junior level education course before and after redesign provided evidence of improved learning and student engagement. The classes before and after redesign were similar in size. The classes were taught by the same education professor, at the same location, using the same classroom instructional equipment, and included participants with similar demographics. Changes in achievement and engagement reflect changes in course design. The course success rate before course redesign was compared to the success rate of the redesigned course during the same semester of the subsequent year.

The course was the first professional development course for education students (teacher candidates). The course was entitled: Professional Development One: Understanding Learners. Students were required to be of junior standing in the university and anticipate graduation (entering the education profession as teacher of record) after three additional semesters of university work. The course included an examination of students and teachers in learner-centered schools. Course topics addressed brain-based learning, cooperative learning, learning styles, strengths of diverse learners, formal and informal assessment of learner-centered instruction. A technology lab and documentation of field experiences was also required. The pre-requisites/co-requisite included a course in child growth and development and minimum of 60 h toward certification or degree requirements. The grading scale used for this course was 90–100 % earnings of course credit equaled the letter grade A, 89–80 % earned a B, 79–70 % earned a C, 69–60 % earned a D and lower than 60 % was failing (F). Students withdrawing from the course, the student received a W on their transcript.

Students enrolled both semesters ($N=154$) were classified as juniors or seniors. The spring 2011 semester traditional instruction group ($N=81$) and the spring 2012 semester redesigned instruction group ($N=73$) differed in the percentage A grades earned. Traditional course students earning A grades comprised 32 % of the class,

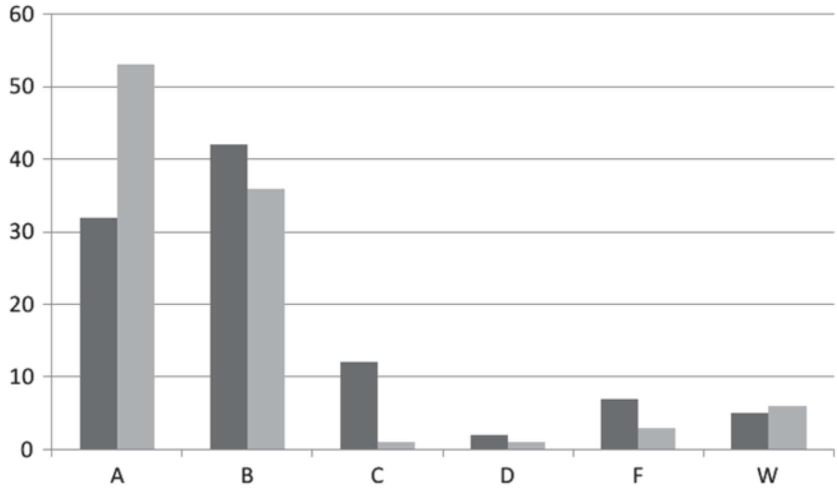

Fig. 16.1 Comparison of course final letter grades. The figure illustrates the comparison of final course letter grades from a traditional course (*dark gray*) and a redesigned course (*light gray*)

compared to 53 % earning A grades in the redesigned course. As a result, students earning B grades in the resigned course decreased to 36 % compared to 42 % in traditional course. Additionally, the students earning C grades decreased in the redesigned course to 1 % as compared to 12 % in the traditional course. The increased number of students earning A grades in the redesigned course reduced the number of students earning B and C in the redesigned course. The percentage of students earning a D remained basically the same both semesters (2 % traditional and 1 % redesigned). While 7 % of students earned F grades in the traditional course, the number narrowed to 3 % in the redesigned course. The percentage of students withdrawing from the course was essentially the same both semesters (5 % traditional course and 6 % redesigned course).

As illustrated in the figure below, a higher percentage of students earned the letter grade A in the redesigned course, which in turn lowered the percentage of the students earning the letter grade B. The number of students earning the letter grade of C also decreased, moving these to a higher final letter grade, B. Initially, the findings suggest the redesigned course assisted students who might have earned the letter grades of B and C to increase their final grade by a full letter (Fig. 16.1).

16.4.2 Practical Application

The course instructor identified three areas of interest for consideration in the course redesign process. The first challenge was the reflective process of organizing the content sequence in order to align content learning experiences both before class meetings and course content applications which occurred during actual class meetings. To meet this challenge, the instructor must identify essential concepts that students must know, understand and be able to apply as a result of the course. After the concepts are recognized, ideas must be codified from basic to complex. Using this system, the professor can build a framework for active learning experiences that move the students along the learning continuum. Students move seamlessly from a basic understanding of course content to constructing their personal knowledge and application of that information in new context including real world circumstances. The practical application of this challenge requires professors to identify exactly what is expected of students in the demonstration of successful learning. The instructor must also commit to a course schedule, active learning and measures of success. While flexibility in student learning must be considered, the predictable structure of before class preparation and during class application of the content will assist novice students' acquisition and creation of knowledge in the field of study.

The next challenge for the instructor was the time required to create the visual and auditory learning objects. Learning two software programs (Captivate and Soft Chalk) required patience and tenacity from the professor in learning new tools. The instructional technology staff was invaluable in the process. Their knowledge and skills encouraged the cohort of faculty members to apply many technology tools in a myriad of ways. Discussions with the faculty fellows kept the course redesign work focused and moving forward. Technical and pedagogical support systems must be in place if course redesign is to become a reality in the university setting.

The third challenge involved creation of learning experiences that would appeal to twenty-first century adult learners while holding them accountable for the application of knowledge gained before class and outside the classroom. As noted, these authentic learning experiences included solving problems presented in real-world scenarios, ranking effective teaching strategies for fictional public school students, and creating artifacts in teams in which each team member was responsible for a unique portion of the final product.

Each of these challenges can be met in a practical manner. Instructors must be organized and commit to a course schedule and identify the measures of success for their learners. Many professors are highly respected experts in their content area, but not well versed in the ways adults learn new information. Consequently, they must be willing to develop their own unique style of pedagogy. Active learning inside and outside the classroom enhances the professors' ability to support effective learning. Technology is not a required component of course redesign, but most college aged students use technology in their thinking and learning processes. By infusing the use of digital tools in a course, students are more likely to engage with the course content acquisition and creation of new knowledge in the field of study (Kahu n.d.).

16.4.3 Limitations

The university's strategic plan includes a goal of becoming the premier student-focused university in the state and beyond. The plan also emphasizes the importance of teaching and research applied in learning communities. These communities include both students and professors. Other universities across the nation resound similar mission statements. While this study provides a framework to make these goals a reality, limitations of the course redesign process and specifically this study must be addressed.

Course redesign experience at this university relied heavily on faculty members who desired to improve their skills as educators and voluntarily offered to participate. Unfortunately, research indicates that when a professor changes the format of course they teach, there is a risk that students will not evaluate the course positively the first or even the second semester (Berrett 2012). The professor must learn the new format and mistakes will be made along the way. If the university relies heavily on student evaluations to determine merit raises and awards, faulty members may choose to continue with the course format that served them well in the past, hence discouraging a course redesign.

The campus administration supported the concept of the course redesign process and offered stipends and/or release time to participants. In order to participate in the redesign cohort, a faculty member made application to the Center for Instructional Innovation. The department chair's approval was required when the application was submitted. In this manner, the department chair agreed to allow the time away from regular office duties so the professor could attend summer workshops and follow up meetings during the academic year. Support of the provost and individual department chairs may be a challenge. A university must have a cohesive vision and procedure to make the strategic plan a reality. The challenge is not unique in the intuitions of higher learning (Dee et al. 2011).

Unfortunately, the tenure system in place at many universities does not encourage redesign of courses. The common areas of university emphasis are publication and securing grant proposals for research and development. Universities are classified in a hierarchy according to their success in these areas. Teaching is not equally valued at all institutions of higher learning (Williams et al. 2013). If success in these traditional areas earns faculty members higher status in rank and increased salaries, the incentive to improve teaching wanes over time.

There exist several limitations for this specific study. First, faculty members could participate in a redesign cohort only once. The initial redesign of the courses required an immense amount of time. Several of the initial cohort participants reported the challenge to schedule time to redesign additional courses on an ongoing basis. These additional courses can be redesigned over a longer period of time, but the focus of the endeavor would be difficult to maintain. To complete the course redesign in a timely manner, the faculty member would be required to give up personal time during the weeks of the academic year. Vacation days could also be used for the endeavor. A balanced use of conversations with course design experts and uninterrupted solitude is required for faculty members to reflect, plan and design effective courses for the current educational needs of today's university students.

Tracking results of the effects of course redesign is time consuming and expensive. Data collection must be a priority. Faculty members who redesign courses and then labor to publish or present a professional research agenda have little time to adopt a second area of research interest. This study would be strengthened if additional data were collected from the traditional instruction courses and redesigned courses. For example, an analysis of key questions on midterm exams and final exams could be compared. Student course evaluations could also be used to triangulate the data and strengthen the study. While graduate students and administrative assistants may assist with this endeavor, focused time must be given to the analysis and reporting of the data by participating faculty members. The additional cost of the process must be a priority of the institution if the course redesign process is to be vetted.

The study would be strengthened if the redesigned course was taught by other faculty members. Their teaching style and perceptions of the course would add depth to this study. The feedback from the professors could provide a reflective change from a new perspective which in turn, improves the course further. Replicating the course by other professors would enable student course evaluations to be added to the data collected for this study.

Since this study was conducted in the field of education, other content areas are not represented in this study. If other course redesign faculty members submitted their students' final course grades to this publication, other professors in similar fields would have data to determine the value of course redesign. If these professors added their perceptions of the process and lessons learned, the study would be more robust.

16.5 Conclusion

The implications for future research are varied. At the university level, the overall drop, withdraw and failure rate of traditionally taught courses could be compared to redesigned courses. A cost analysis could be completed to determine if student success in redesigned courses is cost effective in consideration of a stipend given to the professors in the redesign process. A comparison of student success in lower and upper division courses would inform the redesign practice. At the departmental level, future research could address the impact of departmental faculty cohorts and the effect redesign has on the number of program majors. In addition, retention and graduation rates could be measured. Future research is needed to investigate the professors' experience with redesign in a variety of content areas. Student data from these redesigned courses should be triangulated for a careful and critical examination of the impact course redesign bring to bear on student learning.

The course redesign process began with a cohort of faculty peers who were concerned for student success and the core values of the university. The faculty members studied research based best practice in course design and effective application of digital tools. As faculty peers provided pedagogical feedback to one another, the project moved forward. Faculty fellows and instructional technology staff played a crucial role in the redesign process.

The instructor valued three primary lessons learned from the course redesign process. To conduct a redesign of a university level course, an instructor must first designate a large amount of time for initial construction. Aligning course learning outcomes, learning objects, in-class active learning experiences and reflective assignments requires focused time and attention. Alignment is essential as it sets the pace and scope of the entire course. Investment of time to learn new technologies and teaching methodology is required for student-centered course construction. As the course construction progresses, instructors must ask for peer reviews and be willing to apply their suggestions. The collaborative nature of the faculty cohort model was of great assistance to the education professor. Faculty peers provided a fresh approach and valuable insight to several issues the education professor encountered (holding students accountable upon arrival to class and interactive class learning events). After the course is open to students, the education professor discovered the importance of monitoring student progress closely so adjustments can be made to ensure student achievement. Communication with students is an essential element for course redesign success.

The course redesign model provides a formal description of a paradigm shift. Traditional instructional practices can be altered to reduce faculty and students frustration. The model articulates a process by which faculty members work collaboratively to enhance classroom learning and improve their pedagogy for the newest type of learners. Student frustration decreases because the redesign provides a common look-and-feel in course presentation and expectations. Additional work and effort is required for both parties.

Course redesign may enhance student learning by making instruction authentically attuned to society. In a like manner, course redesign may be the tool that assists faculty members to critically evaluate the essence of courses and adjust assignments and methodology to reflect real-world problems in their fields of study. To empower students with life changing tools, educators must be committed to bold, informed change.

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Chapter 17
Some Psychometric and Design Implications of Game-Based Learning Analytics

David Gibson and Jody Clarke-Midura

17.1 Introduction

The growth of digital game and simulation-based learning and assessment applications has given rise to new considerations about how to make sense of what a user knows and can do based on an analysis of interaction log files. The log files are typically a time-stamped record of all the actions taken by the user in the digital space, so they often provide a high-resolution view of the user's performance over time. The data files can become quite large in comparison to typical educational measurements. For example, it is not uncommon to have thousands of records for a single user's thirty minutes of virtual performance interaction, compared with a dozens or perhaps a hundred responses from a thirty-minute multiple-choice test. Several recently edited books have begun to bring together findings from researchers who are grappling with the issues of time, sequence, action relevancy, big-data pattern recognition, grain size and resolution, overlapping patterns, levels of meaning and other intriguing challenges (Ifenthaler et al. 2012; Mayrath et al. 2012; Tobias and Fletcher 2011). Exploratory analysis differs from hypothesis-driven analysis in that it looks at data to see what it seems to say (Morgenthaler 2009; Tukey 1977). This article aims to provide additional insight for a synthesis of methods that are emerging to deal with data from interactive digital learning applications.

The article briefly describes the context, methods and broad findings from two game-based exploratory analyses and provides an abstract of key explanatory constructs utilized to make claims about the users, as well as the implications for the design and measurement of digital game-based learning and assessment applications.

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17.2 Context and Log Files

The data for the analyses described here comes from two virtual performance assessments (VPAs) developed by the Virtual Assessment Project at the Harvard Graduate School of Education. The VPAs assessed middle school students' abilities to design a scientific investigations and design a causal explanation (Clarke-Midura et al. 2010). The assessments were created in the Unity game engine (http://unity3d.com/) and have the look and feel of a videogame (Fig. 17.1).

The assessments start out with one of two problems that students must solve: Why is there a frog with six legs? What is causing a population of bees to die? Students walk around the virtual environment and visit farms, talk to farmers, collect data, test the data in the lab, and conduct research until they have gathered enough evidence to support a claim that allows them to identify the causal factor.

Every action by every user (e.g. opening a page, saving a note) was time-stamped as an event. The data from pilots of the assessments used in the analysis reported

Fig. 17.1 Screen shots of the Virtual Performance Assessments (VPA)

here consisted of 1987 users (423616 event records) in the frog assessment and 1958 users (396863 event records) in the bee assessment. The data examined in this analysis included the raw event data (up to when they make their final claim about the problem) and the scored constructs: designing a causal explanation and designing a scientific investigation. The scored data was scored using a rubric generated by researchers. The scored data was stored in a file that contained demographic information about students (age, gender, class, teacher) as well as their starting prediction for the cause of the problem.

Designing a causal explanation is defined as the student's ability to support their claim or conclusion with evidence. The measure of students' ability to design a causal explanation (DCE) was operationalized through assigning points based on whether the evidence they provided supported the claim they made. Students were first asked to identify data that was evidence based on what they collected in their backpack and the tests they conducted. They were then allowed to choose from all possible data in the virtual environment, to give students who may not have collected all the necessary data a chance to support their claim with evidence. Then the student indicated for each piece of data whether or not it was evidence for their claim/conclusion, as well as identifying which farm was causing the problem. Most of the evidence and the final conclusion or claim were scored on a scale of (3, 2, 1, or 0 points). A backpack of objects populated by the student contained up to 5 pieces of data, each worth (3, 2, 1, or 0 points). Overall, DCE is scaled between 0 and 24.

Designing a scientific investigation (DSI) is defined as the student's ability to carry out an investigation to gather evidence to support their claim. The measure of students' DSI ability was operationalized through assigning points based on whether they conducted tests in the labs, used controls, conducted multiple samples, and reviewed informational research on the causal factors. These processes were scored dichotomously, if the students performed the action they were awarded a point. If they did not, they received a 0. Overall, DSI is scaled between 0 and 24. This construct was an attempt by the researchers to turn student investigative processes captured in the log data into products.

The raw event data contained the time-stamped actions students took from the moment they logged in until they were ready to make their final claim, which is called the "event file." The event file had multiple records per user based on the number of events triggered by the user during a single testing session, and contained fields including the time-stamp of each event, a code for the zone, action and object of each event (i.e. where in the application, using what interaction method, and on what objects associated with each event), and the results of in-world interactions that produced a result. For example, if the user conducted a blood test, there might be five testing results showing which tests were performed on frogs and the result of each test. Similar data were available for the bee assessment.

The purpose of the analysis was to search for patterns of action that might relate to the performance of the user correlated with the student's final claim. Could the log and score data tell us about the user's performance? Additional questions included:

Table 17.1 Tools used in game-based analysis

Software	URL	Uses
Excel	http://office.microsoft.com/en-us/excel/	Counts, pivot tables
Weka	http://www.cs.waikato.ac.nz/ml/weka/	Data mining with machine learning algorithms
Eureqa	http://creativemachines.cornell.edu/eureqa	Symbolic regression
GraphViz	http://www.graphviz.org/	Network graphs

- Is there a relationship between overall duration and score level?
- Were there performance differences that differed by gender, age, and grade?
- Was there a relationship between someone's prediction at the beginning of the assessment and their claim at the end?
- Did students have different patterns of behavior and resource utilization that were predictive of their claim?
- Were patterns of behavior and resource utilization related to their predictions?

17.3 Tools and Methods

Software tools used in the analyses included Excel, Weka, Eureqa and GraphViz and the associated methods with each tool included raw counts, pivot tables, data mining with machine learning algorithms, symbolic regression, and network graph analysis (Table 17.1). Raw count tables were used to explore cross-tab relationships among variables. From the tables, subsets of data were exported to Weka or Eureqa depending on whether the goal of the exploration was data mining with cluster methods or symbolic regression. Weka was used to visually inspect data relationships, classify datasets, and discover clusters and association rules. Eureqa was used to conduct symbolic regression searches for mathematical expressions that could best capture the dynamic relationships among the variables under study. GraphViz was used to create network digraphs of the association rules found for subgroups and the population as a whole. At the end of this article is a reflection on the strengths and weakness of each of these tools and their relationship to the overall analysis.

In this section, examples of the various methods employed are offered as brief introductions to the approaches and the primary purpose for selecting each one. The goal here is to set the stage for commenting on the psychometric implications by giving an overview of the resulting information obtained with each method and its potential relationship to understanding what a user knows and can do being inferred from the log file of a virtual performance assessment.

17.3.1 Symbolic Regression

To answer the question about whether duration of performance was related to score, a traditional approach might be to seek a correlation and explain the shape of the data from the point of view of the population as a whole. In contrast, the symbolic regression method using Eureqa (Schmidt and Lipson 2009) was selected to attempt to obtain a detailed mathematical expression that would be predictive for any individual score given the user's duration in the digital assessment (or vice versa). Correlation in this case is used as a criterion for the fit of the discovered equation. To preprocess the data, information on duration and total score was smoothed and normalized, and outliers were removed (Fig. 17.2). Note the cyclic data relationship as the total score increases from left to right; this cyclic aspect in the data is due to the nature of the time-stamp, which uses modulo math (e.g. the 13th hour resets the hour clock to 1, the 61st second resets the seconds clock to 1, the 61st minute is an increase of 1 h, with a resulting zeroing out of the variable and thus a cycle). The zero point on the horizontal is the comparable means of the two variables after normalization. A search was performed until equations converged, with Eureqa's default settings for error (squared error) and simple arithmetic expressions (basic operations plus trigonometric building blocks). The selected solution (Eq. 17.1) on the Pareto Curve had r^2 = 0.72 and correlation of 0.85 (Fig. 17.3 lower right hand corner). The Pareto Curve represents the trade-off in efficiency between error and complexity: the less complex the mathematical expression, the higher the error and vice versa. This example of the use of Eureqa provides evidence for the finding that complex nonlinear relationships can be discovered in digital game-based learning data via symbolic regression.

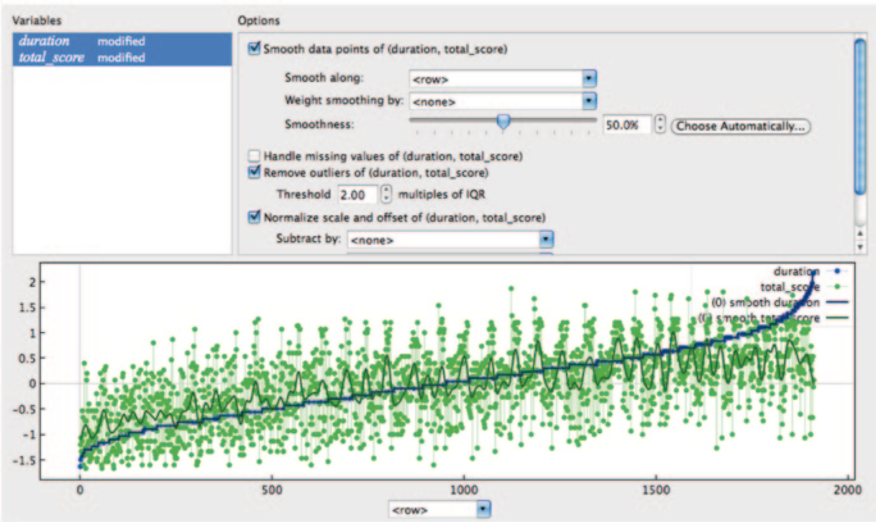

Fig. 17.2 Pre-processing visualization in Eureqa showing smoothed and normalized data for duration and total score

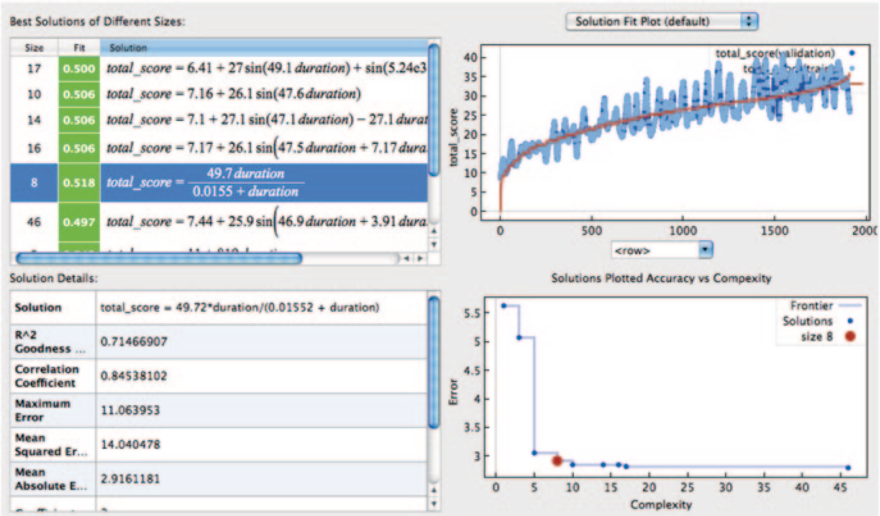

Fig. 17.3 Relationship of total score to duration: solution on the Pareto curve

$$\text{total\_score} = 49.72^{*}\text{duration} / \left(0.01552 + \text{duration}\right) \tag{17.1}$$

17.3.2 Counts

To characterize the relationship of prediction to claim, the next example shows the use of a raw count table to display the unique occurrences of users (by student ID) in a cross-tab matrix of prediction versus claim (Table 17.2). The Pivot Table method in Excel automates selected mathematical and string operations on variables and arranges the results in a matrix that allows quick exploration of the data.

Note that 72 students predicted “aliens” as the cause of the unusual frogs (the total of the aliens row), but only 21 of those offered “aliens” as their claim (the intersection of the row with the aliens claim column). The count table provides the basis for empirical probabilities based on the ratios of students located at the intersection of prediction and claim choices. In a similar population of middle school students, we would expect that 754/1985 or 38 % will likely claim “pesticides.” We can also see that only 8 % predicted that result at the beginning of the assessment, so a significant portion of the test takers arrived at this conclusion after interactions in the virtual assessment. We found that the assessment guided a specific change of opinion from pre to post. This indicates that the assessment may be educative and that user actions can give clues to a user’s thought processes, since changes from pre to post can be tracked for each individual, compared to a population expectation, and compared to expert judgment about the trajectories from pre to post.

Table 17.2 Unique student ID matrix of counts for prediction and claims in A2

Count of student_id	Claim_id					
Prediction	Aliens	Mutation	Parasites	Pesticides	Pollution	Total
.	–	7	12	14	10	43
Aliens	21	7	11	21	12	72
Dunno	18	50	270	310	150	798
Mutation	5	126	168	209	103	611
Parasites	–	5	66	40	9	120
Pesticides	–	1	35	95	30	161
Pollution	1	3	26	65	85	180
Total	45	199	588	754	399	1985

We noted that the number and types of categories in a pre-post comparison should be the same in order to improve the confidence of findings, because in this context, there was a degree of outcome driving by the reduction from seven choices in the pre, to five choices in the post. People in the pre who had said that they did not know were forced to make some other choice in the post. A few people also made no prediction but then made a claim. We checked the amount of forcing and concluded that this assessment still did impact opinions, which was also confirmed by additional evidence noted below. In follow-up research with the same assessment, these empirical probabilities could be used as triggers for interventions during play. For example, the students who start off predicting mutations rather than pesticides could be given additional evidence concerning the time scale of evolution (progeny) versus that of environmental impacts during maturation (ontogeny). Those student who used that evidence and changed their mind from mutation to pesticides would be strong evidence of those who designed a causal explanation due to interaction with the game.

17.3.3 Rule Discovery with Machine Learning

Association rule discovery was conducted with the aid of an algorithm in which unstructured data is searched for repeated patterns of use; that is, in which one resource is associated with another resource via being used in a specific sequence (Table 17.3). In the example here, primary event data that had been labeled as 'control, research, experiment, sampling, and questions' was searched for association rules. Did a student's use of one type of experiment predict the use of another type or any of the other data? A search of the data found the ten best association rules using the "Apriori" algorithm in WEKA (Witten and Frank 2005). This algorithm seeks to find repeated patterns in an exhaustive search of the data, which we later used to produce a rule network graph for the total population (Fig. 17.4) and compared with graphs for the subpopulations that had been identified by the empirical probabilities.

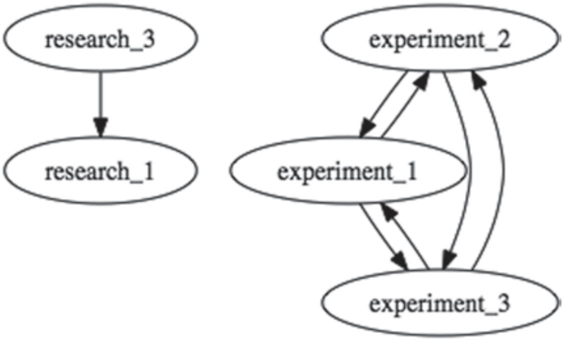

Fig. 17.4 Digraph of best association rules for the total population

The benchmark of 'top ten' association rules reduces the data and focuses later searches by ignoring many event pairs and triads in the following stages of analysis. For example, the following types of events had low confidence levels, meaning that they were not used by large numbers of the population (claim, control_1, control_2, control_3, research_2, research_4, research_5, research_6, sampling_1, sampling_2, sampling_3). This indicates that certain actions in the virtual assessment were marginal to this population's performance and others were critical. We were able to find which actions were critical to best performance via the association rules in conjunction with the empirical probabilities, which we now explain.

In Table 17.3, we can see a pattern of key activities that almost everyone in the population used during the assessment. Reading line 1, we note that 1422 students conducted research #3 before conducting research #1. With a confidence of 100 % we can predict use of each of these events from either bit of information. We also see that it was the most-used pattern of all the evidence-producing interactions made available by the virtual assessment.

Table 17.3 Top ten association rules for the sample population

Rules	Event one	Precedes	Event two	Confidence
1.	Research_3=1422	⇒	Research_1=1422	conf:(1)
2.	Experiment_2=experiment_3=1472	⇒	Experiment_1=1452	conf:(0.99)
3.	Experiment_1=experiment_3=1474	⇒	Experiment_2=1452	conf:(0.99)
4.	Experiment_3=1499	⇒	Experiment_1=1474	conf:(0.98)
5.	Experiment_3=1499	⇒	Experiment_2=1472	conf:(0.98)
6.	Experiment_1=experiment_2=1479	⇒	Experiment_3=1452	conf:(0.98)
7.	Experiment_2=1512	⇒	Experiment_1=1479	conf:(0.98)
8.	Experiment_1=1514	⇒	Experiment_2=1479	conf:(0.98)
9.	Experiment_1=1514	⇒	Experiment_3=1474	conf:(0.97)
10.	Experiment_2=1512	⇒	Experiment_3=1472	conf:(0.97)

We found that the 'top ten' association rules were nearly identical for both testing contexts (frogs versus bees), indicating that the structure of the virtual performance assessment digital space was operating in a similar manner for both cases. Students in different locations and at different times were using the virtual assessment affordances in very similar ways. We also found that subgroups that did not follow the 'top-ten' use patterns were more likely to score poorly on the exam. In effect they did not conduct the right series of key experiments that provided confirming evidence for the best choice of a final claim.

17.3.4 Network Analysis

A digraph of the association rule network was created with GraphViz (http://www.graphviz.org/), which depicts the network of relationships in the data (Fig. 17.4). A digraph is a "directed graph" where the edge from one node to another has a directional meaning – as in causality or implication. An association rule network has directionality if there is not a second rule pointing back from a second node to the first. For example rule one points from research_3 to research_1 with high confidence, but there is no rule pointing from research_1 back to research_3 within the top ten rules, so the digraph captures the one-way relationship and implies that there is more than a random coupling association between these two nodes; the particular direction of coupling is critical to the virtual performance. Experts familiar with the structure and semantics of the virtual performance assessment have to validate whether the one-way causal or implicative relationship is appropriate as evidence of the knowledge and action the virtual assessment is attempting to measure.

Since the rule and network analysis of the frog assessment led to the observation that subgroups whose resource usage did not have a structure of scientific investigation similar to Fig. 17.4, were more likely to have missed important evidence and reached a weaker conclusion, if this information were used during the assessment to re-direct students to important evidence, then the digital experience would potentially be formative for developing their abilities to design scientific investigations.

17.3.5 Cluster Analysis

As a final example of analysis methods, we used cluster analysis to explore the relationship between salient moves and clusters formed from all other data in the record. Salient moves, which had been determined by an expert panel, were identified as part of the conceptual framework of the assessment. Each salient move counted as "1" in this analysis, which searched for the number of such moves in relationship to claim and the user's closest cluster using all data in the record. Closeness was determined using the "Expectation Maximization" algorithm (Dempster et al. 1977). Clusters mapped closely to claims, but were more complex, because they were formed from all available data. For example, students who shared similar search

Fig. 17.5 Number of salient moves vs cluster membership

and resource utilization strategies might be clustered together, even though they reached different conclusions about the data and made different claims (Fig. 17.4).

It is clear from Fig. 17.5 that cluster 2 used far fewer salient strategies than others, indicating that above a certain number of salient moves, we can predict which cluster a student is NOT a member of, narrow down to the remaining groups and use group probability distributions to estimate other aspects of the student's performance such as total score and final claim.

17.4 Explanatory Constructs and Reflections

The above examples of symbolic regression, counts establishing empirical prior probabilities, visualizations, rule discovery, network structure, and cluster analysis methods illustrate some of the new array of tools used in game-based data analysis. In the following sections, a comparison of the methods is presented followed by a summary of main findings and thoughts concerning the design of game-based data collection for educational measurement. This section briefly highlights the main strengths and weaknesses of the analysis approaches when applied to log data collected from a virtual performance assessment. Overall, the strengths of all the above methods come from their use in model building contrasted with hypothesis testing and traditional statistical testing. The methods are useful when the questions about data are open-ended and ill-structured; more along the lines of "what have we got here?" than "to what extent is there an impact?"

Symbolic regression (Schmidt and Lipson 2009) discovers sets of mathematical expressions that capture the dynamics and structures in data, but leaves the decision to the user concerning which expression is best for a particular purpose. The expressions are arrayed from most simple with highest error to most complex with least error, and there is a danger that if an analyst chooses complexity and low error, and performs no other tests or explorations, then an "over-fit" expression will be the result. To ameliorate that threat, cross-validation methods are used; random subsets of the data are used to train as well as test the fitness of the solution. The method is most naturally used with continuous quantitative data, but additional methods can be applied to deal with qualitative data. Groups of such expressions can lead to rule sets, network representations and analysis.

The discovery of association rules among qualitative data can also lead to network representations and analysis (Han et al. 2007). Algorithms in data mining toolsets perform exhaustive searches and optimization routines that result in a descriptive and associative rule set (compared to the mathematical rule set of the symbolic regression method). Such an associative rule set, when considered with the confidence of the rule, can elucidate the hierarchal as well as temporal structure (Campanharo et al. 2011) of the relationships in a virtual performance assessment created by the paths of multiple users traversing the space and utilizing resources. A limitation of this method is that it is used solely with qualitative data, so continuous data would need to be quantized (Miles and Huberman 1994) before applying the methods. Log data of a qualitative nature does not need to be coded into numeric bins, as is the case when using SPSS methods.

Visualization methods have been traditionally thought of as the display of findings, so it needs to be emphasized here that visual exploration is itself a form of inquiry as well as demonstration. See for example (Wolfram 2002) for an example of exhaustive visualization as demonstration. The strengths of the method include the fact that humans have highly evolved visual sense, which facilitates insights from multiple representations and expands understanding of relationships. Thus, WEKA for example, displays visualizations early in the process of data exploration rather than as the last step after analysis. The main weakness is that visualization alone is not enough specific information to convince one of a relationship; so multiple methods need to be combined to tell a complete story of the data.

These strengths and weaknesses are related to explanatory constructs suggested by the VPA data and shared here to stimulate thinking and discussion. In both the frog and bee assessments, a count of unique student ID's on a table of prediction vs claims produced a basis for what might be called the ecological rationality (Gigerenzer and Todd 1999) of the performance space, a foundation for computing the joint probability of variables, for example as the a priori probabilities in a Bayesian analysis. Empirical probabilities computed from the counts provided a basis for making inferences about the cognitive states of the population viz the affordances of the space and in relationship to the world outside of the performance space. For example, a count of the change from prediction to claim options documented a shift in opinion, implying that the structure of the choices as well as the associated action patterns of the populations making those choices provided evidence of the thought processes that accompanied those decisions. The goal of analysis is then to reconstruct the most likely explanations of action patterns given the ecological rationality of the population.

A second observation is that saliency of a particular action is not a property of the action alone, but has to be paired with an object, the action-object pair, as well as a context of the action, which leads to the idea of larger action phrases or motifs. For example, "opening" any page is an action, but "opening the pesticides page" is a specific action-object pair with more meaning. Furthermore opening that page near the end of the assessment when making the decision about which claim to assert, further contextualizes the meaning of that action. The evidence from the two virtual performance assessment analyses suggests the possibility that the larger the unit of appraisal or motif, the easier it is to discover the variations in the action patterns of users; and the more the context is understood, the more that saliency can be associated with some particular intention or goal.

17.5 Psychometric Implications from the Analyses

Psychometrics involves two major tasks: the construction of instruments and procedures for measurement and the development and refinement of theoretical approaches to measurement. With the advent of game and simulation-based applications for learning, the instruments and procedures for measuring learning and performance are shifting away from point-in-time (e.g. means taken on a slice of time) to patterns-over-time methods (e. g. trajectories evolving during some period of time). This moves the discussion around assessment from numbers to the structure of reasoning (Mislevy et al. 2012). The study presented here illustrates some of the implications of the new methods for theory and procedures needed to imply and estimate what someone knows and can do from game-based actions. The implications fall into several types: nonlinear relationships, rule networks, Bayesian probabilities, and semantic structure of actions.

With log data from an educational game or simulation, complex nonlinear relationships can be discovered via symbolic regression and mathematically expressed with a good degree of precision. For example, in both the frog and bee assessments, a relationship was discovered between duration and score and could be expressed with precision.

Differing performance strategies used by subgroups have a discoverable well-defined meaning and expression in terms of association rules and network structure that can be validated with performance outcomes and scoring. The relationships are complex, overlapping and nonlinear. However, if there is no constraint on utilizing resources in the virtual performance assessment space, then there will be consider-able overlap of patterns by all users (everyone uses everything), making the discernment of action patterns more difficult.

Rule networks can be discovered that are useful for making automatic inferences within the constraints of the rule's confidence level. The rules in the VPA for example could classify that the student belongs in or is excluded from a particular performance group, or if the student was already known to be in a performance group, then when time or action sequences are added to the analysis, scores can be inferred. Tuning up rule mappings requires people who are knowledgeable of the performance space affordances to make adjustments for causal and concurrent influences. Once tuned up, the rule network can help define a multileveled perceptron that can automatically categorize inputs within the constraints of cross-validation results.

Prior probabilities for Bayesian scoring and other automated analyses can be based on the prior performances of cross-validation groups. In the VPAs for example, predictions and claims data from the tested population provided a number of prior probabilities.

Patterns of action-object use (i.e. semantic structure) have predictive value, and we suspect that larger and larger phrases and sequences of action-objects will increase their value by enlarging the salience of the actions. In the VPAs the digraphs and association rules for action-objects provide details for differences in strategy patterns, subgroup membership, and performance level. For example, the pesticides group spent more time than others inspecting the red frog, inspecting the green water, and discarding green water. The pollution group talked to the red farmer more than others. The parasites group talked to more to the scientist and the farmer from the yellow farm than others. These sorts of differences in action-object sequences can be used to classify a user during an assessment.

17.6 Implications for Design of Virtual Performance Assessments

The following suggestions based on the analysis and findings reported here are intended to heighten the potential variation among test takers of a virtual performance assessment so that differences in strategies and resulting actions will stand out during analyses.

Designers should plan for larger units of appraisal than the single record event with a time-stemp. If possible, build these recognized units into the application's data collection mechanisms as second order appraisals. The automated recognitions can contain some noise and can also be constrained by windows of time within which all the constiuent action-objects must appear, including "the in-sequence appearance" of action-objects when necessary. Related to this observation, there needs to be a method for identifying action sequences that are unique to specific searches and solutions in the virtual performance space.

Time measures should, in addition to time-stamping events, document the event duration (e.g. the start, duration, and ending as a unit) of salient action sequences and use a non-cyclical amount of time, to avoid introducing cyclical artifacts caused by the modulo mathematics of clocks.

In visualizations, utilize an assessment frame-based reason to place sections of action-object pairs closer to each other. For example, if the variables were organized into action-object groupings related to the conceptual structure of the assessment, then time-based visualizations would reveal new patterns and insights.

To avoid the problem of everyone displaying a similar "use everything" strategy, designers should consider utilizing "anti-scoring" penalties that would further restrict the range of scores to better align with highly valued action-object sequences OR have clearly defined outcome subscales that align with scores. Resource utilization behavior would change if there was a "limited resources" cost to using time or choices, which would lead to more differentiation in the action patterns.

17.7 Conclusion

Highly interactive, high-resolution log file data from virtual performance assessments show promise for documenting in new ways what students know and can do. Data mining, machine learning and symbolic regression techniques are effective tools for analyzing and making sense from the time-based records and for relating those to both automated and human scoring artifacts. New psychometric challenges are emerging due to the dynamics, layered resolution levels, and complex patterning of actions with objects in virtual performance assessment spaces. Learning analytics analyses are helping uncover and articulate the relationship of time-event appraisals, visualization structures and resource utilization constraints on the psychometrics of virtual performance assessments.

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Chapter 18
Self-Assessment and Reflection in a 1st Semester Course for Software Engineering Students

Jacob Nielsen, Gunver Majgaard and Erik Sørensen

18.1 Introduction

How can student self-assessment be used as a tool and become beneficial for both lecturers and students? From an educational perspective, pretesting students is an important part of tailoring a course to fit with the students' prerequisites. When evaluating the students' learning at the end of a course it makes sense to relate that to their prerequisites in order to measure how much the curriculum of the course has affected their learning. Making the students self-assess their knowledge level at the beginning and the end of a course is one approach at making the students actively reflect upon their own learning.

Other recent research has investigated pre- and post-tests of students' self-assessments (Schiekirka et al. 2013), which is based on self-assessment of specific learning objectives related to factual knowledge. They conclude that their tool is easy to implement and assists teachers in identifying strengths and weaknesses on the level of specific learning objectives for a particular course. In our study we measure learning terms rather than learning goals. Our tool is also intended as a student tool, giving the students an opportunity to evaluate their own learning in preparation for the exam. We did, however, not measure this yet.

Within our 1st semester human-computer interaction (HCI) course, we wanted to promote our students' HCI competences and analytic competences. We wanted the students to create prototypes, be reflective and articulate their design process.

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We believe that dialog based on the academic theory and their design experiences reinforces the learning process. This is theoretically supported by Schön (1983) and Bateson (2000).

Furthermore, we wanted to make the students aware of the main topics in the course before the first lecture. We wanted them to take in and reflect on what they were going to learn this semester. This was done through a pre questionnaire. In the pre questionnaire the students became aware of what was expected of them on the conceptual level. This type of learning activity was of a reflective nature and the obtained awareness had the potential to help the students focus on important concepts during the semester.

The other type of learning activity we promoted in the course was active participation while constructing interactive systems. The knowledge achieved by the students was expressed in actual designs of prototypes and reflections on these. Part of the knowledge expressed in action and in the design of prototypes will often be difficult to put into words and can be described as tacit knowledge (Schön 1983; Agyris 1978).

The concept of knowledge-in-action alone is not sufficient in a learning process or in a field practice. It must be supported by a more retrospective form of reflection such as reflection-on-action. Reflection-on-action helps the students to articulate conceptual knowledge on app-programming and HCI. In the retrospective reflection process their own experiences are connected to emerging conceptual knowledge. And conceptual knowledge is used in the professional communication amongst peers.

In the classroom we wanted both knowledge-in-action and reflection-on-action. It is in the interplay between these forms of reflections that the skilled designer unfolds his potential. It is in this interplay that innovative processes evolve. It is also in this interplay that the students achieve a good learning depth.

To put extra focus on the reflection-on-action the students made a self-assessment at the end of the course similar to the one at the beginning. In this assessment the students again were to reflect on their understanding of core concepts in HCI. This type of reflection was not so much linked to optimising their interactive designs; it was more linked to their understanding of the academic concepts in HCI. This type of reflection is important and productive in higher education. The students must understand the academic concepts in depth in order to develop a critical and analytical approach to them.

The testing tool—the questionnaire—used in this work was based on an idea of one of the authors. The primary goal was to make it measure the learning using the SOLO Taxonomy (Biggs and Tang 2007), which divides learning into a hierarchy of five levels: prestructural (misses point), unistructural (identify, do simple procedure), multistructural (enumerate, describe, list, combine, do algorithms), relational (compare/contrast, explain causes, analyse, relate, apply) and extended abstract (theorise, generalise, hypothesise, reflect). The SOLO Taxonomy is often used to form intended learning outcomes for any given course using this hierarchy of verbs, but here we use it to form the grading system presented in the methods section.

Our main objectives for this pilot study were to design and evaluate a simple and easily applicable self-assessment tool for pre- and post-testing in a first-semester engineering course.

18.2 Methods

The research methodology used in our work was based on Design-based Research and action research (Barab and Squire 2004; Lewin 1946; Majgaard 2010; Majgaard et al. 2011). Design-based Research is a branch of educational research that uses the iterative design of educational interventions to exemplify and develop theories of learning. It also brings a change in the behaviour of the target group into focus and allows emerging goals. Experiments and critical reflections are the core of the research method, allowing learning from and through practice. In this research the experiments covered self-assessment before and after the course.

The target group of this study is first-semester Software and IT engineering students. The main academic learning objectives of the 5-ECTS Interaction and Interaction Design course are that the student at the end of the course should be able to:

- Plan a user-centred design process
- Investigate the users, their needs and their practice through interviews and observations, and present the results in ways suitable for making design decisions.
- Involve users in design and evaluation in suitable ways
- Design interactions to fit with the users' needs and practices
- Apply fundamental design rules for user-friendly designs
- Describe different types of interactions
- Use selected types of interactions
- Plan and conduct evaluation of interaction design and present the results
- Develop simple digital prototypes
- Reflect on interactive design processes and the meaning of good design

The book used in the course is Interaction Design: Beyond Human—Computer Interaction. (Rogers et al 2011). The course was followed by approximately 70 engineering students and run in parallel with their 10-ECTS semester project on user-centred design allowing them to work more thoroughly with the theories and methods of the course. Besides the pre- and post-tests the students had an HCI multiple-choice test as well as an oral project examination.

The questionnaire, which is used for both the pre and post student self-assessment in this course is based on a likert-type (Rensis 1932) SOLO-inspired (Biggs and Tang 2007) grading of the students' assessments of their own learning. The questionnaire is comprised of 50 relevant terms within the subject areas: interaction design and user-centred design. The terms are chosen to broadly cover the learning objectives of the course as well as the content of the course book and can be seen from Table 18.1 and 18.2. We are not aiming at a specific number of questions, but rather want to make sure we cover the essential parts of the course material. The

Table 18.1 The first 25 terms used in the pre and post tests were the following

1. Interaction design	13. Expressive interfaces
2. Good desing/ bad design	14. Persuasive technologies
3. Usability and Usability Goals	15. Antropomorphism
4. User Experience and User Experience Goals	16. Gui (graphical user interface)
5. Conceptual model	17. Nui (natural user interface)
6. interaction design process	18. Structured interviews
7. Principles of Interaction Design	19. Focus groups
8. Interaction types (Instruct, Converse, Manipulate, Explore)	20. Questionnaires
9. Interface metaphors	21. Observation
10. Cognition	22. Qualitative data analysis
11. Mental models	23. Quantitative data analysis
12. Social interaction	24. Distributed cognition
	25. Graphical datarepresentation

Table 18.2 The last 25 terms used in the pre and post tests were the following

26. User involvement	39. Use cases
27. User centered design	40. Prototyping
28. Early focus on users and tasks	41. High fidelity/low fidelity
29. Empirical measurements	42. Wizard of Oz—model
30. Iterative design	43. Konceptual design
31. Life-cycle model of Interaction Design	44. Storyboard
32. Stakeholders	45. Participatory design
33. Establishing requirements	46. Evaluation
34. Functional requirements	47. evaluating users in controlled settings
35. Data requirements	48. evaluating users in natural settings
36. Environmental requirements	49. Evaluating in settings not involving users
37. Brainstorming	50. The DECIDE framework
38. Scenarios	

questionnaire has three overall aims. The first is to get a measure of the students' prerequisite knowledge of the selected terms. The other is to get an indication of the learning that takes place during the course through a comparison of the results of the pre and post questionnaires. Our third aim is to get the students to reflect on their own knowledge of the different subjects in this course through self-assessment.

The succession of the terms of the questionnaire are closely related to the succession of the subjects of the book and the course plan, and as such lower-numbered terms are presented early in the course and high-numbered terms at the end of the course.

The questionnaire is handed to the students in paper form at the beginning of the first of 12 lessons within the course. The students are asked to fill in the form, grading each of the 50 terms using the following numbers:

1. I have never heard of this before.
2. I have heard of this before, but do not really understand what it means.
3. I have an idea about what this means, but I don't want to have to explain it.
4. I have a clear idea about what this means and I am able to explain it.
5. I know exactly what this means and I am also able to relate it to other subjects.

The data of the anonymous questionnaires are collected and entered into a spreadsheet, where the average grading of each of the subjects is computed and visualised in a bar graph. The average grading results are analysed and the course curriculum altered accordingly if necessary.

The post questionnaire is handed out at the last lesson of the course prior to the examination preparation period. Following the same procedure as the pre questionnaire. The average grading of the single terms of the questionnaires can now be compared and used as an indication of the teaching and learning results of the course. The terms that receive a low score indicate where extra focus might be needed during the next run of the course, although this has to be compared with the course objectives, the results of the final examinations and the pre-test of the students attending the next run.

18.3 Results

With the pre- and post questionnaires, we attempted to measure the student's self-assessed learning at the beginning and at the end of the course.

The Pre Questionnaire 62 students answered the pre questionnaire, and looking at the results of the average grading of the terms in this test (the dark grey bars of Figs. 18.1 and 18.2), we see that the responses to the 50 terms are widely spread from just above 1 up to ~4.6. The average is 2.47, stating that if we look at all the student answers, the students would rate their own knowledge as "I have heard of this before, but do not really understand what it means".

The Post Questionnaire 43 students answered the post questionnaire, and now the average grading of the terms (the light grey bars of Fig. 18.1) range from just below 2.50 up to 4.60. The average is 3.82, which means that overall the students would rate their understanding of the course as "I have a clear idea about what this means and I am able to explain it".

Comparison The question terms that show the smallest gap between pre and post are e.g. "Questionnaires", "Brainstorming" and "Evaluation". The question terms that show the largest gap between pre and post are e.g. "Wizard of OZ—model", "High Fidelity/ Low Fidelity" and "Life-cycle model of Interaction Design". The average rise from pre to post is 1.36.

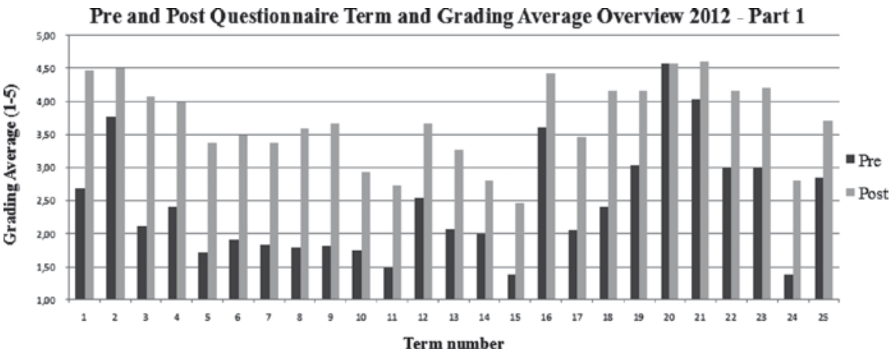

Fig. 18.1 First 25 results of pre and post questionnaires in the course Interaction and Interaction Design, 2012. (See Table 18.1 for terms corresponding to term numbers)

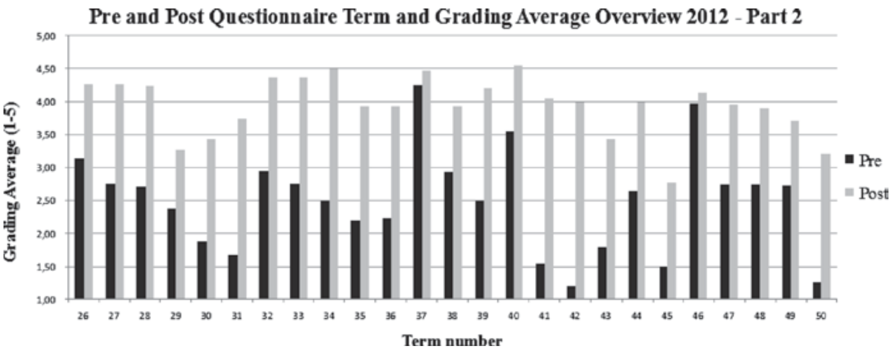

Fig. 18.2 Last 25 results of pre and post questionnaires in the course Interaction and Interaction Design, 2012. (See Table 18.2 for terms corresponding to term numbers)

18.4 Discussion

18.4.1 Analysis of the Results of the Pre Questionnaire

As anticipated from the questionnaire design, the students rate the terms that are commonly known to people at a higher level of understanding. “Questionnaires”, “Observation” and “Brainstorming” are rated above 4 followed by “Good Design/ Bad Design”, “GUI”, “Focus Groups”, “User Involvement”, “Prototyping” and “Evaluation” which are all between grading 3 and 4. We were surprised to see “Focus Groups” and “User Involvement” rated at this level, since we did not expect first-semester students coming from pre-university educations to have any knowledge about this.

At the lower end of the self-assessed level of understanding, we see subjects such as “Wizard of Oz”, “Anthropomorphism“, and “Distributed Cognition”. These are clearly very specific subject terms and looking through the data there are only a few students that rate these higher than level 3. Overall the students have never heard of these terms before.

The results of the pre questionnaire only led to a few changes in the curriculum of the course. First of all, there were only few surprises going through the statistics, and secondly, the spreading of the results of the individual questionnaires was for most subjects large enough that it would still be necessary to let the students work with a given subject in order to be able to reach the same level of understanding. What we did change based on the pre-test was, however the focus on brainstorming within the projects. Here, a large majority of the students rated this high enough to make us assured that they would be able to do proper brainstorming in their project groups. And since the project groups consisted of 5–6 students, we believed that those who did not have any experience in brainstorming would gain this from their fellow students within the groups. If the students scored four in brainstorming, they agreed on being able to explain the concept. This isn't the same as being able to implement a brainstorm and it isn't the same as knowing specific brainstorming methods. But from a debate in the classroom we came to the conclusion that brainstorming was something that most students had actually worked with beforehand and the project groups were all quite confident on how to proceed with this.

From the lecturer's perspective the pre questionnaire resulted in minor adaptations of the course. This can be compared to Schöns reflection-in-action where the lecturer adapts on the fly his curriculum (Schön 1983; Argyris 1978).

From the students' perspective the pre questionnaire gave them a possibility to reflect on the important academic concepts in the HCI-course. The students also obtained a small insight into the gap of what they already knew and the knowledge they were supposed to be familiar with at the end of the course. They might also have obtained some of the same knowledge while browsing in the semester book on HCI. In addition, the questionnaire gave them time to reflect on their own academic knowledge level and the expected knowledge level. This can be described as specific knowledge gaps (Angelo and Cross 1993).

18.4.2 Analysis of the Results of the Post Questionnaire and Comparison From the Lecturer's Perspective

The calculated averages of the post questionnaires show increased levels of self-assessed understanding for all of the terms except one. Luckily, no negative learning was observed at any of the terms. This was first and foremost of great reassurance in terms of the lecturer of the course, but it also gave a good overview of where the students had learned the most and the least and how this would potentially change the curriculum of the course this year and the following. From the results obtained, it is quite obvious that the students have been honest about their learning. Preferably, the lecturers would have liked to see an average for most of the terms just around or above 4, stating that the students would be confident enough with each term in order to be able to explain it and maybe relate it to other subjects inside or outside the curriculum. In the following we have picked out a few of the interesting terms from Fig. 18.1 and 18.2 and analysed them further.

"1. Interaction Design" This term represents the overall subject of the course, and as such it is important that the students leave the course with a high degree of knowledge about what this term means and also an ability to explain it to others, and in the case of their semester project, an ability to work with the different parts involved in doing interaction design. The students enter the course with a knowledge grading of this at an average around 2.70, which means that they probably read the study plan before going to the first lesson, so that they have an idea about what interaction design means and what the contents of the course are going to be. At the last lesson this grading is very close to 4.50, which is considered very good indeed and which assures the lecturers that at least an overall understanding of the course contents has been achieved.

"4. User Experience and User Experience Goals" Setting goals for and assuring specific user experiences are some of the most important aspects of doing interaction design today, so a good understanding of these terms is a must and a necessary prerequisite if you want to work at a professional level with interaction design. The pre questionnaire gives an average grading of these terms around 2.4 and the post questionnaire 4.00. Both usability and user experience have been central subjects in the teaching of the course and it is thus reassuring that the students rate themselves at a high level of understanding at the last lesson of the course.

"6. Interaction Design Process" Looking at the learning objectives of the course, the first objective is for a student at the end of the course to be able to "Plan a user-centred design process", and the other objectives mention process keywords such as Design, Prototyping and Evaluation. In the course we have spent a lot of time teaching the four key elements of the interaction design process (Establishing requirements, Designing alternatives, Prototyping and Evaluation), and outlining that doing interaction design also naturally means doing user-centred design. It therefore comes as a surprise that the students do not reach an average grading of at least 4 for this subject at the end of the course, and therefore we will increase focus on this subject next semester. One analytical, but unsupported comment to the grading of this subject may be, that as the post test was run at the last lesson of the course—before the students' preparations for the exam, and since the course material about the interaction design process is placed at the beginning of the course, the students had less memories about this term and had troubles relating it to the actual content of it.

"20. Questionnaires" As stated above, it was surprising for us to see "Questionnaires" rated at this level (4.56) at the pre questionnaire, and it did not leave much space for improvement in the post questionnaire (4.57). This clearly indicates one weakness with this type of measurement. When the students indicate a high knowledge level at the beginning of the course it is difficult to measure all the new material that they have worked with during the course, i.e. types of questionnaires, different ways of asking questions, measuring quantitatively or qualitatively etc.

"26. User Involvement" and "27. User-Centred Design" These two terms are central to the learning objectives and very much related to the overall interaction design process. Within the teaching of the course there has been great focus on stating the importance of the user and the necessity of involving them in the design process in order to assure usability and the right user experience. It was therefore of great reassurance to see these as rated above 4 with the post questionnaire.

"42. Wizard of Oz—model" The Wizard of Oz term rates, expectedly, as unknown to the students in the pre questionnaire. This does, however, change dramatically during the course, and the term receives an average rating of 4 at the end, being the one term for which the students' average self-assessed knowledge level changed the most. Wizard of Oz is a term for a model of how to simulate interaction with very simple and usually non-interactive prototypes, and thus the term cover a very important part of doing initial prototype evaluation at a stage of design where it is still too uncertain to start spending time developing technologies. This term is therefore regarded an essential part of interaction design and therefore it is very important that it is highly rated in this questionnaire.

"45. Participatory Design" Within the course and especially the students' semester project we did not ask the students to involve the users directly in the design of the prototypes. Therefore, and as an undesired result, the students regarded this term as less important within the curriculum even though, it is actually an important part of doing interaction design. The designer needs to have knowledge about, and be able to choose between different methods of user involvement. Learning of this term will as a consequence be reinforced within the next semester course.

The above was just a small selection and examples of terms and subjects that have allowed us to evaluate this course through the pre and post questionnaires and the students' self-assessment. The following is a list of numbers of the terms and subjects that will receive increased focus in the course next semester: 5–15, 29–31, 43 and 45. Hopefully this will be possible without influencing some of the other terms in a negative direction. From the lecturers' perspective the post assessment was aimed at optimising the course for the next throughput. E.g. the lecturer wanted to increase focus of concepts: 5–15, 29–31 etc. This can be compared to Schön's reflection-on-action, which is the subsequent reflection and evaluation on the process that has happened, and its potential consequences (Schön 1983; Argyris 1978). It is precisely this type of reflection that is desired before running this new course for the second time. As written in the methods section the results of this analysis do, however, have to be compared with the outcome of the final examination as well of the pre test at the beginning of the next run of the course.

18.4.3 Analysis of the Results of the Post Questionnaire and Comparison From the Students' Perspective

From the students' perspective the post questionnaire gave them a possibility to reflect on their current academic level at the end of the course. They could also compare their current level with their initial level and reflect on their progress. Furthermore, the test provided the students with a chance to evaluate their own academic level before preparing for the final examination. These reflections are of adaptive nature and can be compared to Bateson's 2nd level of learning, which provides for good and normal learning (Bateson 2000). But the students also had the possibility to use the test results as a foundation for preparing their exam. In this way the results provided the foundation for a possible layout of a learning strategy. A change in a student's learning strategy can be regarded as level-3 learning. Students in higher education generally benefit from reflections on own learning strategies (Qvortrup 2006; Gleerup 2003).

18.4.4 Evaluation of the Questionnaire

As the above analysis of selected terms demonstrate, it has been quite easy to reflect on the contents of the interaction design course using the calculated and graphically represented results (Fig. 18.1 and 18.2) of the pre and post self-assessment questionnaires presented in this paper. We believe that this kind of assessment should be applicable to other types of courses as well. Using the SOLO Taxonomy for grading knowledge levels of specific course terms through self-assessment is to the best of our knowledge a new approach on measuring learning and evaluating teaching. Others (Schiekirka et al. 2013) have used pre- and post-test student self-assessment for measuring teaching quality but with different test methods.

Strengths What our investigations showed was that this method is easily implemented also in large classes where it becomes a lengthy and often tedious process to pre-test students using traditional assessment techniques. The production of the questionnaire with relevant course terms and subjects can be prepared at the same time as the course plan is made. An electronic version of this kind of questionnaire will be examined next semester, which will speed up the handling of the data.

The process of comparing the results of the pre and post questionnaires becomes easy, because with this method we are able to hand out the exact same questionnaires in both cases and the results can be directly compared and evaluated. With non self-assessment tests, such as e.g. multiple-choice having the same test two times during a course would potentially affect the students' answers and as a consequence influence the validity of the test.

With regards to the students' self-assessment there is theoretical background (Biggs and Tang 2007) for saying that it is going to be beneficial for their understanding of the course material that they are reflecting on their own learning of the most relevant course terms and subjects two times during the course. We do, however, have no measurement of the effects of this yet.

Limitations The results showed in this paper prove an increase in the measured levels of understanding for the different terms stated in the questionnaire, which indicates the validity of our method, but further research needs to determine this.

We do not yet know if the SOLO-inspired rating used in the questionnaire is optimal for this type of self-assessment. Would it e.g. be beneficial to have more or less levels? Would ratings inspired by Bloom's taxonomy (Bloom and Krathwohl 1956; Anderson and Krathwohl 2001) result in more valid results? Also, retrospectively, the self-assessment should focus more on one's ability to work with a given subject, because knowing exactly what a term means does not necessarily make you able to actually use it and implement that knowledge e.g. in developing new interactive technologies. In order to effectuate this, the wording of the grading system will have to be changed.

Another limitation of our method is that we do not capture the increased knowledge that also takes place with the terms that are rated high (4–5) from the beginning. This has been mentioned previously and is something we will have to take into consideration when we formulate our questionnaire next semester. We may avoid using commonly known terms in the questionnaire, or at least put them in the context of course-relevant terms.

A last limitation in the type of self-assessment that students do through our questionnaire is that it becomes difficult to measure any misconceptions the students may have regarding the different learning elements, both at the beginning and at the end of the course.

Comparison with Other Studies When comparing our study to the study mentioned in the introduction (Schiekirka 2013), the two studies clearly differ in the grading system used. They use 6 levels of agreement to the understanding of a given learning objective, while we use SOLO-inspired 5-level grading system to measure understanding of a given course term. Both methods seem valid, but in our opinion the SOLO-inspired grading that we use is specifically formulated for each grading and make it easier for the students to pinpoint the exact grading and better reflect on their learning.

18.4.5 Future Work

As this study presents our first intervention with the questionnaire it is to be considered a pilot study, and we are currently investigating how to best validate the questionnaire in order to be able to present a more thorough statistical analysis of our measurements and thus be able to better support our findings. One challenge when working with Likert-type questionnaires, is determining if they will lead to nominal or ordinal data, which then again determines which statistical methods you may use in your analysis (Mokkink et al. 2010).

At the time of writing, the self-assessment tool has been used for one more run of the course. The data from this run are still to be analysed. The changes made to the new tests were elimination of some of the general and publicly known terms as identified in the discussion, leaving 42 terms to be graded through self-assessment. The grading of the terms was changed as shown below in an attempt to address some of the limitations in how the current tests fail to measure one's ability to work with and implement the knowledge behind the different terms as described previously.

1. I have never heard of this before.
2. I have heard of this before, but do not really understand what it means.
3. I have an idea about what this means, and would be able to discuss it with other students, but I don't want to have to explain it in details.
4. I have a clear idea about what this means and I am able to explain it and use the theory in projects.
5. I know exactly what this means and I am also able to relate it to other subjects, reflect on it and use the concept when I design my own solutions.

The new pre- and post-tests were setup as Google forms, making the data directly available for statistical and visual analysis. This electronic enhancement makes it easier to automate the basic analysis of the tests and provide the students with average class results and also provides the opportunity to run the tests multiple times during the semester.

In order to evolve the self-assessment tool described within this chapter further, it will be beneficial to test it out on other types of courses, which will be our focus in coming semesters.

18.5 Conclusions

In this paper we explored how student self-assessment can be used as a tool for monitoring the student's self-assessed learning and become beneficial for both lecturers and students in the on-going development of the course and the consequential learning taking place. We used a simple self-assessment tool for pre- and post-testing in a first semester engineering course. The students graded their knowledge on human-computer interaction based on their ability to understand and explain specific concepts.

Generally, the assessment tool promoted practice reflection—both reflection-in-action and reflection-on-action. In the pre-test the students became aware of the academic expectations in the course as they assessed their own current knowledge with regards to specific course terms. This awareness allowed them to identify and reflect on the gap between their own current knowledge and what would be expected at the end of the course. The lecturer could right from the beginning sharpen the academic semester plan based on the assessment results.

The post-test proved a potential tool in order for the students to grade their own knowledge in preparation for the final exam. From the lecturers' perspective the post-test was useful in optimising the course for the next run.

Further research needs to be conducted to validate our questionnaire and further evaluate and evolve this tool.

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Chapter 19
Don't Waste Student Work: Using Classroom Assignments to Contribute to Online Resources

Jim Davies

19.1 Introduction

Imagine a teacher wants to train people to repair bicycles in a disaster-hit community that needs bicycles. She instructs her students on a few principles, and then has them get to work on broken bikes that were donated. Over the course of her instruction, all 50 students learn to repair bikes by working on the broken bicycles. At the end of the class, she grades her students, who can all now productively repair bicycles in the community. Finally, she brings all of the repaired bicycles to the dump. When members of the community, which could really have used them, asked her why she discarded them, she said, "The goal of my class was learning, not to produce things for the community."

I hope the incredible waste in this story is apparent to everyone. Though the story isn't true, and I hope no teacher would actually behave like that in the same situation, I will argue that an analogous kind of waste is happening in higher education every day.

As of 2011 there were 23.8 million college and graduate students in the United States alone (U.S. Census Bureau 2012). Every year, these students work on millions of assignments, and instructors and teaching assistants spend millions of hours grading them. The vast majority of these assignments help the students learn, but do no good for anybody else. The *products* of these assignments are usually discarded. This is an enormous waste of resources. I argue that not only should assignments help students learn, but they can also benefit the wider educational and research communities.

In this paper I will describe a number of assignment types I have introduced over the past years that not only have little or no increased cost, but, I believe, (1) facilitate learning, (2) are particularly motivating, and (3) contribute to the greater educational and research communities. Although this chapter will focus on my

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field, cognitive science and artificial intelligence, with some creativity most of the methods will translate to other fields in university education.

19.2 Assignment Types

I will describe five project types that I have used effectively: Paper Summaries, Contributions to Wikibooks, Creation of Mnemonics for a Wiki, Online Flash Cards, and Actual Research. I have also tried Writing Podcast Transcripts, which has not worked as well.

19.2.1 Paper Summaries

When I was studying for my depth exams in graduate school, the other students and I had a long list of papers we needed to read and understand. The test we had to take was open book and "open web," that is, we were allowed to go online for information during the test. I suggested that we split the papers among us and each be responsible for deeply understanding our assigned papers. In our weekly discussion meetings, we knew who to turn to with questions. I also talked them into writing summaries of these papers. With their permission I put these summaries on the web. In 1999 the Cognitive Science Summaries website went online. When I became an assistant professor at the Institute of Cognitive Science at Carleton University, for classes with fewer than 40 students, I started to assign the creation of a paper summary. When they are turned in the summaries are graded, edited, and put on a website I maintain (Davies 1999). The students must summarize a piece of scholarly work that has not yet been summarized on the website. For an example of student work, see Musca (2009).

The summary is supposed to include the basic claims of the paper, and the evidence or arguments for those claims. The students are given a standard template to use so summaries include similar kinds of information. First is complete citation information, in two formats, the American Psychological Association (APA) and BibTeX (for users of the LaTeX typesetting language used in computer science and other technical fields.) This makes it easy for other researchers to copy and paste the reference into their own papers.

Next comes the name of the author of the summary, and his or her permanent email address. I tell my students that unless they say otherwise, their assignments will be put on the website, and if they don't want their names on it, I will publish the summary author name as "anonymous." Approximately 5 % of students wish to be anonymous. Some wish to include a disclaimer that the summary was written when the author was an undergraduate.

I also require the students to include a list of specific things one could cite the paper for. For example, in the summary (Davies, 2000) of Larry Barsalou's paper on Perceptual Symbol Systems, the statement "Amodal symbols are redundant if they just link to the percepts" is in the "cite this paper for" section. It is for claims, argument conclusions, original ideas, names of software systems reported, quotable wording, etc. The motivation for this is search: if you read a fact or claim but cannot remember where you read it, a web search for that fact might turn up the summary, allowing you to cite the paper.

Finally, there is the summary itself, which I allow the students to structure any way they see fit, except that I ask them to associate page numbers with statements, so that readers of the summary can easily find what's being summarized in the original paper.

Approximately 95 % of the summaries I have collected in this manner have been of high enough quality to put on the site, mostly with only minor alterations—usually formatting.

This kind of assignment has several educational advantages. First, because students find their own paper to summarize, they get experience looking through journals, giving some idea of the state of the art. Second, they read several abstracts, and finally choose a paper they are really interested in, which is motivating. Third, they get exposure to real research, reading non-textbook science and understanding an actual scientific paper, which many second-year undergraduates, for example, have never done. Finally, knowing that their work will be on the web is further motivation to do a good job. I have had students email me, complaining that their summary is not on the web soon enough, because they want to use it for their resumes.

Since all fields have scholarly papers, this method applies to any discipline. In fact, many classes already require writing summaries. It's just that the same papers are summarized again and again.

19.2.2 Wikibooks

The Wikimedia foundation, which manages the Wikipedia, also has a series of wikis called "Wikibooks," which are for the creation of free content textbooks that anyone can edit from a web browser. I require students in my artificial intelligence classes to write chapters or chapter sections for the Artificial Intelligence Wikibook (Wikimedia Foundation, 2009a). One year I assigned each student to write a piece about a search strategy that had not already been covered in the Wikibook. Perhaps, in 10 years or so, the book will be sufficiently mature so that my AI students will not need to purchase a textbook at all. As with the summaries, any field can use this method, contributing to (or starting) an online textbook.

Teachers of foreign languages can assign translations of Wikipedia articles into other languages. The English Wikipedia is huge, but the Spanish version, for example, is only 12 % of the its size (von Ahn 2009).

Wikibooks are designed for online use, and as electronic books (e-books), they offer a number of advantages over printed books (Crowell 2005). I will describe several of these advantages.

They are searchable based on user queries. Normal books rely on an index, which can be thought of as pre-run searches by all words and phrases the author believes anyone might use to search with. Indices fail when users wish to retrieve information the author did not see as important enough to put in the index, or when users use unusual search terms.

E-books are compact. In terms of physical space, thousands of e-books can be stored on laptop computers, flash drives, phones, personal digital assistants, or e-book readers. Online need not be stored in a local version at all—any device with an internet connection can access it at any time.

Font can be adjusted according to preference, and font size can be adjusted to accommodate vision problems. E-Books can be automatically read aloud for people with impaired vision, or just for people who want to read while engaging in another activity, such as walking to school.

In terms of content, e-books can include multimedia, including animated images, video, sound, and hyperlinks.

Finally, e-books have a smaller environmental impact than print books.

However, e-books and online books are not without their disadvantages for learning. For the wikibooks project in particular, each individual page in the book can be rendered into a printer-friendly version, or turned into a PDF. Currently there is no function to print or generate a PDF for the book as a whole, *requiring* an internet connection to read without significant effort.

E-books cannot be read without some kind of computer, although that computer can take the form of a phone, PDA, e-reader, or a desktop machine. This is clearly becoming less and less of a problem for students.

It's more difficult to flip through pages rapidly, looking for a particular part of the book that might be spatially indexed in the user (e.g., remembering that a passage is near the end of the book).

As with the summaries, any field can use this method, contributing to (or starting) an online textbook.

For my cognitive science classes, I have started a cognitive science wikibook (Wikimedia Foundation 2009b), but have not yet assigned anything writing for it.

19.2.3 Podcast Transcript Writing

A podcast is a continually-updated series of audio or video files available on the web, rather like an audio web log (blog). The word "podcast" is a portmanteau of "iPod" and "broadcast," meant to be a broadcast you listen to on your phone or computer. There are thousands of podcasts on an enormous number of topics, from people commenting on the life of their pets, to music news, to science education.

I have assigned students to draft transcripts of podcast episodes on the subject of cognitive science. The idea is that after editing, I will have them recorded and put on a cognitive science podcast. However, the first round of this assignment did not yield excellent results. The writing had an enormous variance in both style and quality. I felt that most of them would need to be completely re-written to be good enough for a podcast.

To address this problem I will try to alter the assignment instructions to give the students more structure.

19.2.4 Creation of Mnemonics for a Wiki

One of the most difficult parts of cognitive science education is the memorization of brain areas, in terms of location, name, and function. Most students learn these things through repetitive drilling of the information, rather than using mnemonics, which have proven to be very effective for memorization (Levin and Nordwall 1992). Unfortunately, text books and teachers rarely give students mnemonics to use. Because creating mnemonics requires both knowledge of their effectiveness and a good amount of effort, they are rarely created by students on their own. In my own experience, in spite of my encouragement, students only use the mnemonics I present for them in class.

For each fact that needs to be memorized, however, the whole world only needs a single good mnemonic. The famous "Roy G. Biv" helps everyone remember the colors in the spectrum—it is not that each person needs to create his or her own mnemonic for the colors.

This is the motivation behind the Brain Areas Mnemonics Wiki project (Davies 2009). The wiki is a place where one can find mnemonics for remembering what brain areas are associated with what functions.

Students are required to look at the wiki and see which brain areas have not been addressed, find three unaddressed brain areas, and create mnemonics for remembering the functions in which those areas are implicated. They present these in class, and as a group we improve them through class discussion. The students publish their improved versions on the wiki. A class of 15 students will create 45 mnemonic devices in a single semester.

One student created a textual mnemonic for the association of the basal ganglia with motor control, cognition, emotions, and learning. The mnemonic was this: Imagine a person trying to **learn** to **dance**, unsuccessfully, next to a bee hive. The sudden **movements** make the **B**ee **G**ang (the Basal Ganglia) **angry** and decide to attack.

I can now refer students to this wiki for use in their studies.

Anyone can start a wiki, free, with Peanut Butter Wiki[1].

[1] http://www.pbworks.com/

19.2.5 Online Flash Cards

Anki is a member of a family of programs that implement spaced learning in an electronic flash card format. Anki, the open source system I use, is a program designed to be used every day. The key point is that the software, rather than the user, decides which cards are to be reviewed each day. To use the software, you view the "front" of the card, guess at the answer, and then look at the correct answer, on the "back." You click buttons to indicate whether you got the answer right or wrong. The software keeps track of which facts you got right and wrong to determine how long you should wait before reviewing each fact again. The idea is that the best time to review a fact is just before you're likely to forget it. So if you get a flash card correct, it might present it to you again in two days, and if you get it correct again it will present four days from then, then eight days, etc.

A problem with traditional flash cards is that you waste a great deal of time reviewing information you already know very well. Systems like Anki and Supermemo implement spaced-learning systems (Dempster 1988) and interleaved practice, or, seeing information in multiple contexts (Carpenter 2001). The immediate feedback provides self-regulated learning (Butler and Winne 1995), and asking students to predict the outcome of something increases their conceptual understanding of it (Crouch et al. 2004).

Certain domains require a good deal of memorization (e.g., medicine, biological sciences, foreign languages, law), and programs like this can be of enormous value. With Anki, users can create decks of cards and share them with other users. Any time one wants to remember a fact, one can type it into the program in a question and answer format.

In my assignment, I asked each student to pick one lecture from the class and to make a deck that covered all of the factual information from that lecture.

Like mnemonics, the flash cards only need to be created once for everyone to benefit. Anyone can download decks of cards to memorize the facts therein. After only 2 years of teaching and assigning the creation of cards, all the notes from lectures and readings were in flash card form for future students to use. This gives them more time to focus on the non-memorization aspects of the course.

Because creating Anki cards does not require any computer science-specific knowledge, this assignment can be used in any discipline.

A final benefit of this kind of assignment is that students are introduced to programs like Anki, which can help them in their studying in other courses and endeavors.

19.2.6 Actual Research

Finally, students can be assigned to conduct actual scientific or otherwise scholarly research as a class assignment. The feasibility of this method varies greatly from discipline to discipline. In high-energy physics, for example, being able to do new scientific research requires years of graduate training and very expensive equipment. In contrast, for artificial intelligence it’s relatively easy, because there are a great many problems that have *never* been addressed by anyone.

Any project that requires computer programming can be broken into assignment-sized chunks. This requires some software engineering and up-front planning by the course instructor, so that the assignment is well-defined in terms of the assigned code’s input and output. But with careful planning, a large relatively large piece of software can be built gradually by students completing class assignments.

One downside to this is that because all of the students, or student groups, are doing different assignments (having them all do the same assignment wastes work), the grading is more challenging. On the other hand, the instructor can view such grading as doing research.

For several years in my artificial intelligence class, I gave an assignment to write a function to detect a spatial relationship between two objects in a photograph. Each student did a different relation (e.g., one did “above-below,” and another “occlusion.”) This work led to a peer-reviewed publication with many students’ names on it (Smith et al. 2010).

Not all fields require programming, nor do all students have programming knowledge. However, many fields have some kind of data collection that can be conducted with student assignments, and all fields can benefit from literature reviews, which I will describe next.

Students can be assigned to write literature review papers for topics that need them. However, writing literature reviews for some large topics can be too big a job for a class assignment. There are a few solutions to this.

First, papers can be written by groups of students. This will make some topics manageable.

Second, students can write first drafts of papers, at a high level of abstraction. For example, one can assign students to write a six-page paper that gives a very general overview of a complicated topic. This forces them to synthesize information and to be concise. Then, the next time the course is taught, an instructor can assign students to expand the paper into a 20-page paper with more detail. This new batch of students will have experience reviewing and re-writing other students’ texts, which is also a valuable learning experience.

A downside to writing programs and literature reviews is that it’s sometimes difficult to know ahead of time whether all of the assignments are of equal difficulty. Some software ends up being very complicated, and others nearly trivial. An instructor might assign a literature review on a topic for which there is very little published. One solution is to keep in touch with the student projects as they progress, and see if the work is too little. If it is, the instructor should step in and expand the assignment. I require my students to give an in-class oral proposal of their project before too long, by which time they are usually clear about what it will take to complete it. After watching the presentation, the instructor can recommend that they do the original project, plus this or that extension, or perhaps something smaller.

19.3 Conclusion

My teaching philosophy is to not waste student work. To this end I have devised a number of class projects that contribute not only to the education of the students who do them, but for the broader educational and scholarly communities. My hope is that other instructors will use similar methods in their own classrooms to promote this kind of indirect collaboration. Before the World Wide Web, there was no mechanism for sharing the products of student assignments. Now that anyone can publish online, there is no excuse for wasting the millions of hours our students spend working on class assignments (Fig. 19.1).

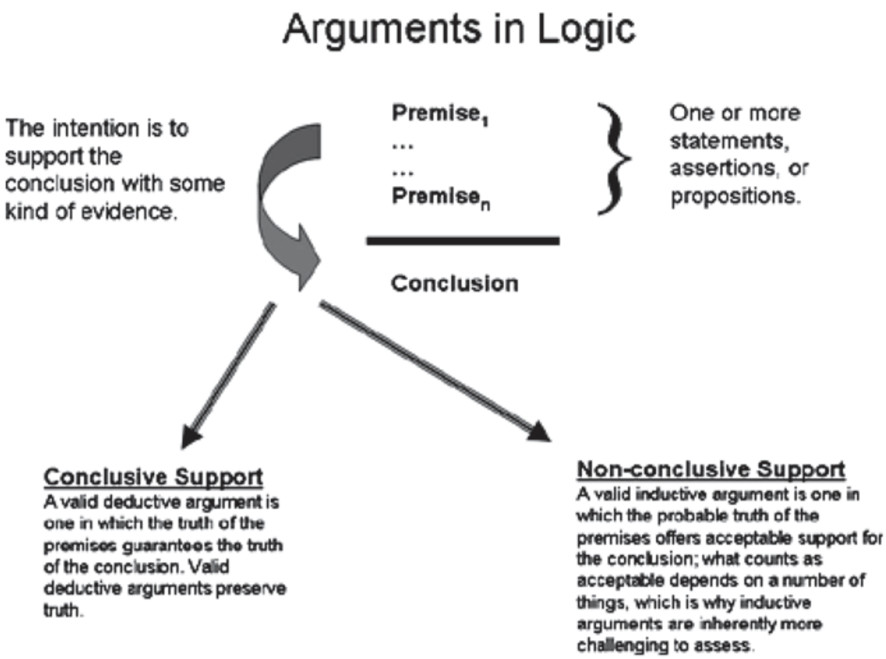

Fig. 19.1 Provide Caption here

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Chapter 20
The Ancestor Project: Aboriginal Computer Education Through Storytelling

Marla Weston and Dianne Biin

20.1 Introduction

Within British Columbia, the Aboriginal population accounts for 4.4% of the general population, but its youth cohort is larger than that of the general population; according to Census Canada (Statistics Canada 2008), the Aboriginal youth population in British Columbia (15–24 years) will be 54,000 by 2013. In Canada, the term "Aboriginal" includes peoples who are descendants of the Indigenous peoples of North America and are identified as both status and non-status Indians, First Nations, Métis and Inuit.

Even with such a young population, Aboriginal graduation rates from high school and the number of Aboriginals who pursue higher education are lower (almost half) than those of the general Canadian population. This disconnect of Aboriginal students with mainstream education has a historical and political context in Canada. The multi-generational effects of colonization practices and assimilation legislation have restricted and denied educational success. Grass roots resistance since the 1970's (Native Indian Brotherhood 1972) for more control of education (what is taught, who teaches, how and where) has had many Aboriginal educators, scholars and administrators create frameworks and processes for educational participation. The majority of educational institutions in Canada are only now actively looking to make curriculum relevant to Indigenous pedagogies and values and create welcoming spaces.

The basic problems faced by Aboriginal youth in Canada are not unique. Similar issues have been faced by Indigenous people around the globe. For example in Africa, colonization resulted in the submergence of cultural diversity by the exclusion

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of most African traditions from education (Woolman 2001). Fleming and Southwell (2005) note that the dropout rate for Aboriginal students in the Australian education system is very high and that the relevance of the white, Eurocentric school curriculum is one of the key factors. Similarly, native Hawaiians are over-represented in special education and under-represented in higher education, perhaps because the students' school experiences are different from their experiences in their home communities (Yamauchi 2003). When Camosun's Aboriginal Education and Community Connections department asked what helped contribute to their success at the secondary and post-secondary level, adult Aboriginal learners confirmed that culturally relevant curricula, inclusion activities in and out of the classroom, and support systems (cultural and academic) enable an environment to succeed.

One form of Indigenous pedagogy being incorporated into mainstream curriculum is storytelling (Burk 2000). An important outcome of storytelling is personal empowerment as youth incorporate traditional knowledge into their current learning environment rather than being passive recipients of knowledge. Telling or sharing a story gives value and significance to events in a student's life (Brown 1995). The original vision for the ANCESTOR (AborigiNal Computer Education through STORytelling) program was to use storytelling as a means to promote an interest in technology for Aboriginal youth and adult learners, and to increase cultural literacy. Courses and/or workshops with such a focus encourage Aboriginal learners to build computer games or animated stories related to their culture and connections to the land. In an active learning environment, learners gain mathematical and computation skills, think creatively and reason systematically in a fun and personal way. By using Indigenous realities as a foundation to learning, the content becomes relevant to Aboriginal learners and builds competencies.

Transferring the Aboriginal oral storytelling tradition to a digital expression has not been without controversy. Todd (1996) questioned whether Aboriginal world views could find a place in cyberspace. She argued that they are completely different ideologies. Hopkins (2006) stated that in the ten years since Todd expressed her views, that "Cyberspace has been occupied, transformed, appropriated, and re-invented by native people in ways similar to how we've always approached real space. Like video, digital technologies have become a medium for speaking and telling our stories." This transformation of digital expression is also occurring in mobile software development where First Nation traditional language "apps" are on the rise, thus creating a digital community of cultural learners and storytellers (First Peoples Cultural Council 2012).

There are many definitions for the term "digital storytelling". It can be as simple as "using digital media to tell stories", to the more detailed "At its core, a digital story is a narrative expressed in digital form for a variety of purposes, with applications ranging from education to personal expression, record keeping to movement promotion and everything in between." (Sussex 2012). Barrett (2006) felt that digital storytelling facilitates the convergence of four, student-centered learning strategies: student engagement, reflection for deep learning, project-based learning, and the effective integration of technology into instruction. Many of these strategies fit in with the skills deemed by the "21st Century Literacy Summit" (2005) as key elements to developing essential digital literacy skills for the future. The

Literacy Summit report states that "Access to tools that empower expression in these new forms must be as ubiquitous as word processing software or spreadsheets. In schools, tools for creating new media should be available as early as possible, even in primary grades, and more advanced tools provided as students' progress and gain facility using them." (p. 14). The report encourages a community approach to literacy.

McKeough et al. (2008) noted that "There is substantial evidence that Aboriginal youth face serious challenges in schooling, in general, and in literacy development, specifically." (p. 148). They emphasized the need to design early literacy programs that engage Aboriginal children. Within British Columbia, the Headstart Programs (http://www.ahsabc.net/), delivered on and off reserve, are building literacy and cultural competencies of young First Nations children. Other initiatives such as "Success By 6" (http://www.successby6bc.ca/) are also addressing engagement and comfort with literacy for both toddlers and their parents.

It is important that both traditional literacy (reading & writing) as well as digital literacy be addressed. As noted by Becker et al. (2013), the brains of digital learners are physically different from those learners who have not had ongoing exposure to technology. Jukes (2006) examined issues raised by the "digital divide" and how these issues affect communication, motivation and understanding, and ultimately learning styles. Jukes stated that this new digital landscape is a global trend regardless of socio-economics, culture, race or religion. Today's youth need to be part of this landscape or be left on the wrong side of the digital divide. Culturally relevant curricula can help Aboriginal learners cross this divide.

The adoption of culturally relevant curricula has proved to be of value in many different countries. For example, using culturally relevant "entry points", researchers found that they could make computer science more relevant to students in the Kidugala Secondary School in Tanzania (Duveskog et al. 2003). Richards (2004) found that integrating IT education in the context of cross-cultural dialog and interaction in Asian educational contexts have formed the basis for effective change. The use of technology in the Hawaiian Language Immersion Program (HLIP) has generally been recognized as a success, but there remains concerns about the "… balance of technology (*'enehana*) and traditional Hawaiian knowledge (*'ike ku'una*)" (Yong and Hoffman 2013, p. 1331).

20.2 Designing the Curriculum

Carnegie Mellon University's "Alice" is a 3D programming environment that allows learners to create animations for telling a story, or developing an interactive game. Alice itself was developed as a teaching tool for introductory computing, and is freely available to download from the Alice website (http://www.alice.org). Alice is used by approximately 10% of U.S. colleges and universities, as well as by many high schools around the world (WebWire 2007). Alice has also been used successfully to incorporate cultural perspectives into the teaching of programming by the University of Hawai'i at Hilo (Edwards et al. 2007).

For Aboriginal youth, Alice has an additional advantage in that the programming environment is expressed in terms of a “world”, which provides an effective parallel to an Indigenous world view. Traditional cultural expressions through storytelling and transference of history (Young-In 2008) are done in a protected and respectful manner to ensure relevance of place to peoples. It is this detail of creating an effective, interconnected world that matches the logic of the Alice environment. Thus, Alice was selected as the learning environment for the ANCESTOR program. The challenge was to connect the Alice world with an Indigenous world view, while still maintaining an effective pedagogical approach.

To develop culturally relevant curricula, we incorporated an Indigenous lifelong learning approach to build competencies and inclusion, for the teacher, community and student. As noted by Assembly of First Nations (2009), “The First Nations Holistic Lifelong Learning Model is the outcome of a February 2007 workshop that brought together First Nations learning professionals, community practitioners, researchers and governments to begin discussing and identifying the many aspects of lifelong learning that contribute to success for First Nations. The First Nations Holistic Lifelong Learning Model is a living draft…” (see Fig. 20.1). This model acknowledges the impact of informal and formal learning in a cultural context (family, language, the natural world and ceremony). It illustrates the purpose of different

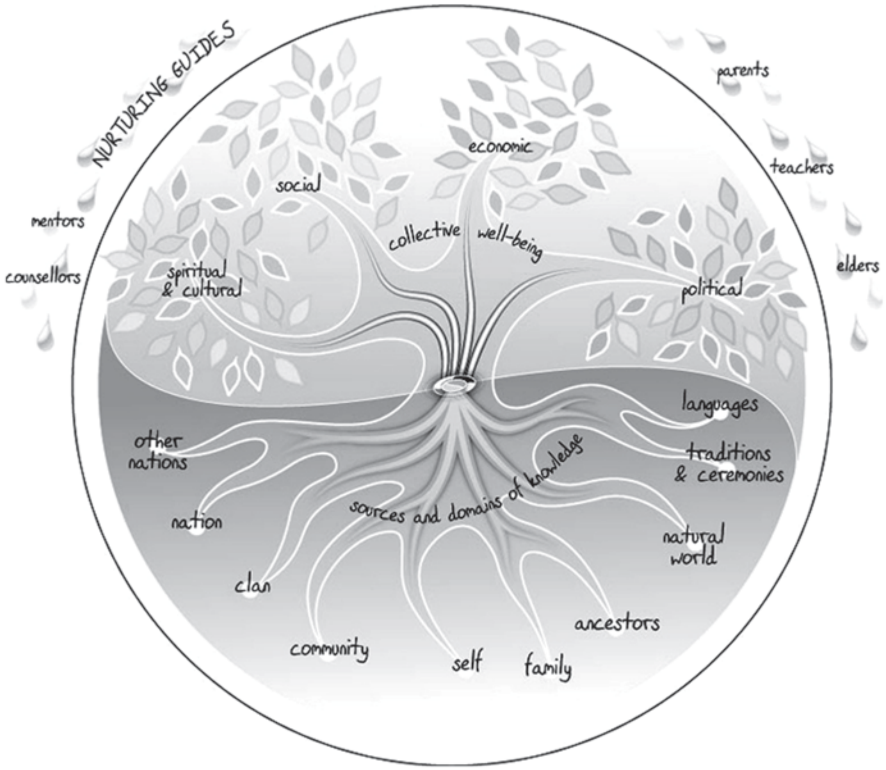

Fig. 20.1 First nations holistic lifelong learning model. (Canadian Council on Learning 2007)

sources and domains of knowledge; articulates the process of how learning and personal development (emotional, physical, spiritual and intellectual) occurs in a cyclical manner; and recognizes that the outcomes of life-long learning support community wellness. Learning is experiential, it occurs through observation and imitation, can be reinforced through storytelling and ceremony, and is an adaptive process as First Nation learners integrate two realms of knowledge—traditional and western (Cappon 2008). Building success based on local terms is the foundation for the lifelong learning model.

A team consisting of Camosun College faculty from Computer Science and from Aboriginal Education and Community Connections, plus two Computer Science students, built a test curriculum. Three distinct curricula were created, each spanning a different time frame. These curricula included a one-day workshop called "Alice is fun!". This workshop was designed to encourage learners by having them create a fun, simple animation. A one-week workshop and a semester-long course were also developed. The curriculum was largely derived from the extensive online resources available for teaching Alice. In all cases, the curriculum examples had an Indigenous focus, using examples that are culturally relevant, respectful of traditions and knowledge, and appropriate to share.

20.3 Refining the Curriculum

We first tested the semester-long course material with Aboriginal students in grades 7–10 at the LÁU, WELṈEW̱ Tribal School near Victoria, B.C. Canada. As reported by Weston and Biin (2011), at the end of this test at the Tribal School students were: (a) more comfortable in their use of computers, (b) more interested in learning about computer science and programming, and (c) more interested in their cultural stories. In fact this third result was one of the most positive outcomes from an Indigenous cultural perspective. Many of the students were exposed to storyboarding and how to tell an effective story. They were encouraged to take this tool and seek guidance from their cultural knowledge keepers, to ask questions such as: Was this done the right way? Would this tell the story in the right context? What if I incorporated this dialogue or interaction? One student further developed his story to include the SENĆOŦEN language (his traditional language) as recorded dialogue. He incorporated male and female voices into his story, using new language learners, which demonstrated an innate balance of form and structure in Indigenous world view.

Despite all the positive outcomes, there were significant problems, particularly in the way the material was delivered. The curriculum was generally too advanced for the students, and more repetition was needed. The proposed solution was to develop a series of simple video tutorials that the students could replay as often as needed within and outside the classroom.

With the help of a second team of computer science students from Camosun College, we developed a total of 17 video tutorials that were then uploaded to YouTube (http://www.youtube.com/ancestorproject). All tutorials are less than 10 min in length, with many less than 5 min. All examples used in the video tutorials have an Indigenous theme and, in some cases, are presented as part of a larger creation story from the local W̱SÁNEĆ peoples. The tutorials were built to progress from simple methods to more advanced methods, and were divided into beginner, intermediate and advanced levels.

We then tested this newly revised curriculum, complete with the video tutorials, with non-Aboriginal high school students as part of a Technology Access Program given several times at Camosun College starting in 2011. Students taking this access course were self (or parent) selected based on their interest in technology. As a result, these students were very comfortable with technology and were what the twenty-first Century Literacy Summit report calls "digital natives." (2005, p. 2). Any issues these "technology savvy" students had with the curriculum were noted and immediately addressed. If these students were having problems, then it was likely that students with a more general background would have even more difficulty.

To emphasize the storytelling approach, we subsequently added a formal section on storyboarding to the curriculum. The use of storyboarding also follows the recommendation of numerous authors such as Porter (2006) who stated, "Teachers need to be diligent about requiring scripts and storyboards as a readiness ticket before using any technology. Scripts and storyboards ensure that the content is accurate and robust and demonstrate that media choices are effective and designed to support the message." (p. 29). Drawing in part on the expertise of animation specialists from Emily Carr University of Art and Design (Vancouver, B.C., Canada), we added the new segment on scripting and storyboarding and set it to precede any full scale animation. While storyboarding is a western concept in storytelling, we wanted to see if the learners would pick-up on the concept of themselves as the storyteller (setting the space, tone and interactions) rather than recounting an event.

We tested this revised curriculum with Aboriginal students. We first delivered the curriculum in a summer camp for the Songhees First Nation in 2012. This was followed by a fall elective at Shoreline Middle School (both in Victoria, BC, Canada). In December of 2013, we traveled to two remote (limited access) communities along the central coast of British Columbia. We gave workshops to high school students (grades 11 and 12) at Bella Bella Community School and elementary students from kindergarten to grade 7 (multi-grade classroom) at Shearwater Elementary School.

This revision to the curriculum supported a self-guided process for the summer camp, elective and workshop participants in order to build comfort levels and gain digital literacy skills with the Alice programming environment. We then tailored the offerings to the audience, time available and resourcing needs.

The summer camp took place over three weeks (approximately 20 hours of instruction) with participants between ages of 11–22 years. With one lead facilitator, the cohort was facilitated through a cultural storytelling exercise where oral narrative was interpreted into a 3-D animated sequence.

The fall elective at Shoreline Middle School ran for 7 weeks with one hour of instruction per week and was delivered in the Aboriginal support room at the school. Shoreline Middle School consists of about 300 students from grade 6 to grade 8 with an Aboriginal population of about twenty-five percent. The Aboriginal community consists of students from two local reserves, and non-status and Métis students. An opportunity to have some students participate in this test was seen as a positive way of introducing digital storytelling to a small group of students as a pilot program.

We introduced the student group at Shoreline Middle School to a scripted story within Alice to determine interest in pursuing the elective through the remainder of their academic term. Once ‘hooked’ the selected group went on to learn simple programming methods and experimented with creating their own characters for an animated sequence. For this group the video tutorials were not utilized during classroom time; instead, the lesson was guided one-on-one by facilitators and educational assistants.

The delivery in the remote communities occurred over 3 days prior to the Christmas holiday break. Students’ workloads had been reduced prior to the holiday so there was the opportunity to bring in alternate curriculum as morning or afternoon workshops. In the morning we worked with Shearwater Elementary for 2 hours and then took the water taxi to work with Bella Bella Community School students in the afternoon for 2 hours.

Due to the age range (4–12) of the elementary school students at Shearwater, Scratch was used instead of Alice. Scratch, an online freeware program developed out of MIT (http://scratch.mit.edu/about/), is a storytelling and games platform aimed at a younger audience. We paired the 14 students (aboriginal and non-aboriginal) on laptops so they could learn how to remix games and the ‘Hour of Code’ (http://csedweek.org/) Christmas cards and stories.

At Bella Bella Community School, we worked with 10 Aboriginal high school students from grades 11 and 12 who were enrolled in an arts class section. Participation was voluntary so not all students took part in the animation workshop. A similar method was used where scripted stories in Alice 2.4 were introduced to the students to re-acquaint (about a third had prior experience) or introduce them with the programming language and they then created their own animated sequences and characters.

20.4 Lessons Learned

Each of the five testing scenarios contributed significantly to our knowledge regarding learning paradigms for Aboriginal students. The testing scenarios and outcomes are summarized in Table 20.1 below. Details regarding the curriculum and outcomes are given in following sections.

Table 20.1 Overview of the approach for the test groups

Delivery location: timeframe	Cohort	Curriculum	Results summary
LÁU, WELṈEW̱ Tribal School: Semester: 1 h per week (2010–2011)	Computer science elective	Lessons available online (Moodle) No video tutorials	Students found the curriculum too advanced With only one hour/week students forgot previous material Needed more repetition
Technology access program: 3 h per week for 3 weeks (4 sessions 2011–2013)	Non-Aboriginal, selected technology savvy students	Curriculum revised and video tutorial added Lessons available online (Moodle)	Video tutorials were successful, although some were too complex and were revised Students liked moving at their own pace
Summer camp: 2.5 h daily 3 days a week for 3 weeks (2012)	Voluntary sign-up	Curriculum altered for time frame Additional video tutorials added A segment on storyboarding added	Video tutorials now at right level Storyboarding a difficult concept at the beginning Students worked well together and supported each other
Middle school elective: 1 h weekly for 7 weeks (2012)	Referred and selected	One-on-one facilitation. Storyboarding concept delayed Prizes used to encourage participation	One-on-one facilitation helped overcome the frustration factor Delay of storyboarding concept more successful Students very supportive of each other Students love prizes
Remote coastal community school workshops: 2 h daily for 3 days. Mornings elementary, afternoons high school (2013)	Enrolled and voluntary	Repetition of sequences and one-on-one facilitation 2 models used to match literacy and proficiency levels (Scratch & Alice 2.4) Explored Alice 2.4 YouTube tutorials to build own sequences	Due to age range of participants, repetition and one-on-one facilitation used simultaneously for elementary students Elementary students enjoyed re-mixing Scratch stories and games. Girls created stories, boys re-mixed and evaluated games High school students quickly learnt Alice programming concepts Prizes acknowledged participation

20.4.1 LÁU, WELṈEW̱ Tribal School

Many of the students at the LÁU, WELṈEW̱ Tribal School have only limited exposure to computers, and thus the curriculum had to find the right balance to accommodate disparate skill sets. Also, the one-hour per week class time meant the students forgot what they had learned the week before and had to review before continuing. Since the Alice environment is so rich, students would often get lost and thus frustrated. It was clear that more repetition was needed which led to the development of the online video tutorials.

Even though the students had some problems with the curriculum, the teacher commented that as soon as the students saw the gallery elements with the cultural 3D images, they were very excited and encouraged to try to create traditional stories. The teacher also noted that the students taking the elective showed significant improvements in the analytical skills. She was very impressed by how much better the students were performing in their other courses such as math.

Fleming and Southwell (2005) identified the lack of cultural relevance in the Australian curriculum as a major factor leading to Australian Aboriginal students leaving school early. Students respond better and are more engaged if they can see themselves reflected in the course content. Although the students at the LÁU, WELṈEW̱ Tribal School faced challenges with the technology, the school promotes a holistic approach to education in which the community and culture is embraced. At the Tribal School, students connected with local knowledge keepers for their animated stories, and were encouraged by them. This integrated approach was no doubt responsible for the Tribal School students persevering in spite of curricula and other challenges.

20.4.2 Technology Access Program

The "technology savvy", non-Aboriginal Access students represented a distinct contrast to the Tribal School students. For one, these students were generally older; most were grade 12 students. For another, all were very comfortable with technology as evidenced by the large number of student owned smart phones and tablets.

The Access students were quick to provide feedback on any part of the curriculum they felt did not meet their needs. As a result, topics and/or video tutorials that were too complex were quickly identified and corrected for the next offering. On the whole, the students were enthusiastic about the online video tutorials and lesson material. Students liked that they could proceed at their own pace through a lesson, replaying tutorials as needed. After a brief, introductory lecture at the start of each lesson, the instructor was then free to provide one-on-one help and encouragement.

By contrast, the Tribal School students were less likely to criticize the curriculum and more likely to withdraw when they encountered a problem. This can be attributed to an appropriate cultural response where the students did not want to disrespect the experience. Also, unlike the Access students, many of the Tribal School students had had very limited exposure to computers, so they faced an additional learning curve beyond the basic curriculum topics. The "digital divide" as described by Jukes (2006) was well in evidence here. While the students had a dedicated, modern computer room in their school, access to the room was restricted and many did not have a home computer. Furthermore, for most of the Tribal School students there was a disassociation between using and controlling the technology. The Access students were looking to careers in technology, while the Tribal School students were more likely to see themselves as consumers rather than as developers of technology.

20.4.3 Summer Camp

The summer camp had one lead facilitator, and the cohort was facilitated through a cultural storytelling exercise where oral narrative was interpreted into a 3-D animated sequence. Once guided through a storytelling example, participants then spent their time between learning new programming with the self-guided tutorials available on a Moodle course site prepared for the camp to scripting their own one to two minute animation sequence with sounds and recorded dialogue. The facilitators provided problem-solving assistance when participants began building their animation sequences. At the end of the camp, participants screened their animations for all to see and were provided gifts to acknowledge completion of the camp.

The video tutorials proved of great value in the summer camp. Students who were more comfortable with technology could work ahead at their own pace. Those less comfortable could watch the tutorial as many times as needed. A key component to making the tutorials successful was to keep them short and simple. In addition, the tutorials are of value for distance delivery as well as basic support for teachers who are not familiar with the Alice programming environment.

An early segment of the summer camp was devoted to oral histories and storytelling. In this segment the oral tradition was reviewed and was then followed by a discussion of local, traditional stories. A series of books written by storytellers from the area were brought in and a traditional tale was shared with participants. The participants then had to identify a scene from within the story and create a storyboard sequence. Hand-drawn, the storyboard would show key camera angles, dialogue, and scene. It was difficult for youth to imagine sequences on their own, so the facilitator provided options for scenes and re-read certain sections of the story. After this exercise, participants debriefed and realized that listening to a story, building a character and creating a scene from the story required different skills.

Of all the various concepts and tasks we introduced to the students, we were perhaps most surprised by the difficulty the students had with storyboards. We naively assumed that they would be familiar with the concept through their own cultural, oral traditions and/or from movies and television. This was most definitely not the case. Even those students who came from a storytelling tradition at home did not see the relevance of storyboarding. Upon reflection, we realized it wasn't so surprising that the oral tradition did not translate well to storyboarding. Telling a story is different from developing a script and scene. When telling a story, the story is likely to change each time it is told. It changes with the teller of the story as it depends upon the audience. It is these contextual changes that make oral stories so rich, personal and place-based. A storyboard imposes a structure and consistency that is important to an animation, a movie or other such media. The traditional oral tale is not bound by such formal parameters. Storytelling and storyboarding have different outcomes and, even though they both emit an emotional connection, traditional storytelling reflects the current moment while storyboarding guides the mechanics of a story in a visual medium.

20.4.4 Middle School Elective

The fall elective was given in 2012 at Shoreline Middle School. Unlike the Summer Camp, the video tutorials were not utilized during the class time for this group. Since this elective was a trial to see if the Aboriginal students would be interested in Alice, the elective was guided one-on-one by facilitators and educational assistants. Another major difference when compared with the Summer Camp was related to use of scripting and storyboarding. For the school elective, the scripting and storyboarding segment was removed. Based on the experience at the summer camp, it was likely the students would find that segment difficult especially in such a limited time frame. To keep the students engaged, they were sent straight to the computers, and they worked with the computers from day one to build a basic animation skill set. Carefully prepared animated scenarios were presented to the students, and one of the facilitators would walk through the solution on a projected screen while the students followed along on their own computers. Depending on the confidence level of the student, he or she would move ahead on his or her own. The students were provided with extra motivation to complete the animated sequence by awarding small prizes to the first three students who completed their animation

The decision to not have the students in the middle school elective create a storyboard first seemed to work well. Walking them through an existing animated story at the beginning helped clarify the process. The students were then able to use this foundation, along with their imagination, to create new scenes and characters. As Keiran Egan stated, " [I]magination is not some desirable but dispensable frill, but … is the heart of any truly educational experience; it is not something belong properly to the arts, but is central to all effective human thinking. … Stimulating the imagination is not an alternative educational activity to be argued for in competition with other claims; it is a prerequisite to making any activity educational" (Egan 1989, p. 458). In reality, by the end of the elective, all had 'won' prizes, so the motivation was not the awarding of prizes but rather accomplishing animation sequences and becoming accustomed to Alice's programming language.

Comparing the ease and speed at which the non-Aboriginal, "technology savvy" students in the Access course worked through the curriculum reveals more fundamental differences. As in the Tribal School, many Aboriginal students had never seen or used a flash drive. As a result, much of the first class was taken up with reviewing some basic computer skills. There were also literacy issues to consider when developing the curriculum. Care was taken to make certain the handouts were at the correct level. Minimal text and the use of screen shots of the sequence and programming code ensured that the students did not experience literacy barriers. Certainly some of the differences were a result of the age ranges involved, but as noted by the Canadian Council on Learning (2010), literacy levels of Aboriginal youth in BC are statistically lower than the general population. Hence, the handout materials used different modalities of learning to ensure youth were engaged and did not become discouraged or frustrated into silence.

Although the students faced numerous challenges, they worked well together and supported each other. We delivered this elective in the “Aboriginal support room” at the middle school where one of the co-facilitators was not only a teacher but also a member of the local community. The students felt both comfortable and safe with this teacher. No doubt that this contributed to the willingness of the students to interact with each other. Fleming and Southwell (2005), in their examination of the education of Indigenous Australians, identified the importance of strong Aboriginal community involvement in the schools as well as Aboriginal teachers, teacher aides and administrators who can provide an inclusive environment. We saw this in action at Shoreline Middle School.

20.4.5 Remote Community Workshops

Working in a remote community tested our technological and travel abilities. In the winter of 2013, we worked with two schools over 3 days. Internet access was intermittent (broadband is available, limited line access) and the winter storms limited our time in the communities. While urban schools actively engage with technology, we wanted to see how technology was incorporated into learning in remote coastal communities. The approach varied with each school due to age range and technological capability.

Bella Bella (Waglisla) is located on Campbell Island in the Central Coast of British Columbia. It is only accessible by plane and ferry, and is considered a transportation hub for the Central Coast. There are approximately 1450 residents, 90 % of which are from the Heiltsuk Nation, 5 % are other First Nations, and 5 % non-First Nations (CCRD 2014). Approximately 50 % of the population of Bella Bella is under the age of 25.

Bella Bella Community School is a First Nation independent school and offers a cultural and educational technology focus through small classes and distance education. Its “mission is to develop, in a caring and respectful environment, students who are independent life-long learners, [and] incorporat[e] our community traditions and culture with the acquisition of skills needed to succeed in both the traditional and modern worlds.” (Bella Bella Community School 2014). The school operates kindergarten to grade 12 and in 2013/2014, the school had 175 enrolled students, with over sixty percent of Aboriginal descent.

Bella Bella Community School has a modern computer lab so students could use Alice on USB drives. A smartboard was available which allowed us to demonstrate sequences and showcase culturally created content. We also connected with fluent Nuxalk speakers to animated sequences over the three days. The first day was spent reviewing various programming scenarios to re-acquaint students with the platform. Many had attempted animations previously and about a third of the class had used older versions of Alice. Once again, the students appreciated the culturally appropriate assets library. For the next two days students created their sequences. While awaiting the water taxi to return to Denny Island, we sat with fluent speakers to figure out a sequence using the Alice mascot "visiting the top cultural places in Bella Bella". Mascot sequences were built in the evening and revealed to the high school students the next day. While the workshop was voluntary, participation drop off was minimal. Of the 10 who started, 7 completed 1 minute or more animation sequences on either their athletic realities (basketball drills), funny family sequences (Inuit family and fire), popular culture (zombie thoughts) or revising our original sequences into short stories (disco dog).

The imagination and creativity of the Bella Bella students was remarkable and none were afraid to experiment and stretch the programming platform to its limit. The IT expert for the school had a technologies room where students from grades 10–12 could work on solving mechanical and design problems in teams. For instance, one student was creating a 3-d printer model of a gear for a marine motor. It was the openness to experimentation, real-life problem solving, and experiencing how technology works that enabled the animation students to not be intimidated by coding. Yet, once again, none felt comfortable incorporating their traditional stories into animated sequences. The students had separated cultural literacy from technological literacy upon entering the computer lab. Even though we could see the feast house from the lab window, none of the students felt comfortable using their traditional language while in the computer lab. However, in the hallways or at the Nuxalk speakers room, students and staff would freely use the traditional language.

Shearwater Elementary is on neighboring Denny Island and has a multi-age classroom that works with students from kindergarten to grade 7. With one teacher and aide, higher grades are covered through distance education and out-of-class learning through field trips are common.

Shearwater also had a smartboard as well as a series of laptops that could be arranged in the building to enable team playing and creating. Shearwater's online access was limited, so many of the Scratch animations would freeze or not load properly. We brought in a Finch robot (http://www.finchrobot.com/) so kindergarten youth could learn how to manipulate the robot. Collaborative learning came naturally to the Shearwater elementary students due to their classroom environment, so once older students grasped the concept of program re-mixing, they would assist younger students. For those who wanted to play online games, the facilitators asked that a series of games be critiqued. Students would play the series and provide feedback on what they liked and didn't like about the games. They were then walked through a re-mixing of a game, experimenting with the drag and drop coding features.

Many of the students spent the next few days re-mixing games or revising animated greeting cards. For those too young to read, facilitators and teachers guided them through the Scratch animation processes. All students had a great time and two hours went quickly. On the last day, the facilitators debriefed with the group and provided some early Christmas gifts (toys and models). This was the first time students had been exposed to programming, so it was a steep learning curve; however, concepts were easily grasped and then manipulated.

Although it would seem that Aboriginal students in an urban setting, such as Victoria (e.g. the summer camp and middle school), would be far more comfortable with technology than Aboriginal students in a very remote setting such as Bella Bella or Shearwater, in fact, the opposite was the case. In both Bella Bella and Shearwater, the students were comfortable with technology and were keen to learn new techniques. Both schools actively integrated community and culture with education. The schools promoted a holistic approach to education in which community traditions and culture were integrated with those skills needed to succeed in both the traditional and modern worlds. This approach is emphasized in the Bella Bella Community School mission statement. In both of the remote schools, the students had a safe, inclusive environment in which their achievements and diversity were celebrated.

20.5 A Holistic Approach

The First Nations Holistic Lifelong Learning Model emphasizes interactive cycles over disconnected events, the importance of "learning guides", and the principle that learning is experienced holistically (CCL 2007). As noted in the introduction to this volume, an advantage of e-Learning is that it is both dynamic and flexible, and is increasingly able to respond to the challenges of a student-centered approach. The Holistic Lifelong Learning Model further states that there is not a single, linear approach to learning but rather it encompasses learning experiences at all stages of life in both traditional and non-traditional settings.

Both flexibility and a non-traditional setting for learning have been well demonstrated by Schifter et al. (2013) who investigated the use of online video games as a mechanism to learn problem solving, persistence and innovation. As a result of their work, they concluded that online games could give learners the opportunity to construct knowledge in meaningful ways. We found similar results in our work with Aboriginal students. Our young Shearwater students were immediately engaged by the Scratch online games and were excited by the idea that they could control the game itself. Their imagination soared as they shared their ideas with others and experimented with options.

In all of our test scenarios, "learning guides" or, in more formal terminology, "scaffolding" played a critical role. Belland et al. (2013) report that the process involves "…(a) enlisting student interest, (b) controlling frustration, (c) providing feedback, (d) indicating important task/problem elements to consider, (e) modeling expert processes, and (f) questioning" (p. 187). As it turned out, all of these points were critical in our work with Aboriginal students. Entering each of our test scenarios we knew we had to be flexible in our delivery. We often changed our lesson plan and other processes in midstream because we realized we were losing student interest or they were getting frustrated.

We also employed all three of the scaffolding variations Belland et al. (2013) identified: one-to-one, computer-based, and peer-to-peer. We typically began with one-to-one, and used our context-specific, computer-based YouTube videos to provide additional support. As the learners became more confident with the tools and approach, peer scaffolding took over as the critical element. We found that showcasing class work proved inspirational. When viewing their classmates' work, students would quickly want to incorporate some special feature another had found and asked that student for help. Davies (2013) found similar results when creating assignments that would specifically develop lasting online contributions. He believed that these types of assignments "…(1) facilitate learning, (2) are particularly motivating, and (3) contribute to the greater educational and research communities." (p. 389). In our case, we had to be careful with the online publication of student animations for a variety of confidentiality and privacy reasons. However, within the classroom, seeing the work of others encouraged the students to work harder and learn from each other.

20.6 Conclusions

Citing numerous references and statistical results regarding literacy levels among Aboriginal Canadians, the Canadian Council on Learning (2008) concluded that schools need to be more culturally inclusive of Aboriginal students and Aboriginal approaches to learning. They specifically stated:

> A number of studies have demonstrated that, in different cultures, different aspects of learning are emphasized and valued. For example, researchers have observed that many Aboriginal students prefer co-operative rather competitive learning, and that many learn through imitation, observation, and trial and error rather than direct instruction. Given that learning style factors can contribute to the alienation of Aboriginal students within classrooms, attending to these factors should contribute to more successful outcomes among Aboriginal students. (p. 6).

The results of our curriculum trials fully support the conclusion of the Canadian Council on Learning. Students in the tribal school, summer camp, the middle school elective and the remote community workshops worked well together and were keen to share new skills with each other. Walking through initial examples with the students allowed them to build the confidence to move forward on their own. It was important to distinguish learning the tool (in this case Alice) from learning how to create a story. We found that the students first needed to see what the tool could do before they could see how it applied to a story. As we discovered in the summer camp, creating or listening to a story, then building a character and creating a scene from the story, required different skills. This was borne out at the middle school. Although the students had seen many movies, and had heard and read stories, it was clear that starting with creating a storyboard and script was not going to work for this group of students. They first needed to build a comfort level with the computer and the animation tool, before they were ready to let their imaginations loose. The students also gained new perspectives from their classmates, which led them to push their skills to new levels. Living in remote communities requires active problem-solving using limited resources and quick adaptation and understanding of one's environment. It was readily apparent that these skills transferred to their academic learning in Bella Bella and Shearwater.

Reviewing the results of our curriculum tests, we identified several areas upon which we can improve and expand. Our planned actions in these areas are as follows:

1. Incorporate more opportunities for Aboriginal students to work co-operatively and thus learn more through imitation and observation. One method of accomplishing this is to divide a traditional story among all members of the class. Each student, or team of students, would work on a segment of the story. The segments can then be assembled into a complete story at the end of the course.
2. Explore using the basic curriculum to support a Language Arts program. The animation skills could be used in many ways such as retelling a legend while incorporating traditional language(s). The use of animation allows students to have a fun tool to express their learning.
3. Use a self-assessment questionnaire, such as the one proposed by Nielsen et al. (2013), both to help us fine-tune our curriculum in advance and allow the students to reflect upon their own learning.
4. Work with elders to bring more traditional stories to the students. Our next planned summer camp for the Songhees Nation includes a visit to a nearby transformation site with an elder. The elder will recount the tale in both English and Lkwungen (a traditional language). The students will then return to the classroom to create the animation in Alice. A variant of this approach has been successfully applied in Hawai'i (Edwards et al. 2007).

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We all support and serve Aboriginal students in their lifelong learning journeys.

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Chapter 21
Perceived Affordances of a Technology-Enhanced Active Learning Classroom in Promoting Collaborative Problem Solving

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21.1 Introduction

In recent years, there has been a growing interest in designing technology-enhanced classroom space to facilitate collaborative learning (Kim and Hannafin 2011; Montgomery 2008). Research shows that "space matters," and it effectively enhances students' learning (Montgomery 2008; Oblinger 2006). Many educational institutions engage in initiatives of building Active Learning Classrooms (ALCs) to promote student interaction and collaborative learning (Walker et al. 2011). ALCs are typically equipped with large round tables capable of seating several students with gooseneck microphones, 360-degree marker boards around the classroom walls, and large LCD screens all around the room or attached to different tables. Presumably, ALCs have the advantage of facilitating group work, encouraging peer interactions, engaging students in critical thinking, and applying knowledge to solving problems through furniture arrangement and space design. ALCs place students in the spotlight of learning, in which a student's role is changed from a passive learner to an active learner and an instructor's role is changed from an information transmitter to a coach.

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A number of empirical studies have been conducted to understand the impact of ALCs on students' learning outcomes and instructors' teaching approaches (e.g., Brooks 2010; Walker et al. 2011; Whiteside et al. 2010). The results of the studies show that the ALCs have a positive impact on student learning outcomes. In addition, the results also show that ALCs enhance students' conceptual understanding, improve their problem-solving skills and attitudes, and increase their motivation (Beichner et al. 2007; Dori et al. 2003). In the meantime, evidence suggests that classroom features not only influence how students learn, but also how instructors teach (Brown and Long 2006; Chism 2006; Chism and Bickford 2002; Lomas et al. 2006; Oblinger 2006). ALCs provide greater ease of movement for instructors to communicate more frequently with students, and the learner-centered classroom setting prompts instructors to align their instruction with the classroom features and adjust their teaching methods accordingly (Walker et al. 2011; Whiteside et al. 2010). Compared with the older technology, the most distinctive characteristic of the ALC technology lies in its capability to create a flexible and supportive learning environment to promote student-centered learning with its space layout, furniture arrangement, and a suite of technology devices and equipment. ALCs not only suggest newer technology, but also a completely new way of conceptualizing learning and instruction.

However, the previous studies did not reveal what factors influence or motivate students' learning in ALCs. The current research we have found mostly focused on students' learning achievements, such as course grades, quizzes, exams, and homework. There is insufficient research examining students' and instructors' perceptions of, and experience in ALCs. Apparently, the research on the impact of learning space on students' academic achievements has just begun, and many issues remain to be explored further.

The purpose of this study was to investigate the impact of an ALC on learning and instruction, particularly, to uncover what is going on inside the "black box". Specifically, we are interested in (1) exploring students' and instructors' perceptions of, and experience with technology affordances in facilitating collaborative problem solving, (2) examining their use of technologies, and (3) understanding instructors' decisions in selecting instructional technologies and strategies.

21.2 Theoretical Frameworks

This research is framed with the lens of ecological psychology and cognitive psychology. Ecological psychology is a school of psychology that stresses the importance of an environment, particularly the (direct) perception of how the environment of an organism affords various actions to the organism (Gibson 1979; Gibson and Pick 2003). From this theoretical perspective, an environment has an impact on human's perceptions, which prompt individuals to react to the environment (Gibson 1979; Gibson and Pick 2003). It is argued that individuals are information detectors who are capable of perceiving affordances in the environment and how they become apprised of these possibilities for action (Young et al. 2000). There are two key concepts that are important to ecological psychology: *affordances* and *effectivities*. *Affordances* are the properties of an environment, specified by the information field that enables action. *Effectivities* are the abilities of an individual to take actions. The existing literature suggests that the ALC space not only facilitates students to collaborate on projects and their inquiry learning, but also allows instructors to modify their teaching methods or styles to be aligned with what the environment affords. Since perceptions of affordances determine effectivities of actions, it is very important to understand what influences a human's perceptions, and how and why individuals perceive and interpret things differently. In other words, what affordances do instructors perceive in an ALC, what influences their perceptions, and how do their perceived affordances of technology lead to their instructional decisions?

Unfortunately, ecological psychology does not offer explanations to those questions, and thus we must rely on cognitive psychology to help us understand instructors' perceptions, attitudes, motivation, needs, experiences, beliefs, values, and considerations. Research indicates that epistemological beliefs of instructors affect their teaching beliefs and behaviors (Marra 2005). Epistemological beliefs are developmental, and they can be categorized at different levels. An instructor's teaching approach can indicate his or her belief level, which can influence students' learning and their epistemological development (Fosnot 1996; Hashweh 1996; Windschitl 2002). Therefore, instructors' beliefs about knowledge, learning, and instruction guide their instructional decisions and their selection of strategies and technology use.

Jonassen (1991) identified two philosophical assumptions: objectivism versus constructivism, the two fundamentally different paradigms regarding reality, mind, thought, meaning and symbols. Objectivism believes in the existence of the real world, which is external to humans and independent of human experience. Objectivism argues that there is reliable knowledge around the world we strive to gain. On the contrary, constructivism believes that reality is more in the mind of the knower and that the knower constructs a reality based on the individual's prior knowledge and experience. Each individual constructs his/her own reality through interpreting his/her perceptual experiences of the external world instead of mapping the reality onto the mind. Jonassen's (1991) work on different philosophical paradigms was used as a framework to guide this study for understanding the instructors' epistemological beliefs.

It appears necessary to explore not only the relationship between the affordances of the ALC environment and the effectivities of both professors and students, but also how this relationship influences learning and instruction, and most importantly, how individuals' epistemological beliefs influence their perceptions, decisions, and practice regarding learning technologies when teaching in an ALC. In this study, we particularly focused on the instructors by examining their instructional decisions and practices in an ALC, as well as their perceptions of the technology affordances and their epistemological beliefs about knowledge, learning, and instruction. In addition, we also collected data from the students through interviews and questionnaires to obtain their perceptions about the ALC technology affordances and their experiences with the technology.

21.3 Research Questions

The purpose of this research was to go beyond our current understanding of ecological psychology and tap the area of epistemological belief in order to understand the underlying factors influencing individuals' perceptions of technology affordances that enable them to take appropriate actions, such as generating appropriate solutions and selecting appropriate instructional plans, in the context of an ALC. The study sought to answer the following research questions:

1. How do the instructors use the ALC technology to carry out their instruction?
2. What are the instructors' epistemological beliefs about knowledge, learning, and instruction?
3. Is the instructors' instructional practice influenced by their value beliefs?
4. What are the students' perceptions regarding the affordances of the ALC technology?
5. What kind of technology do the students use to facilitate their collaborative problem solving?
6. What is the impact of the ALC technology on students' motivation and self-efficacy in collaborative problem solving?

21.4 Method

This was a mixed-methods research study using qualitative research as a main research tool and quantitative method as a supplemental tool to provide better understanding of the questions under investigation (Creswell 2012). The qualitative research was conducted in all the four participating classes (two classes—Case 1 and Case 2 in the first semester, and the other two—Case 3 and Case 4 in the second semester), using the multiple-case design through observations and interviews, which was intended to describe the perceptions of the ALC technology affordances and to interpret the behavioral patterns regarding the use of the ALC technology by both the instructors and the students (Stake 2005; Yin 2013). The multiple case studies were conducted through class observations and interviews in both semesters.

In addition, in the second semester a quantitative study in the form of surveys (i.e., self-reports) was conducted to the two classes (Case 3 and Case 4) that were taught in the ALC in the second semester. The main purpose of the quantitative study was to examine the effect of the ALC environment on learners' self-efficacy and competence in collaborative problem solving and to provide the researchers with additional information through the quantitative data. The surveys were administered in the second semester was because the ALC was just introduced into the institute in the first semester, and we decided to explore in the first place how an

ALC worked and what issues might come up related to teaching in an ALC, and so we determined it was appropriate to start our research with case studies in the first semester. In the second semester, based on the qualitative data collected from the first semester, we felt a need to further examine more the impact of an ALC on students' learning experience, including self-efficacy and competence in collaborative learning, so we added a quantitative study to our research.

The lead author conducted all the interviews with both instructors and students. The interviews were audiotaped using a digital device, and the digital audio files were transcribed by the second and the third researchers, under the supervision of the lead researcher. Specific information about data analysis is presented below in 4.3.

21.4.1 Participants and Context

The study was conducted at a university in the southwest of the United States, where the first ALC was just built and the instructors were invited to use the ALC and encouraged to experiment with teaching in the new setting. The researchers first obtained the instructors' consent to participate in the study; then the researchers invited their students to participate in the study and sign an informed consent form if they agreed to participate. All the classes were one-semester long, and each of the classes was regarded as an individual case unit.

As a result, four classes of various domains (i.e., chemistry, life science, physical science, and meteorology) that were taught in the ALC participated in this study. A total of 92 students agreed to participate in the research. Each of the four classes was treated as a single case. A total of 22 students from the four classes over the two semesters were interviewed. In addition, 21 students from the two classes in the second semester completed both pre-surveys and post-surveys, including three of the interviewees.

Five instructors from the four classes (two of the instructors co-taught one class) participated in this study through interviews and observations by the researchers. Four of the instructors were male, and one was female. All of them were senior faculty members who had taught the classes under investigation for years, and they had used computers or laptops, projectors, static whiteboards and/or smart boards to conduct instruction in their previous teaching experiences. Some of them also had experience using document cameras and other technology devices. They all had some experience of conducting group work in a traditional classroom setting, and they were all motivated to explore new ways of teaching to improve students' learning.

The detailed information about the participants and the four cases, including the classes and the course content, is presented in Table 21.1.

Table 21.1 Participant, class, content information

	Case 1	Case 2	Case 3	Case 4
Domain	Life science	Physical science	Chemistry	Meteorology
Content	Complexities of biological conserva-tion through a quantitative exploration	Introduction of the physical pro-cesses associated with atmospheric composition, radiation and energy concepts, and the equation of state	Basic reaction mechanisms, spectroscopy and fundamen-tal synthetic transforma-tions of organic chemistry	The science and technical aspects of solar, wind, hydro, and bio-mass power sys-tems and the key role of climate in determining feasible energy alternatives
Required or Elective	Elective	Required	Required	Elective
Number of Students	13 (M=7; F=6)	61 (M=41; F=20)	23 (M=10; F=13)	59 (M=40; F=19)
Number of participants	13 (M=7; F=6)	25 (M=15; F=10)	22 (M=9; F=13)	32 (M=22; F=10)
Level in College	Master students and junior or senior undergraduates	Sophomores	Sophomores (Honor)	Master students and senior undergraduates
Major	Biology mainly	Meteorology and other related majors	Chemistry and other related majors	Meteorology mainly
Class Length	50 min each, meeting twice a week	50 min each, meeting 3 times a week	75 min; meeting 3 times a week	75 min; meeting twice a week

21.4.2 Data Collection and Sources

The observations were conducted at different points of the semester, recorded in the form of field notes, with particular focus on instructional approaches, class activities, use of technology in the ALC, and the interactions between instructor and students and among students. The observations were conducted regularly throughout the semester based on the pre-arranged schedules with the instructors according to the nature of the class activities that had been planned. Instances when there were no observations included quizzes, mid-terms, final exams, guest speakers, instructor on a professional conference trip. Each time there were at least two of the researchers in the classroom taking field notes and recorded the types of activity an instructor used, type of technology used for each activity, and the duration of each activity. After class, the researchers would compare and discuss their notes to validate the observation data. We conducted an average of 15 observations for each of the four cases.

The interviews for the students (each lasting about 30 min) were conducted in the middle or the end of the semester, and the interviews for the instructors (each lasting about 45 min) were conducted at the end of the semester. A semi-structured interview protocol was prepared as a reference to guide the interviews. The interview questions for the students included the following parts: (a) epistemological beliefs about knowledge, learning, and instruction (e.g., "In your perspective, what is knowledge, what is learning, and what is instruction?"), (b) their perceptions and experience about the ALC technology (e.g., "How do you feel about taking a class in the ALC classroom? Can you describe your learning experience in this kind of classroom setting"), (c) the impact of the ALC technology on their collaborative learning (e.g., "In what ways do you think the ALC facilitates or motivates collaborative problem solving? Can you provide a couple of examples?"), and (d) their perceptions of challenges with learning in an ALC (e.g., "What challenges do you perceive in participating in class activities, such as collaborative problem solving, in an ALC?"). The lead researcher conducted all the interviews with one of the other researchers present each time.

The interview questions for the instructors consisted of three parts: (a) epistemological beliefs about knowledge, learning, and instruction, (b) perceptions and experience of teaching in an ALC, (c) their instructional approaches and decisions (e.g., "What do you perceive an ALC can do that the traditional classroom can hardly do?" "Do you think your teaching approach has been modified or shaped due to the ALC classroom setting and the availability of the technology? If yes, in what ways?"), and (d) their challenges in teaching in an ALC (e.g., "What do you see as the major challenges when teaching in an ALC?"). The lead researcher conducted all interviews with each of the instructors face-to-face.

The pre-survey was conducted at the beginning of the semester and a post-survey at the end of the semester. The surveys consisted of questions in three areas asking students' perceptions about: (1) intrinsic motivation, (2) problem-solving confidence, and (3) problem-solving skills related to their subject domain. The surveys were administered via paper to 54 participants (Case 3 and Case 4) in the second semester. Due to some issues related to the data collection, for instance, many participants did not write their names on the post-surveys or some participants did not complete either survey due to their absences, only 21 completed survey data were collected.

21.5 Data Analysis

We used both inductive and deductive approaches to analyze the interview data. First, the second and the third researchers transcribed the interview audios. Then we used an inductive approach to generate substantive codes about the instructor's beliefs about knowledge, learning, and instruction from the interview data. The second and the third researcher performed the initial codings to each of the transcriptions independently, particularly focusing on the interviewees' responses to the interview questions. After they finished the initial codings, they compared their codes and discussed their notes. Afterwards, the lead researcher went through all the codes with them again to modify or consolidate the codings or generate new codes to add to the coding list. After several iterations of data coding and validation, a list of codes was agreed upon and finalized by all the researchers. The codings were then grouped into several categories and then themes were generalized based on the semantic similarities (Bogdan and Biklen 2006; Strauss and Corbin 1998). For example, regarding epistemological beliefs the following categories were arrived at through the coding process for *knowledge*—"information", "information process", "Information + information process"; for *learning*—"knowledge constructed by human beings", "acquisition +"; and for *instruction*—"constructivism", "passing information + inquiry", and "creating by experience". Following the inductive analysis, the researchers used the deductive approach by clustering the emerging categories into either "objectivist" or "constructivist" theme based on Jonassen's (1991) theoretical framework. We were able to categorize all the codes that had been inducted from the previous data codings into either of the two priori categories, "objectivist" or "constructivist".

With respect to the analysis of observation data, we focused on the class activities and observed how instructors used the ALC technology for each activity at 5 min intervals. Based on the observation notes, we categorized student activities into students' individual work, collaborative activity, interaction between students and instructors, lecture, and students' presentation. The researchers recorded the time students spent on each of the activities during a period of class, which was later converted into percentage.

In addition, the use of technology was categorized into laptops, big screens, the Internet, static whiteboard, and iPads. Finally, the total minutes of the class activity in all the classes observed were summed up, which were divided by the total number of minutes of the class time to arrive at the percentage for the time distribution for each kind of activities. The percentage distribution of class activities was an important data source for us to interpret the instructors' instructional approaches and infer their perceived technology affordances and their beliefs about knowledge, learning, and instruction.

As for the survey analysis, a paired-samples t-test was conducted to compare the students' perceived intrinsic motivation, problem solving confidence, and problem solving abilities between the beginning and the end of semester.

In the last stage of the data analysis, all the sources of data were triangulated. Particularly, we examined if there was an alignment between the instructors' teaching practice, their perception of the ALC technology affordances, and their beliefs about knowledge, learning, and instruction. It was assumed that those instructors who held objectivism tended to deliver information to students and spend more class time lecturing or presenting information. On the contrary, those instructors who believed in constructivism tended to engage students in knowledge construction and collaborative learning activities, and additionally they tended to provide more opportunities for interactions between the instructor and the students and among students. The instructional practice was analyzed based on the type of activities the instructors led and their students engaged in and the amount of time spent on each type of activity. Then the instructors' teaching behavioral patterns were linked to their claims on how students should learn and how they should teach. Furthermore, we also triangulated the students' data with the instructors' data, as well as the students' survey data and their interview data.

21.6 Findings

21.6.1 Use of the ALC Technology for Various Learning Activities by Different Instructors

There were big variances among the instructors on instructional activities they carried out in the ALC, and how and when they used the technology, from those who had more balanced time distribution on different activities to those mainly dominated by lectures. Figures 21.1, 21.2, 21.3 and 21.4 demonstrate two contrasting groups of four cases, Case 1 and Case 4 as opposed to Case 2 and Case 3, by the percentage of time spent on group work, individual work, lectures, student-instructor interactions, student presentations, and quizzes. As shown by the figures below, Case 1 and Case 4 were more balanced with the time spent between instructor lecturing and students' activities, including collaborative work, individual work, and presentations, etc., while Case 2 and 3 were largely dominated by expository or lectures.

In addition, we observed how the instructors employed technology to promote collaborative learning and to scaffold their students through the problem-solving processes (Ge and Land 2003; 2004), which was summarized in Table 21.2. It ap-

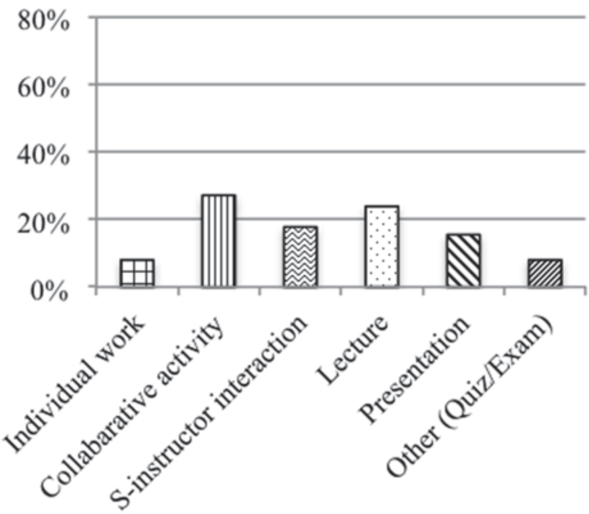

Fig. 21.1 Class time distribution of Case 1: Balanced usage of the ALC technology

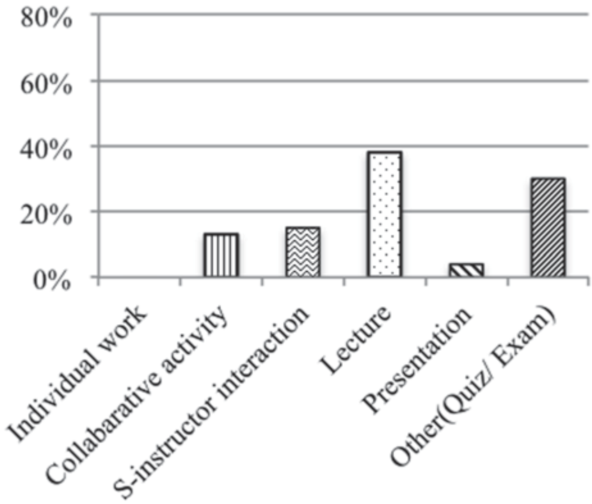

Fig. 21.2 Class time distribution of Case 4: Balanced usage of the ALC technology

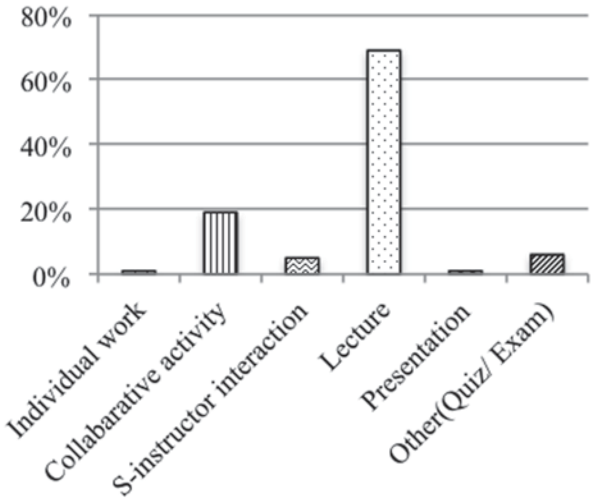

Fig. 21.3 Class time distribution of Case 2: Less balanced usage of the ALC technology

peared that the instructors of Case 1 and Case 4 took full advantage of the technology provided in the ALC by encouraging the students to use technology for group work and promoting collaborative problem solving while the instructor also used internet resources to bring in real-world cases to the class for group problem solving. However, the instructor of Case 2 and 3 only limited the use of technology to big screens and iPads focusing on the visual displays to help the instructor to illustrate difficult concepts to students. For example, the Case 4 instructors mainly used the big screen to play movies to introduce real-world problems to the class as a starting point for class discussions or debates. In contrast, the Case 2 instructor mainly used the document camera to display illustrations from some teaching materials, which were projected to the screen to help his students understand different

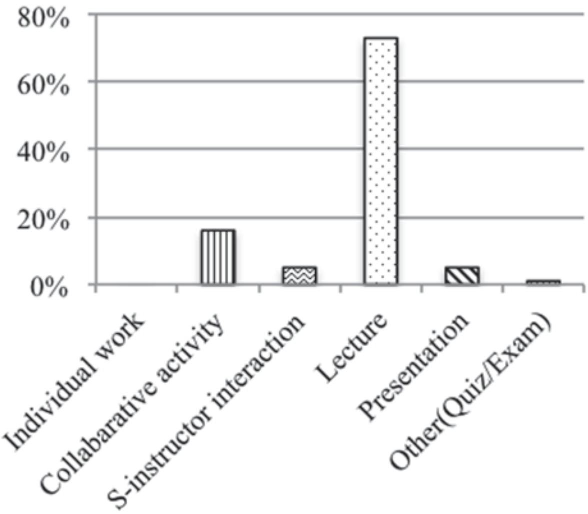

Fig. 21.4 Class time distribution of Case 3: Less balanced usage of the ALC technology

Table 21.2 Use of different types of technology for different activities by different cases

Class activities	Technology use				
	Laptops	Big Screens	Internet	Whiteboard	iPads
Individual work	C1,				
Collaborative activity	C1, C4	C1, C3, C4	C4	C1	C3
S-instructor interaction		C1, C3, C4	C4	C1	C3
Lecture	C4	C1, C2, C3, C4	C1, C4	C1	C3
Presentation	C4	C2, C3, C4	C4	C1	C3
Others					

C1 Case 1, *C2* Case 2, *C3* Case 3, *C4* Case 4

concepts of meteorology. He barely used other technology equipment. It seemed that the instructors used technology differently according to their perceived needs to fulfill their instructional purposes. The use of technology might also depend on the needs of teaching specific domain content.

21.6.2 Use of the ALC Technology for Various Learning Activities by Students

In general, the five instructors we interviewed were happy about teaching in the ALC. They all indicated the capability of the physical space and the technology setup allowed them to conduct team work and collaborative learning more easily, which they perceived beneficial for their students. Yet, the extent to which how the ALC technology was used varied from instructor to instructor. Obviously, the in-

Table 21.3 Students' use of technology for collaborative problem solving

Problem solving processes	Technology use				
	Laptops	Big screens	Internet	Whiteboard	iPads
Problem representation	C4	C1, C2, C3, C4	C1, C4		C3
Generating solutions	C1, C4	C1, C4	C4	C1	C3
Making justification	C1, C4	C1, C4		C1	C3
Monitoring and evaluation	C4	C1, C3, C4	C4	C1, C2	C3

C1 Case 1, *C2* Case 2, *C3* Case 3, *C4* Case 4
During this semester no iPads were available in the ALC for Case 1 and Case 4

structors' instructional decisions determined what activities the students were going to have and how the students used the technology. From Table 21.3 it was observed that the students of Case 1 and Case 4 engaged in more problem-solving activities and used a variety of technology tools while Case 2 mostly focused on the big screens or white boards, which makes sense because the instructor spent most of the class time presenting information, which was projected through the big screens. Case 3 students used iPads frequently, in addition to the screens due to the nature of the class in which the instructor demonstrated molecular structures through the visual representation of graphics. Case 1 and Case 4 probably would have used iPads, but iPads were not provided in the ALCs the semester when they were having classes there.

Table 21.3 also demonstrated what technology tool was used at what problem-solving stage. It was found that the students of Case 1 and Case 4 used almost every type of technology in all the four problem-solving processes, namely, problem representation, developing solutions, making justifications, and monitoring and evaluation (Ge and Land 2004), while Case 2 and Case 3 mostly used the big screens and the static whiteboard for presenting problems and providing feedback provided by the instructors because in these two cases, the students did not have many chances to work on the problems in groups or by themselves. This evidence was aligned with our observation of the instructors' patterns for arranging activities and the use of the ALC technology.

21.6.3 Instructors' Beliefs About Knowledge, Learning, and Instruction

Table 21.4 illustrates instructors' beliefs about knowledge, learning, and instruction. Two instructors indicated that knowledge is more than information, and that it is both information and process (i.e., "knowing how to do things"). However, Case 1 and Case 3 held the view that knowledge exists external to the human mind, and that it is "factual information about world, and things that you know to be true." However, Case 2 and Case 4 believed that knowledge is something of "humanization

Table 21.4 Instructors' belief about knowledge, learning and instruction

	Knowledge	Learning	Teaching
Case 1	Factual information about the world… knowing about process" [information + information processing]	The acquiring the facts and processes [Acquire + process]	To encourage the difference… encourage which is how we decide among all the possibilities… support the alternative hypothesis [Passing information + Inquiry]
Case 2	Incorporate into one's life either professionally or personally [Knowledge constructed by human beings]	Being able to simulate information from new situations [Constructing knowledge]	A way of transferring my knowledge [Passing information + other]
Case 3	The body of information at the simplest level [Information + information processing]	Being able to apply to not just the static body, but use of that information [Acquire knowledge + application]	To get the students to learn the details of that body of information [Passing information + other]
Case 4	Perception of the world… affected by each person's individual experience as well as interaction itself [Information + information process]	Gathering without bias… to respect other person's opinion whether you agree or not, and understand where their knowledge come from. [Constructing knowledge]	To help students find their way to learning and developing their base knowledge. [Knowledge created by experience]

of learning". Their definition of learning and instruction was consistent with their definition of "knowledge". Learning was defined as either knowledge acquisition plus "inquiry process" or "apply" (objectivist view), or a knowledge construction process (constructivist view). All the instructors agreed that teaching was more than passing information; it was "to get the students to learn the details of that body of information and how to apply that body of information" or to "help them find their way to develop their knowledge base."

By comparison, it seemed that the instructors of Case 1 and Case 3 showed more objectivist views while the instructor of Case 2 and 4 were leaning more towards constructivism.

It could be seen that there was a fairly good alignment in Case 1, Case 3, and Case 4 between the instructors' value beliefs about knowledge, learning, and instruction and their instructional practice. However, there was a surprising misalignment in Case 2, whose claim of instructional practice and beliefs was conflicted with his instructional approach. This data was an exception to our assumption that one's individual belief influences his/her perceived affordances about technology, which in turn influences his or her responses to the use of technology.

21.6.4 *Students' Perceptions and Experiences About the Impact of the ALC Technology on Their Motivation and Collaborative Problem Solving*

The students were overall positive about their ALC learning experiences. Many students interviewed agreed that "the layout of the room and the synthesis of technology make group learning possible." Almost every student said that the classroom setting (e.g., round tables) made it easier to "talk to each other" and "get to see each other easily"; the "space" facilitates interactions and small group work. The physical set up prompted students to work together more freely and they were more at ease interacting with the instructor. One student even mentioned that he felt "relaxed" in such a learning environment, which helped him to focus more on the content area. For Case 1 and Case 4, the group projects required the students to use Internet resources frequently; therefore the students also mentioned access to the Internet and data sets as one of the advantages. It seemed that the ALC had an added value to the group work flow to facilitate this process. A student summarized the value of the ALC as "interactive, engaging, and effective."

The students from Case 3 mentioned the benefits of screens and displays more than once because in this course (chemistry) difficult concepts had to be illustrated using visuals. What the instructor did was download an app to his iPad so that he could display the structure of molecules and the dynamic interactions of molecules in various ways, and he could annotate on the graphics as he was explaining the abstract concepts.

Several students mentioned that with the ALC facility and technology they could upload their work to be shared with the class a lot easier, although this convenience also created some pressure for some students, as indicated by a couple of students in an honors class, which compelled them to make sure that their work was "correct" before it was uploaded and shared.

In speaking of the benefits of the ALC, students often related it to the advantages of group work, which seemed to indicate that the ALC was associated with collaborative learning. Some students, particularly from Case 4, indicated that they had "learned from multiple views and how to reach consensus". In their class, learning from multiple perspectives and compromising students' own perspectives seemed to be an important emphasis of the course. The collaboration aspect associated with the ALC had led some students to extend their in-class work outside the class. Several students mentioned in their interviews that they often met outside the class to continue their group work.

However, there were some concerns regarding the use of the ALC. One of the concerns was running out of time for group activities concerning the current class structure (1 hour per class, 3 times per week), leaving little time for groups to engage in intensive discussions. There were also indications that some professors did not use technology to its full potential, the ALC was unnecessary for some classes because the instructor did not use the technology much in the class, or some professors did not have adequate training in using the ALC technology. In addition, some

Table 21.5 Mean differences between pretest and posttest in students' perceived intrinsic motivation, perceived problem-solving confidence, and perceived problem solving skills

	Paired difference					
	Mean	SD	t	df	Sig	Effect size
Intrinsic motivation	(+) 4.19	12.79	1.50	20	0.149	0.101
Problem solving confidence	(+) 24.76	48.23	2.35	20	0.029*	0.217
Problem solving skills	(+) 5.19	14.30	1.66	20	0.112	0.121

* $p < .05$

students also expressed concerns regarding some group members who did not prepare for the class or contribute to group projects.

Table 21.5 shows the survey results indicating a significant difference in students' perceived problem-solving confidence between pretest (M=308.10, SD=44.34) and posttest (M=332.86, SD=32.58). Students achieved significantly higher confidence scores in the posttest, as illustrated by Table 21.5, $p<0.05$. However, there were no significant differences in their perceived intrinsic motivation and problem-solving skills. Yet, in both measures the mean scores seemed to have increased in the posttest compared with the pretest. We believe that with a larger sample and a longer period of training, we might be able to see a stronger effect size and significant gains in the areas of perceived motivation and perceived problems solving skills.

21.7 Discussion and Implications

The students' self-reports through the surveys indicated that collaborative learning in an ALC had a positive impact on their self-efficacy and confidence in completing problem-solving tasks. There was also an indication that students' motivation, problem-solving, and metacognitive skills increased over time in an ALC environment. The other findings indicated that although both students and instructors recognized the benefits and affordances of the ALC technology for learning in many ways, their perceptions of and experiences with technology could be different based on their beliefs and understandings about learning and instruction, the nature of the courses, the class sizes, and the course structure.

It was found that there was a wide gap between instructors who used technology to its potential by utilizing various pieces of the ALC technology and those who used the technology minimally by only using one or two tools. Some instructors used the ALC technology mainly for group work and collaborative activities, some used it mainly for illustrating complex concepts through visual representations while others used it mainly for delivering information. However, when reflecting on the four cases about the instructors' teaching practice and their beliefs, we found that these four cases represented different developmental stages of epistemological on a continuum from objectivism to constructivism.

According to the ecological theory, an ALC should provide affordances for improving learning and instruction, yet it relies on the users' ability to take actions (effectivities). In the first place, the users must perceive the meaningfulness of technology and consider their needs (Gibson 1979; Gibson and Pick 2003). From our observations, we found that the instructors used technology differently according to their perceived needs, which could be based on the nature and the content of the courses. For instance, the instructor of Case 2 said that the document camera was very helpful for him to illustrate the domain content related to atmospheric physics, while Case 3 instructor indicated that an app frequently helped him illustrate the structure and the interactions of chemistry molecules and his students to engage in manipulating and observing molecules in 3-D view on their iPads. Case 4 relied on the displaying device for video playing in order to introduce real problems to his students as an anchor to stimulate their critical thinking.

Overall, the study indicates that technology affordances depend on individuals' epistemological beliefs, perceived meaningfulness, and needs (Gibson 1979; Gibson and Pick 2003). However, we found an exception in Case 2, whereas the instructor's teaching approach was not aligned with his claimed beliefs about learning and instruction. There could be several explanations. One explanation could be due to the fact that he taught a large class of over 60 students, which made it difficult to organize and manage student-centered learning activities according to the instructor. The second explanation was the misalignment between "knowing" and actually "doing." Just as Marra (2005) indicated, instructors might have their "scripts" about how to teach, which could be contradictory to their beliefs and made their teaching relatively fixed and difficult to change for the time being.

This study once again confirms the benefits of the ALC affordances. In the past, the instructors used the technology (e.g., computers, laptops, and projectors) to present information or instructional materials through PowerPoint, Internet resources, video or other media resources while students did not have much opportunity to use technology during the class. Although sometimes students brought their laptops to class, they used them mostly for taking notes of lectures. In other words, in the old technology paradigm the instructors generally take control of the students' learning process while students do not have time or opportunity to interact with their peer students and receive feedback from an instructor— an important aspect and process of knowledge construction. Students have very little autonomy for what they need to learn and how they want to learn. In the new technology paradigm, however, the most distinguishable feature of an ALC is the design and layout of the physical setting of a classroom, namely the space, the space of teaching, the space of learning, and the space of critical thinking, enabled by other technology devices, including laptops, mobile devices and visual presentation technologies. In an ALC, the teaching space and the learning space become congruent and fluid, and learning and instruction become dynamic and spontaneous. Students have equal access to technology where they can easily interact with their instructors, engage in constructive dialogues, and receive timely feedback from the professors. In this new learning paradigm, the ALC setting allows students not only to have access but also autonomy to their learning.

Having said that, the findings of this study inform us that active learning does not happen automatically in an ALC environment, and that effective instructional design strategies are needed to make active learning happen. The use of ALC technology requires a fundamental paradigm shift on the part of the instructors, which includes a new way of viewing and thinking about knowledge, learning, and instruction. In addition, it is necessary to provide extensive examples and trainings to instructors on two dimensions (technological and pedagogical) and to help them reconceptualise learning and instruction.

For future research, it would be interesting to further explore the relationships between students' beliefs about learning and their actual learning strategies and approaches, and to examine the impact of the instructors' value beliefs on the students' value beliefs about knowledge, learning, and instruction. Regarding the assessment of students' learning achievement in the ALCs, instructors should work with instructional designers and researchers closely to develop a sound instructional and evaluation plan. Meanwhile, the researchers are encouraged to seek alternative methods to collect data on learning gains and to address the constraint of designing and conducting experimental studies with a control group in real practice, which has been a limitation to this study.

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