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*Editors*

# Learning and Instruction in the Digital Age

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Editors

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*We dedicate this volume to the future of learning and technology. We hope that the small steps taken in our generation will lead to giant steps forward in educating people all around the world.*

# Preface

Advances in both cognitive psychology and computing have affected the educational arena. The convergence of these two disciplines is increasing at a fast pace and affecting academia and professional practice in many ways. Paradigms such as just-in-time learning, constructivism, student-centered learning, and collaborative approaches have emerged and are being supported by technological advancements such as simulations, virtual reality, and multi-agents systems. These developments have created both opportunities and areas of serious concerns. The CELDA (Cognition and Exploratory Learning in the Digital Age) have been targeting the convergence of advances in cognitive psychology and ICT (information and communications technologies), especially with regard to the implications for learning and instruction, for the last 6 years (http://www.celda-conf.org/).

The chapters included in this edited volume were selected based on peer ratings of papers presented at the CELDA (Cognition and Exploratory Learning in the Digital Age) 2008 Conference in Freiburg, Germany, in October 2008. Only the top 30 papers were considered. The authors were invited to expand and modify their papers based on feedback received at the conference from participants and from the editors and their reviewers. Seven of the best papers ended up as a special issue in *Educational Technology Research and Development* (*ETR&D*) appearing in 2009 with Ifenthaler, Isaías, Spector, Kinshuk, and Sampson as guest editors. Nearly all of the remaining best papers are included here. These papers underwent a review process very similar to that used by *ETR&D*.

CELDA 2008 included the typical CELDA thematic areas such as acquisition of expertise, assessment, collaborative learning, exploratory technologies, learning communities, learning paradigms, lifelong learning, technology and learning, and virtual worlds. Of particular interest and focus at CELDA 2008 were topics such as learning in complex domains, mental models in learning, student-centered learning, and Web 2.0 in learning and instruction. Three of these themes – assessing learning in complex domains, cognition in education, and technology and mental models – formed the basis for the *ETR&D* special issue, which should be considered as a companion to this volume.

We organized the chapters included in this volume around five themes: (a) cognitive approaches to learning and instruction, (b) knowledge representation and mental models, (c) technology-facilitated tools and technologies, (d) communications and methods, and (e) integrative methods and online learning. Each of the editors took lead responsibility for reviewing and editing the chapters associated with one theme. The reviewers who contributed are recognized at the end of the Contributors' section.

This is the first edited volume to result from a CELDA conference. Every CELDA conference has resulted in a special issue of a journal, and we hope to continue that tradition. When we have so many outstanding papers as were presented in Freiburg, we will certainly seek to also have an edited volume, as this benefits the entire professional community.

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Lisboa, Portugal — Pedro Isaías
Athabasca, AB, Canada — Kinshuk
Piraeus, Greece — Demetrios G. Sampson

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# Part I
# Cognitive Approaches to Learning and Instruction (Spector)

# Chapter 1
# Learning and Instruction in the Digital Age

## Introduction

**Dirk Ifenthaler**

**Abstract** The modern digital age is characterized by powerful information and communication technologies that can have a significant impact on learning. The 2008 CELDA (Cognition and Exploratory Learning in the Digital Age) conference in Freiburg featured a number of papers that addressed the intersecting areas of knowledge, pedagogy, and technology. Individualized and independent learning has been made possible by the Internet and Web 2.0 technologies. However, the advances reported in this volume and presented at CELDA are likely to be hardly more than a footnote in the history of educational technology if advances continue at such a hectic pace. In the not-so-distant future, we might see the genuine meaning of constructivism emerge as learners become active constructors of their own learning environments, setting individual goals and creating content structures for the knowledge and content they intend to master.

## 1.1 The Dawn of the Digital Age

The dawn of the digital age can be dated back to 1623 when Wilhelm Schickard invented the first calculating machine. The mechanical calculator performed addition and subtraction of up to six-digit numbers (von Freytag-Löringhoff, 1987). Another important invention can be dated to 1679 when Gottfried Wilhelm Leibniz developed the binary number system based on 0 and 1. The binary number system is the basis for modern electronic data and information processing (Burkhardt, 1980). In 1810 Joseph-Marie Jacquard introduced the punch card, which represents a very early version of modern information storage, and with the invention of the analytical machine by Charles Babbage in 1832 came the fundamental idea of program-controlled computing (Aspray, 1990). The Z3, invented by Konrad Zuse in 1941, is regarded as the first properly functioning computer containing a binary

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calculation system, a memory function, and a central data processor (Rojas, 1998). In 1945, J. Presper Eckert and John W. Maulchly brought the ENIAC, the first digital general-purpose computer, to completion. The first integrated circuit was developed by Robert Noyce and Jack Kilby in the late 1950s, which enabled the development of smaller and faster computers (Williams, 1997).

In the years that followed, the microcomputer was developed further, featuring audio, colors, peripherals and input devices, and a graphical user interface (GUI). Starting in the late 1960s, the Internet emerged from experimental networks in the United States (Abbate, 1999). Today, the Internet links millions of computers worldwide and is the biggest machine ever invented and built by humankind. According to usage statistics, a total of 1,574,313,184 people use the Internet today (Miniwatts Marketing Group, 2009). Accordingly, the digital age generates an ever-growing amount of information which is rapidly distributed and widely available at any time and any place.

However, learning is not a simple matter of information retrieval. Learning is regarded as an active process and requires the construction of mental models and schemata to understand phenomenon of the world (see Ifenthaler, Pirnay-Dummer, & Spector, 2008; Johnson-Laird, 1983; Piaget, 1950; Resnick, 2002; Seel, 1991). Accordingly, the digital age and its new technologies have created both opportunities and areas of serious concern for learning and instruction. Hence, we have just arrived in the digital age and it is up to researchers, technologists, educators, and philosophers to make sense of these powerful technologies.

## 1.2 Opportunities and Concerns for Learning and Instruction in the Digital Age

A quarter of a century ago, the American psychologist Greenfield (1984) took up the topic of new media and communication technologies and discussed their possible effects on the learning and behavior of children. She approached the topic from a fundamentally positive, albeit critical, perspective. She understood the new technologies as cultural artifacts which demand complex cognitive skills for their use which are not learned or taught in school, but rather only through active manipulation and practice in everyday life. Although Patricia Greenfield was not alone with her positive stance toward the so-called new media, the discussion in the 1980s was dominated more by critical voices. Günther (1986), for instance, warned vehemently against an overly hasty introduction of computers in schools and was only prepared to accept it if the schools also offered regular outdoor excursions and field trips. The well-known proponent of educational reform von Hentig (1987) recommended waiting as long as possible to offer computer courses to school students.

Haft (1988) commented on this discussion by pointing out that every technological advancement in history has led to a perceived loss of immediacy, belief, and confidence in one's own experiences but that in most cases the pessimistic predictions concerning the proliferation of new technologies have turned out to be ungrounded. Whereas ardent educational reformers warned of the dangers of the computer, parents and children were quick to see the potential of the computer, and the PC made its way rapidly into children's bedrooms – more rapidly, at any rate, than into schools.

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 & 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 already touched on above that information and communication technology were increasingly becoming a part of the daily lives of children and teenagers.

The dawn of *multimedia* and the *digital age* was heralded in with many optimistic visions of the future, but of course also accompanied by fears. Today, multimedia is an important part of our daily lives at home and at work – from MTV to the Internet. Computer simulations have also found their way into the living room: Youths spend a lot of time with entertainment programs and video games, and it has become something of a tradition in the general public to regard such activities as *dangerous* for the emotional and moral development of children and teenagers. More often than not, these claims are put forward without any rational or scientific basis, and we will thus not comment further on this issue here (Seel & Ifenthaler, in press).

Like it or not, the general proliferation of computer-based information and communication technologies is irreversible, and computers now play an important role in human learning in everyday life as well as at educational institutions.

Today, there is widespread agreement among educational theorists on the point that educational applications of modern information and communication technologies can be made more effective when they are embedded in *multimedia 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 (Ifenthaler, 2009; Seel, Ifenthaler, & Pirnay-Dummer, 2009). The key to success is seen not so much in how the information is presented as in how well the learners can manipulate the different *tools* available in the multimedia learning environment on their own. Extensive use of a computer as a *tool* for solving problems can help learners to concentrate on understanding and solving problems rather than the finished product or the acquisition of declarative knowledge and can awaken their curiosity and creativity. Several characteristics of the new technologies contribute to this effect:

- The new information and communication technologies are interactive systems.
- The learners themselves are placed in control of what and how they learn.

- The computer can model real situations and complex systems and simulate their behavior.
- The learners can receive immediate feedback on their activities.
- In many cases, the computer can also execute complex operations (e.g., simulations of dangerous situations) which cannot be executed as well or at all by other media (Seel & Dijkstra, 2004).

Indeed, when one considers that modern computers can represent all forms of information and knowledge needed for learning and problem solving, the current state of computer technology seems to make the tedious process of integrating traditional media (such as texts, graphics, and video) technically superfluous and obsolete. Moreover, recent developments in the area of interactive software provide unique possibilities for creating virtual learning environments and modeling complex systems without professional guidance. The options for independent development of interactive environments are manifold, and the graphical capabilities of new software programs include exciting animations and simulations of highly complex processes. Last but not least, everything is comparatively inexpensive and thus readily available to the broader public.

However, the advantages of *learning in the digital age* lie not only in the area of education, but also in administrative, financial, and social domains. The main educational advantages may be summed up as follows:

- The *independence of learning and teaching from the constraints of time and space*: Learners (e.g., college students) can follow a course from any point on the earth and at any point in time, and the courses can be offered worldwide.
- The *individuality of learning*: Courses can be adapted to the needs of each individual learner, and course materials can be reused and rearranged as often as one likes (provided that they are organized in modules).

Although these advantages are actually all beyond question, the discussion on the educational use of learning in the digital age often suffers from being limited to the technological potential of information and communication technologies (Ifenthaler, 2008; Seel & Ifenthaler, 2009). The technological possibilities for designing multimedia 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. For this reason, the discussions and presentations at the CELDA conference in October 2008 in Freiburg concentrated on the pedagogical aspects of learning in the digital age. The chapters of this volume thus contribute in a major way to this exceedingly important discussion.

## 1.3 A Step Forward: Personal Learning Management Systems

The term *Web 2.0* is used to refer to a new perception of and way of using the Internet (Kerres, 2006). The “old” *Web 1.0* distinguishes clearly between author and user. The authors are the people who create, add to, and maintain the websites. The users are generally only consumers. They can access the information but do not have the possibility to change it or add to it.

The Web 2.0 applications do away with this distinction. Users can assume the role of authors and create, evaluate, add to, and change their own content. Such applications, which enable users to cooperate and communicate, are also referred to as *social software*. This results in the following paradigm shifts, which are typical for Web 2.0 applications in the context of learning and instruction (Kerres, 2006).

*User versus author*: The dividing line between user and author is becoming increasingly indistinct. Not only is the Internet brought to life by authors, but also users generate content and make it available to other users. This is made possible by various user-friendly authoring systems and portals.

*Local versus distant*: Due to the ubiquitous access to the Internet (on various devices and in various places), it makes sense to save data directly on the Web and implement applications directly in the browser. This makes it easy to access all kinds of media from different devices which are synchronized with one another. By using gadgets, widgets, RSS feeds, and various other standard formats, the user can organize information effectively and subscribe to it.

*Private versus public*: The Internet makes it possible for people to present themselves to a large public and use various kinds of media to communicate their interests. This phenomenon is reflected in developments like the formation of Internet communities. What it means for learning is that not only the learning outcome can be made public, but also the learning process itself, e.g., through the publication of learning journals on a Weblog.

Web-based systems designed to optimize or supplement online learning are cropping up everywhere. The rapid pace of these technological developments makes it nearly impossible to integrate them into comprehensive systems (Ifenthaler, 2008).

Therefore, so-called personal learning systems (PLS) are being developed to enable users to select various Web applications individually to meet specific learning goals (Seel & Ifenthaler, 2009). The requirements and features of a PLS are as follows.

*Portal*: Rather than an isolated island, a PLS is an open portal to the Internet which is connected with various applications and collects and structures information from other sources. The content can be created by both learners and teachers using simple authoring tools.

*Potential for integration*: Information is offered in standard formats which learners can subscribe to and synchronize with their desktop applications. In this way, the learning environment is integrated into the user's daily working environment and connected to it.

*Neutrality of tools*: Tasks in the learning environment are designed in such a way that the learners themselves can choose which application they wish to use to work on them. The portal can make recommendations and provide support. The media competence acquired in this manner can also be useful in everyday life (see Attewell & Seel, 2003).

*Symbiosis*: Instead of creating new spaces, a PLS uses existing resources. The portal works with existing free social networks, wikis, blogs, etc.

All in all, personal learning systems require increased personal responsibility both from the learner and from the teacher. At the same time, however, they offer more freedom for individual learning.

## 1.4 Beyond the Digital Age

Much of what we discussed at the CELDA conference in October 2008 in Freiburg is already dated in a technological as well as a pedagogical sense and will in a few years be hardly more than a historical footnote like the Jasper Woodbury Series (Cognition and Technology Group at Vanderbilt, 1997) or the goal-based scenarios (Schank et al., 1994). We believe that the days of preprogrammed online courses are numbered, in which the learner – as in the classical paradigm of programmed instruction – is viewed more as an audience than as an active constructor. In the near future, learners will be the constructors of their own environments and create the structures of the content units on their own.

It is of course difficult to predict new developments or trends in the domain of online learning and instruction with any kind of precision, but for us one thing is certain: They will continue to be dictated to a great extent by the general development of information and communication technology.

Following the introduction of the term *Web 2.0* to describe the latest developments on the Internet, the term *Web 3.0* has now been coined to describe the coming wave of innovation. There are of course many opinions as to the course further development of the Internet will take – starting with concepts like *emergent technologies* or the *Semantic Web*, which will change the way we use the Internet and constitute a step in the direction of artificial intelligence, and ranging all the way to the prediction that due to the increasing amount of connections to the Internet, modular Web applications and improved computer graphics will play a key role in its further evolution.

In the past years, Web 2.0 has become the established term for the second generation of the Internet. In contrast to the first generation, Web 2.0 gives the user more options for participating in the creation and use of information. Whereas *Web 1.0* was primarily a publication medium, Web 2.0 may be understood as a *social revolution* in the use of Internet technologies (Lassila & Hendler, 2007).

One of the main strengths of Web 2.0 is the increased possibilities for *user-generated content*, and in this respect it is far superior to its predecessor Web 1.0. Further defining characteristics of Web 2.0 are information sharing and a decentralization of its management and use. Web 1.0 was primarily an information platform (*read only*), whereas Web 2.0 represents a shift toward a *read and write* environment, inasmuch as the users themselves can participate actively in the creation and management of content. Web 3.0 will go a step further and allow users to modify the information resources on their own. We believe that existing websites will serve as the building blocks for the development of Web 3.0 – but with one important difference: *Web 3.0 will be intelligent* (in the sense of artificial intelligence) and will understand or rather learn what the user wants and suggest the content he or she is seeking. Web 2.0 already offers many so-called APIs (application programming interfaces) which allow users to use and exchange available data and services. If developers are to succeed in making Web 3.0 so intelligent that it understands a user and always provides him or her with meaningful search results, they must first integrate and analyze all information resources and data from Web 2.0.

Web 3.0 will thus have a *service-oriented architecture* with distributed databases. The first step toward Web 3.0 will be the emergence of a *data network* consisting of a collection of structured data records published in the Web in repeatedly reusable formats (such as XML, RDF).

Web 3.0 will be characterized not only by a service-oriented architecture, but also by a *link to artificial intelligence*. Indeed, some experts claim that Web 3.0 could be the realization and extension of the concept of the Semantic Web (Lassila & Hendler, 2007). This involves the idea of providing software for logical reasoning and intelligent agents – an old dream of artificial intelligence: Such applications will be designed to execute operations of logical thinking using a multitude of rules which express logical relationships between terms and data in the Web. However, in view of the countless unfulfilled promises of artificial intelligence in the 1980s and 1990s, one would be well advised to remain skeptical at this point. Nevertheless, the integration of artificial intelligence into the Internet is a goal of the development of Web 3.0.

Should our vision actually, as has been prophesied, be realized within the next 10 years, it would bring about another Internet revolution and open up new horizons for multimedia educational applications. The first step in this process might be to enable users of the Web to modify websites and information resources and create their own structures. In this way, Web 3.0 could provide the basis for *free learning environments*, which have been regarded by educational theorists as the quintessential form of learning environment for decades. We will meet again at CELDA conferences in the near future and discuss latest developments of learning and instruction in the digital age.

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# Chapter 2
# Cognition and Student-Centered, Web-Based Learning: Issues and Implications for Research and Theory

**Michael J. Hannafin and Kathleen M. Hannafin**

**Abstract** During student-centered learning, the individual assumes responsibility for determining learning goals, monitoring progress toward meeting goals, adjusting or adapting approaches as warranted, and determining when individual goals have been adequately addressed. This can be particularly challenging in learning from the World Wide Web, where billions of resources address a variety of needs. The individual must identify which tools and resources are available and appropriate, how to assemble them, and how to manage the process to support unique learning goals. We analyze the applicability of current cognitive principles to learning from Web-based multimedia, review and critically analyze issues related to student-centered learning from Web-based multimedia, and describe implications for research and theory.

## 2.1 Introduction

The effectiveness of didactic methods has been demonstrated, but significant recent interest has been evident in user-centered, Web-based multimedia. This chapter focuses on student-centered learning in Web-based environments wherein the individual determines goals, selects or devises approaches to address the goals, and interprets and constructs meaning. We emphasize primarily research on learning from and/or with the Web, as well as related cognitive and multimedia research with implications for Web-based learning. We compare the cognitive demands of ill-structured and externally structured learning, review and analyze research and practice related to student-centered learning from Web-based multimedia, and describe implications for research, theory, and practice.

While many research-based learning and cognition principles are readily applicable to student-centered, Web-based learning, epistemological shifts and advances in

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technologies raise important and unanswered questions. Constructivists suggested basic shifts in both beliefs as to the locus of knowledge and educational practices (Jonassen, 1991). Technologies have extended, augmented, and/or supplanted individual cognitive processes, reflecting a shift from delivery to tools that support and enhance thinking (Iiyoshi, Hannafin, & Wang, 2005). Thus, the role of technology in student-centered approaches has become increasingly dominant in the efforts of Web-based learning theorists, researchers, and practitioners.

Hannafin, Land, and Oliver (1999) described student-centered activity during open learning where the locus of activity and control shifts from external to individual responsibility for establishing learning goals and/or determining learning means. As a result, the cognitive demands shift from selecting and processing externally organized stimuli to anticipating and seeking based on individual needs and goals. In many cases, the associated cognitive shifts have proven problematic when students lack requisite self-regulation skills (see, for example, Azevedo, Guthrie, & Seibert, 2004; Kauffman, 2004; Whipp & Chiarelli, 2004). Researchers have noted that students failed to develop theories or explanations and retained initial misconceptions (de Jong & Van Joolingen, 1998), to reflect or enact metacognitive processes (Atkins & Blissett, 1992; Azevedo, 2005; Hill & Hannafin, 1997; Wallace & Kupperman, 1997), and to develop coherent, evidence-based explanations (Nicaise & Crane, 1999). Land (2000) concluded that without effective support, "misperceptions, misinterpretations, or ineffective strategy use . . . can lead to significant misunderstandings that are difficult to detect or repair. When learners have little prior knowledge. . .metacognitive and prior knowledge are needed to ask good questions and to make sense out of the data and events being modeled" (pp. 75–76).

According to Hill and Hannafin (2001), "Predigital educational resources conveyed meaning consistent with and supportive of established goals and standards" (p. 38), but a digital resource's "meaning is influenced more by the diversity than the singularity of the perspectives taken" (p. 40). In effect, the potential for increased and largely unregulated granularity alters the cognitive demands associated with resource access and use. Accordingly, self-regulation, metacognitive, and navigation capabilities vary widely across a vast and ill-structured array of Web resources. Thus, student-centered, Web-based learning reflects fundamental shifts in cognitive requirements as well as the foundations and assumptions underlying design and use (Hannafin & Land, 1997). In this chapter, we briefly highlight key assumptions, discuss several issues that have emerged through efforts to design and validate, and identify implications for research and theory related to student-centered, Web-based learning.

## 2.2 Assumptions Underlying Student-Centered Learning

With the resurgence of constructivism, many researchers have shifted from objectivist models that emphasize external mediation and meaning to uniquely individual perspectives (Land & Hannafin, 1996). According to constructivists, meaning is derived from and interpreted through individual beliefs, experiences, and social contexts. Thus, individual meaning is constructed through personal interactions with the world rather than assimilations (Phillips, 1995). Building from extensive cognition and learning research and theory, the American Psychological Association published learner-centered psychological principles (APA Work Group of the Board of Educational Affairs, 1997) wherein they delineated criteria for effective student-centered learning design and implementation (Alexander & Murphy, 1998). Several assumptions differentiate constructivism from externally based perspectives. We focus on assumptions regarding the locus and nature of knowledge, role of context, and prior experiences.

### *2.2.1 Locus and Nature of Knowledge*

Constructivists assert that learners construct meaning uniquely based on personal interactions with society, individuals, and objects; constructivist-inspired learning environments often provide resources for learners to manage their own learning through exploration, hypothesis formation, and student-relevant feedback. Papert (1993), for example, employing student manipulation of a Logo Turtle, fostered deeper mathematics understanding than directed classroom activity. Among college-age students, Uribe, Klein, and Sullivan (2003) reported collaborative dyads outperformed individuals working alone and spent more time investigating ill-defined problems in an online course. Using online supports and group collaboration, learners explored ill-defined problems, considered and tested hypotheses each might have individually overlooked, and improved their understanding of problem-solving processes.

Although student-centered learning environments are purported to foster exploration and hypothesis formation, validation has proven problematic. McCombs and Whisler (1997) described learner-centered environments as places where learners engage in complex and relevant activities, collaborate with peers, and employ resources to collect, analyze, and represent information. However, Remillard's (2005) synthesis of research indicated that teachers' content knowledge, pedagogical content knowledge, beliefs, and their interpretation of the curriculum influenced and often dominated how presumed learner-centered activities were enacted. Researchers have documented similar instances where teachers undermined learner-centered activities by supplying rote algorithms for students (Doyle, 1988).

It has also proven difficult to establish conclusive relationships between technology and student learning (e.g., Roschelle, Pea, Hoadley, Gordin, & Means 2001). Some researchers have documented positive effects using technology to facilitate problem solving, conceptual development, and critical thinking (Ringstaff & Kelley, 2002; Sandholtz, Ringstaff, & Dwyer, 1997). Wenglinsky (1998) reported that where teachers used technology in conjunction with learner-centered pedagogies, students scored significantly higher on the mathematics portion of assessments of educational progress than students that did not: Eighth graders who used technology for mathematics drill and practice scored significantly lower than peers who used no technology.

Although some research suggests that Web-based approaches can promote deeper learning when intended strategies are followed, these strategies are often not utilized. In an effort to deepen understanding of mathematics through investigation, Orrill (2006) created an extensive Web site including open-ended investigations, a mathematics dictionary, discussion board, and electronic portfolios. Teachers explored available resources, selected problems, and identified their own instructional paths (combined with attendance in face-to-face workshops). Improvements in mathematics skills and depth of knowledge were expected, but teachers typically focused on technology skills and did not refine their understanding or skills.

### *2.2.2 Role of Context*

Student-centered learning environments often rely on authentic experiences or realistic vignettes to facilitate interaction and learning. In the Jasper Woodbury Series (CTGV, 1992), students watch a short video to provide context and orient learning before solving mathematics problems situated in realistic settings (e.g., determining how much gas is needed and what route to take to navigate a boat to desired locations). Thus, contexts may help students to identify learning goals, form and test hypotheses, and situate learning in authentic experiences (Land & Hannafin, 1997). Knowledge is constructed while individuals engage in activities, receive and provide feedback, and participate in multiple forms of interaction. When authentic, active engagement enables learners to gain access (i.e., enculturation or identify formation) to the ordinary practices of a culture from a real-world perspective (Brown, Collins, & Duguid, 1989).

In externally directed contexts, "an external agent (e.g., teacher, instructional designer) typically establishes the venue (real or virtual), meters the pace and sequence of resource use, facilitates the interactions and related learning activities, and establishes goals for the learner to achieve" (Hill & Hannafin, 2001, p. 43). While student-centered learning may occur, the basic environment is designed to ensure that goals considered to be important to others are addressed. In learner-generated contexts, typical of student-centered learning environments, the individual establishes his/her goals which influence where to seek resources and what resources are needed (as well as when those goals have been attained). Guidance (scaffolding) may be sought from humans or support technology, but assistance is provided when sought. Negotiated contexts, perhaps most typical of student-centered learning in formal settings, emphasize partnerships in the learning process. While context is established to support predefined goals, interpretation guides "the learner in establishing individual meaning, defining sub-problems, and selecting and implementing strategies. In determining which resources are best suited to the problem or need, the participants negotiate the relative value of the resources, generate additional questions to pursue, and consider alternative approaches" (p. 43).

### *2.2.3 Role of Prior Knowledge and Experience*

Prior knowledge and experience uniquely influence how individuals interact with and acquire meaning during student-centered learning (Schuh, 2003). They affect not only how constructed knowledge emerges, but the individual's goals, knowledge-seeking activity, cognitive repertoire, cognitive load associated with learning, metacognitive awareness, and cognitive monitoring (Land & Hannafin, 2000). Prior knowledge and experience provide the capacity to assess and evaluate information, to detect inconsistencies and contradictions between new and existing understanding, and to determine when learning goals have been achieved (Shapiro, 2008). Prior experiences shape beliefs about both learning generally and the value associated with given learning tasks and demands. Prior knowledge and experience shape the formative, often naïve and incomplete theories in action learners employ as they attempt to interpret, make sense, and understand.

## 2.3 Nagging Issues

### *2.3.1 Technical System Knowledge and Familiarity*

Research suggests that familiarity with Web-based tools may play a significant role in individual success or failure. Song and colleagues (2004) found that college students who preferred online learning reported greater previous knowledge of online tools and managed their time more efficiently than students preferring traditional instruction. Hill and Hannafin (1997) asked teachers to locate Internet content and grade-appropriate materials on a subject of their choosing and reported that those with previous experience with the Internet were more successful and reported greater confidence in the task – regardless of their prior teaching experiences. In both studies, prior tool expertise facilitated learning more than prior domain knowledge or experience. In some student-centered learning contexts, familiarity with available Web-based tools may better predict success than prior domain knowledge and experience.

### *2.3.2 Disorientation*

Becoming *lost in hyperspace*, initially described for hypertext navigation (e.g., Edwards & Hardman, 1999), has become increasingly problematic during Web-based, student-centered learning. Learners need to identify, select, and evaluate available resources based on their unique tasks and goals (cf. Hodges, 2005). Often, Web resources provide physical locations and narrative descriptors to convey their contents, but recently metadata have emerged to catalog and describe functionality. Different metadata mechanisms and standards (e.g., Dublin Core, SCORM) have emerged. While beneficial in cataloging Web-based materials based on designer-intended goals and objectives, current metadata methods may be insufficient to support student-generated goals. Cataloging systems often rely on content creators to generate metadata tags for online materials (Maule, 2001). Intelligent tutoring systems have used prior assessment results, individually selected learning goals (limited to those embedded within the system), and learning traits to personalize instruction (Papanikolaou, Grigoriadou, Magoulas, & Kornilakis, 2002). While potentially effective, truly adaptive tools are rarely available in Web-based learning environments (Azevedo, Cromley, & Seibert, 2004; Kauffman, 2004). Thus, current metadata technology may provide generic, cursory references and prove insufficient to support unique learner goals.

### *2.3.3 Canonical Versus Individual Meaning: Misconceptions*

Constructivists learning environments often emphasize personal investigation, hypothesis formation, and testing. Without explicit support, however, in such environments learners may be unable to detect inaccurate information or reject erroneous hypotheses even in the face of contradictory evidence (Kirschner, Sweller, & Clark, 2006). In Land and Zembal-Saul's (2003) student-centered labs and computer-based inquiries into the nature of light, participants obtained evidence during experiments, stored it in portfolios with their findings, and generated hypotheses to orient future inquiries. While some groups benefited from computer-assisted inquiry, others relied on faulty results from prior experiments and subsequently misdirected future inquiries and retained erroneous results even when later studies contradicted them. The authors suggested that student-centered inquiry functioned as anticipated only when students had sufficient background knowledge, self-evaluated their knowledge limitations, engaged in critical questioning and clarification, and challenges faulty explanations. The "situated learning paradox" suggests that prior knowledge, important for orienting and helping learners to make sense of phenomena, is often based on incomplete and inaccurate misconceptions. Without support, misinformation and disinformation may go undetected; fundamental misunderstandings may become reified rather than reconciled.

### *2.3.4 Knowledge as Accretion Versus Tool*

Whitehead (1929) distinguished between knowledge as a tool and inert knowledge. Tool-based knowledge, valued in student-centered learning, is presumed to facilitate goal acquisition and transfer: When students grasp the underlying reasoning behind the algorithms and their application to authentic problems, knowledge becomes a tool to facilitate problem solving in related contexts. Yet, researchers suggest that tools touted to support student-centered learning are often used inappropriately and foster inert knowledge (CTGV, 1992). Because learners select individual goals, resources, and activities, existing metadata may fail to support student-centered Web-based learning and the resulting knowledge may or may not prove transferable.

### *2.3.5 To Scaffold or to Direct*

Several frameworks have been proposed to account for similarities and differences between human and technology-enhanced scaffolds (see, for example, Dabbagh & Kitsantas, 2004, 2005; Jacobson, 2008; Masterman & Rogers, 2002; Puntambekar & Hubscher, 2005; Quintana et al., 2004; Shapiro, 2008). Traditional scaffolding supports the learning of externally defined concepts, but the shift to individually mediated learning has become increasingly process oriented. Saye and Brush (2007) distinguished between *hard* and *soft* scaffolds. Hard scaffolds are presumed to support common learning needs across students, freeing the instructor to provide adaptable, on-demand, and contextually sensitive support based on emergent, individual needs (cf. Azevedo, Cromley, & Seibert, 2004). Kim, Hannafin, and Bryan (2007) proposed a scaffolding framework to optimize the interplay between and among technology, teachers, and students in everyday student-centered, Web-based learning contexts. However, little progress has been made in scaffolding the individual's unique learning efforts in open, largely ill-structured learning environments.

### *2.3.6 Attitudes, Beliefs, and Practices*

In student-centered environments, the individual assumes responsibility for goal attainment and resource selection, thereby increasing the cognitive demands associated with learning. Similarly, engagement is influenced by individual prior beliefs, goals, and expectations, which affect how learners approach and interact with learning activities. According to Song, Hannafin, and Hill (2007), conflicts arise when learners encounter resources that are inconsistent or incompatible with their individual goals and beliefs – especially when they are unable to identify and reconcile the differences. Thus, while designers and instructors of Web-based multimedia may assume that extending the array of resources will enhance learning, the individual's familiarity, beliefs, motivations, and practices may influence the extent to which available resources complement or confound student-centered learning.

### 2.3.7 Cognitive Load

Many researchers have concluded that hyperlinked learning materials can significantly increase extraneous cognitive load (Brunken, Plass, & Leutner, 2003; Niederhauser, Reynolds, Salmen, & Skolmoski, 2000). Eveland and Dunwoody (2001), for example, compared the performance of students assigned to browse a Web site with different hyperlinking and navigation structures with a paper-only format. The paper-based control group outperformed two of the online groups, indicating that hyperlinking may increase extraneous cognitive load. Given the unusual demands associated with student-centered, Web-based learning, the ability to meter or manage cognitive load may prove essential for online students (Bell & Akroyd, 2006; Hill, Domizi, Kim, Kim, & Hannafin, 2007; Hill, Hannafin, & Domizi, 2005; van Merriënboer & Ayres, 2005). Nonlinear Web sites may increase germane cognitive load for particular types of learning, while simultaneously increase extraneous load for text-based learning (Eveland & Dunwoody, 2001). Eveland, Cortese, Park, and Dunwoody (2004) concluded that students learned facts best from linear Web sites, but understood relationships better from nonlinear Web sites.

### 2.3.8 Metacognitive Demands

Students who have, or develop, metacognitive strategies tend to perform more successfully than those who do not (Shapiro, 2008). Smidt and Heigelheimer (2004) interviewed high-, middle-, or low-performing adult learners regarding their Web learning strategies; only advanced learners used strategies (as well as cognitive ones). Intermediate and lower-level students relied on cognitive strategies only, suggesting that advanced metacognitive abilities may be associated with effective online learning. Land and Greene (2000) suggested that metacognitive knowledge can compensate for limited subject understanding, noting that a few participants demonstrated metacognitive knowledge based on their domain knowledge, but those with low domain knowledge did not.

## 2.4 Implications for Research, Theory, and Design

### 2.4.1 Can Student-Centered, Web-Based Learning Be Scaffolded?

While research has yielded useful guidelines for supporting externally specified learning, research on scaffolding student-centered learning has only begun to emerge. Since individual prior knowledge, goals, and intents are not known in advance, and they can vary dramatically across learners using the same Web-based multimedia, scaffolding often focuses on cognitive processes. Research is needed to examine where and when to provide process scaffolding, the types of scaffolding needed, and the extent to which individual goals and intents are addressed effectively.

### *2.4.2 Will Students Critically Assess the Legitimacy, Veracity, and Accuracy of Resources?*

Web resources are largely unregulated, with quality varying widely in terms of accuracy, authority, and completeness. Web resources have been criticized not only for containing naïve and ill-informed information, but also for propagating deliberate misinformation, disinformation, and propaganda. Since students must assess veracity and relevance while attempting to address their individual learning needs and monitoring their understanding, research is needed to examine how students' evaluate and adapt based on perceptions of a resource's integrity.

### *2.4.3 Will Scaffolding Help Students to Manage Cognitive Complexity?*

Existing research suggests that soft scaffolding technologies have the potential to address the varied needs of individual student-centered learners. Unlike domain supports, soft scaffolding provided by teachers, peers, and other human resources is thought to accommodate real-time, dynamic changes in learner needs and cognitive demands. Given that research on learning strategies has provided little evidence of transfer, this claim needs to be validated.

### *2.4.4 Will Students Negotiate Their Individual Learning Needs?*

Web-based resources have been developed for a broad array of needs and purposes. Some intact resources may address student-centered learning needs effectively, but many will not. Understanding is often derived by examining individual resources that provide partial, potentially contradictory information. Their meaning must be interpreted and derived. Research is needed to examine how negotiation occurs, meaning is assembled differentially based on unique needs and goals, and the extent to which individual needs are addressed.

### *2.4.5 Will Students Identify Appropriate and Relevant Resources?*

Despite increases in availability and improved accessibility, metadata standards offer only limited pedagogical utility for student-centered, Web-based learning. The fundamental student-centered learning task – identifying candidate resources appropriate to an individual's need – is complicated by the raw number of false hits generated by typical search engines. Research is needed to develop and refine alternative metadata standards that support student-centered learning and to refine and customize search engine technology capable of identifying user-relevant resources.

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# Chapter 3
# Testing as Feedback to Inform Teaching

## Using Response Spectrum Evaluation (RSE) on All Answers

**J.C. Powell**

**Abstract** Beginning with a procedure that bypasses the linear-dependency problem with alternative-answer scoring, this chapter proposes a way to use large-scale testing for both summative (administrative) and formative (diagnostic) purposes. It builds a model for the dynamics of learning using an adaptation of the multinomial procedure to obtain estimates of the proportion of variability explained. This alternative to current test scoring is based on cross-tabulating all answers. It trebles the information available from large-scale testing. Interview-based interpretations and actual student responses are used to provide examples of learning patterns derived from response evaluation interpretation. Illustrations of how RSE scoring can inform teaching are presented.

## 3.1 Introduction

Wainer and Thissen (1994) suggested that there are three purposes for large-scale testing: first as a contest, second as a measurement tool for schools and of school systems, and third as an instrument of social change.

Large-scale testing has become a fact of life in many publicly supported school settings. When tests are scored right–wrong, they serve the first two purposes reasonably well and the third purpose poorly because of the relationship between group size and measurement error. When scored differently, these tests can also serve the third and a fourth purpose, as feedback to inform teaching. Thus, testing can be seen as a

1. Contest where tests identify superior performance in specific competencies for admission to colleges, certification in and admission into the professional training or other competitions.

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2. Measurement tool where tests are used to compare educational program effectiveness among jurisdictions, ranging from schools within specific districts to international comparisons.
3. Device to induce social change where tests need to provide more detailed information about individual student performance than is available from right–wrong scoring.
4. Source of feedback where tests need to provide teachers with in-depth information with which to alter, confirm, or expand their intervention strategies.

Response spectrum evaluation (RSE) recovers the information lost when scoring tests right–wrong by capturing the students' performance status from all their answers.

Part of the problem is that right answers can be achieved using several different means. Knowing that such answers are correct does not explain how such answers were produced. Deriving diagnostic information from such tests, when scored right–wrong, limits their formative value (DiBello & Stroud, 2007) because they lack answer homogeneity.

### *3.1.1 Summative Versus Formative Testing*

There has been a long-standing issue in testing circles between attempts to provide assessment-purpose answers to the "How much is known (summative)?" which is essentially an administrative issue and "What specifically is known (formative)?" which is essentially a teaching support issue. However, if precise achievement information and performance change can be made available, then test scores may be able to serve both purposes.

The summative argument is as follows:

If the test is a good representative sample of what students should know their scores should be proportional to their knowledge, both testing as a contest and testing as summative measurements apply.

The formative argument is as follows:

A single number (or scaled score) does not provide much information about a student's specific capabilities. Subtest score reporting (Sinharay, Haberman, & Puhan, 2007) and concept inventories (Halloun & Hestenes, 1985; Beichner, 1994) have been used to overcome this problem.

Subtests are shorter than the full test, increasing measurement error. Concept inventories, often confined to subject areas of high construct agreement, augment their analysis with interviews. Interviews were also used to the establish selection strategies for wrong answers in the studies reported here but are prohibitively expensive for large-scale testing.

The social change position:

This approach requires agreement that such change is needed and deciding toward which issue(s) such efforts should be directed. The no child left behind (NCLB) initiative implies both a need and a direction. However, this approach presents two problems.

First, the concept of being left behind implies that everyone should be learning the same material at the same pace, ignoring human diversity.

Second, right–wrong scoring does not provide enough information about individual students to empower teachers to make good judgments toward these objectives.

The fourth position (testing to inform teaching) taken here is as follows:

Large-scale testing can be used for feedback to inform and support the educational processes in classrooms provided that they are scored differently from current common practice.

### 3.1.2 Substituting Memorization for Understanding

Computers can memorize; only living things can understand. This thought was explored by Powell and Miki (1985). A pre–post testing of a unit in ninth grade mathematics was studied using a combination of right–wrong scoring and interviews for understanding.

The 2-by-2 discrepancy table for both the pre- and post tests is given in Table 3.1.

Although scores increased substantially from pre- to post-testing in both dimensions, understanding the concept and giving right answers remained statistically unrelated to each other. At least in this case, total scores are not very helpful for either the summative or the formative approach.

**Table 3.1** Memorization versus understanding

| | Answer conformity | | |
|---|---|---|---|
| Reasoning conformity | Right | Wrong | Total |
| *Pre-test* | | | |
| Understood | 20 | 20 | 40 |
| Misunderstood | 32 | 36 | 68 |
| Total | 52 | 56 | 108 |
| Ø = 0.03, Not significant | | | |
| *Post-test* | | | |
| Understood | 56 | 20 | 76 |
| Misunderstood | 13 | 7 | 20 |
| Total | 69 | 27 | 96 |
| Ø = 0.08, Not significant | | | |

### 3.1.3 The Test Interpretation Problem

The interpretation problem, from a diagnostic or feedback standpoint, is that the right answers can be achieved using diverse approaches, differing styles (verbal, visual, mathematical, etc., Gardner, 1983), differing maturity levels (from finger counting to matrix algebra), and levels of understanding (ranging from rote memorization to profound appreciation). Additionally, each item deliberately measures a different skill or knowledge. That is, right answers do not form a homogeneous category of events.

The statistical problem arises from the linear dependency introduced by including all answers into the analysis, leading to the assumption that learning can be represented as random because of the shape of the output distribution. Randomness often has two components, continuous and discrete. If the discrete component is meaningful, the random assumption is false.

### *3.1.4 Meaning from Alternative Answers*

Here is an illustration from a four-alternative multiple-choice reading-comprehension test (Gorham's Proverbs Test, 1956) that will be used throughout this chapter to illustrate. The answer interpretations were drawn from interviews. In both studies, answer selections were shown to be based upon the ways the respondents interpreted the questions. This test was given only once (Powell, 1968, 1977) in the first two studies.

Item 18 will be used for illustrative purposes as it represents all developmental levels found. The children's age modes of the wrong-answer clusters from this test (Powell, 1977) were determined from the data and their selection reasoning using interviews.

This test has 40 abstract right answers, 20 concrete right answers, leaving 100 wrong alternatives. Powell (1977) found that 91 alternative answers clustered into 12 subsets of at least four members. At least half but less than two-thirds of each cluster had a common selection strategy. The age modes of these wrong-answer categories showed a very strong sequential relationship to the ages of the students ($r = 1.00$). This sequence paralleled the one reported by Piaget (see Flavell, 1973). Figure 3.1 depicts item 18 of the Proverbs Test.

QUICKLY COME, QUICKLY GO (Easy come, Easy go):

A) Always coming and going and never satisfied (modal ages 14 and 18).

B*) What you get easily does not mean much to you (modal age 16).

C) Always do things on time (modal age 8).

D) Most people do as they please and go as they please (modal age 10).

* = designated right answer.

**Fig. 3.1** Selection age level of multiple-choice test answers

These interview interpretations (Powell, 1977) are given in response-clusters age order.

Alternative C (Always do things on time) was chosen most frequently by 8-year-olds. Their reasoning, "That's what the teacher always says," shows that they had interpreted "Quickly come..." as it represented their personal physical activities in their third grade classroom. They had many changes of activity in a school day, all of which required that they finish on time. In Piaget's terms, they are egocentric in their thinking (see Flavell, 1973), attending primarily to their personal activities and needs. They were attending to "Quickly..." in the stem.

Alternative D (Most people do as they please and go as they please) was chosen most frequently by 10-year-olds, with their reasoning reports suggesting they were looking for the best literal interpretation of the proverb. This change in reasoning shows them as being no longer egocentric but are thinking concretely. Piaget's proposal suggests that they now recognize an independently existing reality for which they must discover the rules by which to live, requiring them think concretely (Piaget, 1926). This interpretation focuses upon the "Come and Go" part of the stem.

Next in age sequence was alternative A (Always coming and going and never satisfied), most commonly chosen by 14-year-olds. They have moved away from literal and concrete thinking in their reasoning into more figurative interpretations, yet another expansion of their cognition. They were now interpreting this proverb as "A rolling stone gathers no moss," paying more attention to "Quickly..." than to "Easy..."

The right answer B* was chosen most commonly by 16-year-olds. Either they have reached formal operations or answered from memory because of personal familiarity with this proverb. The fact that this answer is correct does not reveal which interpretation applies. Interviews were not conducted for right answers in the (Powell, 1977) study.

Finally, about 5% of the older children chose A and rejected B* because of they felt that the pejorative use of this proverb was better expressed with the "never satisfied" phrase in A. These students have gone beyond the expected interpretation by adding a correct sociological dimension. They were interpreting the concept through contingent thinking and giving it a valid alternative interpretation.

Thus, this discontinuous portion of these data (their wrong answers) contained considerable performance information about their answer selection processes. These strategies are developmentally appropriate uses of legitimate thinking procedures. Each stage abandons the thinking of the previous one while adding a meaningful new component to their thinking. These strategy changes produce a discontinuous process that appears random when mathematically collapsed into linearity. RSE scoring extracts the discrete component from apparently random observations and shows them to be meaningful. How is this extraction achieved?

## 3.2 An Alternative Approach to Test Scoring

Transitions between wrong-answer clusters cannot be determined from a single administration of a test. As a result, this same test was given twice to a new sample of students (grades three through the end of high school, $N = 3000+$) for study 3.

### *3.2.1 Solving the Linear Dependency Issue*

Crosstabulating all answers (Powell & Shklov, 1992) provides frequency matrices for every answer with every answer in each item, containing the joint selection for each pre–post response pair. With 5 months (October–March) between administrations, the data set was partitioned accordingly (>96 months through <220 months), giving 27 4-by-4 tables for all 40 items.

Missing data added no information about the dynamics of answering, leaving 2810 students. For each table there are four pieces of information to consider invariant:

1. Each cell's observed frequency – the number of times the members of the sample chose both members of the pair of responses (the observed frequency; $Oij$, when $i = j$, identical choices were made both times).
2. The column total – the number of times this group chose the first member $m$ of the pair on the first administration (the column total, $Ci = \sum Oij$, where $i$ ranges from 1 to 4, with $j$ constant).
3. The row total – the number of times this group of students chose the second member of this pair $n$ on the second administration (the row total, $Rj = \sum Oij$, where $j$ ranges from 1 to 4 with $i$ constant).
4. The table sum or group size – the total number of observations in the entire frequency table (table total $N$).

Looking similar to typical contingency or $\chi^2$ tables, the concern here is with the independent contribution of each cell to the table. Table 3.2 displays the age group 166 months through 170 months (median age 168 months; about 14 years old in October) from Table 3.6.

**Table 3.2** Cross-tabulated answers for item 18

| Frequency of answers | | | | | |
|---|---|---|---|---|---|
| | Pre-test | | | | |
| Post-test | A | **B***  | C | D | Totals |
| A | 11 | 5 | 3 | 9 | 28 |
| **B*** | 8 | **33** | **2** | 5 | **48** |
| C | 3 | 2 | 0 | 2 | 7 |
| D | 7 | 6 | 3 | 11 | 27 |
| Totals | 29 | **46** | 8 | 27 | 110 |

An example of the procedure using multiple-choice test data.

The box in the table indicates that 30% of these students gave the right answer on both administrations. Next we collapse the table around a chosen cell. For illustration purposes, the joint choice of the right answers is used as shown in Table 3.3.

**Table 3.3** Analysis step 1

| Post-test | $Column_2$ | $Columns_{1+3+4}$ | Totals |
|---|---|---|---|
| $Row_2$ | **33** | 15 | 48 |
| $Rows_{1+3+4}$ | 13 | 49 | 62 |
| Totals | 46 | 64 | 110 |

The results of collapsing Table 3.1 around Cell $O_{22}$.

Using our (Powell & Shklov, 1992) adaptation of the multinomial procedure, we determine the cumulative probability of the observed frequency or less for this cell and the maximum cumulative probability that this cell contributes to the entire table. This second calculation is not the expected value, which is 20.07.

The quotient of two cumulative probabilities is the proportion of contribution (þ) of this cell to its maximum potential. In this case, the quotient is 1.000. The observed frequency of 33 (the joint frequency of the right answer selection) accounts for almost all of the possible variability that particular cell can provide.

This procedure showed similar stability for repeated choices for all the wrong answers as well. With the off-diagonal elements, the results were counterintuitive. If two of the main diagonals were high, their rectangular associate would show a near-zero contribution, even when it was numerically large. Apparently, this is the way the linear dependency between these cells emerges. We conducted a second-order analysis on the off-diagonals, replacing the main diagonal with zeros beforehand.

## *3.2.2 Interpreting the Patterns*

Using a proportion of þ $\geq$ 0.945 as our definition for "meaningful," we calculated the þ value for every cell in each of the 27 matrices for all 40 items. Our results for the age level 168 months in item 18 are given in the Table 3.4.[1] The frequencies in bold face fit our meaningful criterion. These first- and second-order processes were applied to every cell in Table 3.2 to produce Table 3.4.

Referring to the wording of the question, from an RSE approach, we see immediately the meaningful change from D to A (9) and from A to B* (8) following the sequence of cognitive increase already reported. The change from D to A is slightly behind this group's modal age of 14, and the change from A to B* is slightly ahead. The stability of choosing A both times is age appropriate.

The decline in cognitive functioning shown by the change from B* to D follows the deteriorating pathway we identified as typical of those students who left school early (see Fig. 3.3). Similarly, the stable selection of D is consistent with the observation that around 10% of the students graduated from high school are still thinking concretely (like 10-year-olds).

[1]A program for this analysis is available from Better Schooling and Information Systems (P.O. Box 12833, Pittsburgh, PA 15241). A book, *Making Peasants into Kings*. (Powell, 2009), which describes this discovery anecdotally with classroom application illustrations is also available from this source.

**Table 3.4** RSE ratings of all cells from Table 3.2 data

| Frequency of answers | | | | | |
|---|---|---|---|---|---|
| | Pre-test | | | | |
| Post-test | A | **B***| C | D | Totals |
| A | **11** | 5 | 3 | **9** | 28 |
| **þ** | **0.977** | 0.846 | 0.805 | **0.988** | |
| **B*** | **8** | **33** | 2 | 5 | 48 |
| **þ** | **0.989** | **1.000** | 0.624 | 0.778 | |
| C | 3 | 2 | 0 | 2 | 7 |
| **þ** | 0.851 | 0.796 | 0.510 | 0.674 | |
| D | 7 | **6** | 3 | **11** | 27 |
| **þ** | 0.922 | **0.968** | 0.839 | 0.993 | |
| Totals | 29 | 46 | 8 | 27 | 110 |

The change from A to D, which is close to our criterion, may be an age-appropriate level of uncertainty about how to answer this question or it may be a signal of beginning deterioration in performance. Flagging these nine students could alert their teachers to pay closer attention to them.

Those who changed from B* to A provide a different challenge. How many of these five students are showing deterioration in cognitive functioning and how many are advancing to more open-ended cognition (to A+)? We will illustrate a way to answer this question later.

In this section, we considered the implications of such analyses for group determination. We will address the diagnosis of individual students later.

## 3.3 Implications for Testing Theory

Except for the uncertainty of B* to A changes, all students above the main diagonal, for this item, are functioning at or above the expectations established by the selection modes for each alternative. Those who moved from C to D are showing progress, while being 2 years behind their age peers. Those below the diagonal except for the A to B* changes (23 out of 110 or about 20% of the entire group) could be of performance concern. If we include the 11 who stayed on D, this group of concern makes up 34 out of 110 or about one-third of the entire group.

Considering the cognitive implications of these selections (C being egocentric, D being concrete, A being transitional, B* being right, and A+ advanced), we can provide a performance maturity sequence for these students of (C [8] → D [10] → A [14] → B* [16] → A+ [18]).

The complete array of strategies, as far as our research has gone, is given in Table 3.5.

With the more complete information from the RSE interpretation of the entire test, more detailed interventions can be planned. In addition, the effectiveness of

**Table 3.5** Students' developmental sequences from ALL answers

| General cognitive functioning | Developmental stage: Egocentric strategies | Concrete strategies | Figurative strategies | Elaborative strategies |
|---|---|---|---|---|
| Fragmentation | *Isolated responses* | *Word associations* | *Oversimplification* | (Digression) |
| Reduction | *Partial translation* | *Literal reductions* | *Simplification* | (?) |
| Rearrangement | *Redefined terms* | ? | *Transpositions* | (Inversions) |
| Extension | (Continuation) | (Extrapolation) | *Over-generalization* | (Category confusion) |
| Transition | **Concrete answers** | *Irrelevant answers* | | (Frame shifts) |
| Balancing | *Personalization* | *Literal interpretation* | **Abstract answers** | Contingent thinking |
| Deterioration | Memorization | Confusion | (Self-deprecation) | (Acquiescence) or rebellion |
| Age level | **7 8** | **9 10 11 12** | **13 14 15 16** | **17 18 19+** |

Notes:
1. The 12 "wrong-answer" categories drawn from Powell (1977) are *italicized*.
2. The categories added from Powell and Shklov (1992) are underlined.
3. Those inferred from child development literature are in (parentheses).
4. The definitions and examples from Powell (1977) could help designing alternatives.

these interventions can be determined by subsequent administrations of this same test, using this same pattern-scoring approach and interpreting the change patterns.

Including the concrete right answers, there are five subscores at the modal age of 8 years, two at 9, and one for each of the other age levels. The age levels for Elaborative strategies have not been determined. Further research is needed to establish the identifiers for those who have progressed beyond the age of 16 and formal operations

If we teach thinking skills, using content as the vehicle, this list could be used to design our curriculum. It could also be an intervention-selection guide while considering when and how to use each thinking–learning strategy effectively. For test developers, this list could aid in designing alternatives. Pattern scoring diminishes the security risk involved in using this same test more than once.

### *3.3.1 Heads or Tails: The Dichotomy Dilemma?*

What about information loss when tests are scored right–wrong?

This illustration in Fig. 3.2 exemplifies the principle behind "right–wrong" scoring. In this coin toss of the 20 items, there are seven right answers (heads). These are put into this student's Piggy Bank as his or her earnings on the test and the rest disappear in cyberspace.

**Fig. 3.2** A 20-item test as a coin toss

Because the normal distribution is the upper limit of the binomial expansion, such as $(a + b)^n$ (where $n \rightarrow \infty$), the mathematics requires a true dichotomy to be applied. However, if either of the values in the dichotomy is not singularly interpretable, or if either of them is discontinuous, then the apparent randomness becomes spurious.

Random numbers may actually be a composite of a continuous and a discrete distribution. Since our results have shown the right answers are not homogeneously interpretable and we have successfully extracted discontinuous data from the wrong answers, the right–wrong scoring principle must be mathematically invalid for formative application.

### *3.3.2 A Dicey Alternative*

Figure 3.3 shows an alternative way of conceiving the scoring of multiple-choice items as a roll of dice.

The array of dice is a better way to envision four-option multiple-choice tests. The $R_u$ dice (right answers from understanding) are arranged on the top left. The $R_m$ dice (right answer from memorization) are arranged on the bottom right, presuming that giving an answer from memory requires less mental effort than any thoughtful attempt to solve a problem.

This array also has six right answers. All 20 items are numbered to remain identifiable. The wrong answers ($W_1$, $W_2$, and $W_3$) are arranged downward and to the right in descending order of maturity. At the extreme top left is $W_3$+, which represents answers that go beyond the intention of the question. More profoundly informed students can lower their scores by reading too much into the questions.

These six categories of behavior make the dice-roll model for each item more reasonable than the coin toss model. If there are scale position differences among

**Fig. 3.3** A 20-item test as a dice roll

the alternative answers between $R_u$ and $R_m$ answers in these items, we may have more than six levels of performance to observe. In fact, our analysis of the 40-item Proverbs Test has given us 17 categories at six levels.

### *3.3.3 Exposing the Dynamics of Learning*

The next step was to show that the transitions fall between the stable (repeated) answer selections. Thus, as in Table 3.4, the findings with the single administrations cross-validated. This change pattern was supported for nearly every transition in all 40 items (Powell & Shklov, 1992).

Figure 3.4 shows this pattern of change for item 18. It also shows a second (deterioration) pathway already inferred by the declines witnessed in Table 3.4.

This step in the data mining has revealed that this approach to scoring successfully separates the discontinuous (discrete) portion of the random answer variables in this test from the continuous (answer changing) part. Figure 3.4 shows the two distinct complete developmental patterns exposed by the RSE approach. Age gives the data for Tables 3.2, 3.3 and 3.4 above.

The increase in performance is shown from bottom to top and left to right in the left panel in gray boxes and arrows. The deteriorating performance pathway, shown in black on the right, goes from B* at the lower age levels and progresses upward to the left in the reverse order from the growth pathway. Two-thirds of the students who withdrew from school between the October and March administrations chose either C or D as their answer in October, more like 8- or 10-year-olds than 16+ year-olds.

| Age in Months | C to C | C to D | D to D | D to A | A to A | A to B* | B* to B* | B* to A | A to A | C to C | D to C | D to D | A to D | A to A | B* to A | B* to B* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| >220 | 1 | 0 | 5 | 3 | 3 | 5 | 35 | 5 | 3 | 1 | 0 | 5 | 1 | 3 | 5 | 35 |
| 218 | 1 | 0 | 5 | 3 | 3 | 4 | 16 | 4 | 3 | 1 | 1 | 5 | 6 | 3 | 4 | 16 |
| 213 | 1 | 0 | 7 | 1 | 9 | 5 | 38 | 6 | 9 | 1 | 2 | 7 | 2 | 9 | 6 | 38 |
| 208 | 0 | 1 | 7 | 3 | 3 | 8 | 38 | 7 | 3 | 0 | 1 | 7 | 1 | 3 | 7 | 38 |
| 203 | 0 | 1 | 13 | 7 | 9 | 11 | 38 | 12 | 9 | 0 | 3 | 13 | 4 | 9 | 12 | 38 |
| 198 | 1 | 3 | 14 | 6 | 7 | 18 | 48 | 9 | 7 | 1 | 2 | 14 | 10 | 7 | 9 | 48 |
| 193 | 0 | 4 | 17 | 8 | 15 | 14 | 56 | 10 | 15 | 0 | 1 | 17 | 7 | 15 | 10 | 56 |
| 188 | 2 | 1 | 18 | 5 | 16 | 14 | 63 | 15 | 16 | 2 | 6 | 18 | 6 | 16 | 15 | 63 |
| 183 | 1 | 2 | 18 | 10 | 9 | 20 | 70 | 15 | 9 | 1 | 3 | 18 | 10 | 9 | 15 | 70 |
| 178 | 3 | 3 | 22 | 12 | 15 | 17 | 54 | 5 | 15 | 3 | 3 | 22 | 14 | 15 | 5 | 54 |
| 173 | 3 | 2 | 22 | 13 | 16 | 17 | 60 | 6 | 16 | 3 | 5 | 22 | 7 | 16 | 6 | 60 |
| 168 | 0 | 3 | 11 | 9 | 11 | 8 | 33 | 5 | 11 | 0 | 2 | 11 | 7 | 11 | 5 | 33 |
| 163 | 1 | 1 | 11 | 6 | 10 | 5 | 16 | 4 | 10 | 1 | 4 | 11 | 4 | 10 | 4 | 16 |
| 158 | 5 | 2 | 5 | 10 | 10 | 8 | 20 | 9 | 10 | 5 | 4 | 5 | 5 | 10 | 9 | 20 |
| 153 | 0 | 3 | 14 | 4 | 11 | 3 | 14 | 5 | 11 | 0 | 3 | 14 | 11 | 11 | 5 | 14 |
| 148 | 2 | 3 | 9 | 7 | 10 | 8 | 16 | 5 | 10 | 2 | 4 | 9 | 5 | 10 | 5 | 16 |
| 143 | 3 | 3 | 12 | 16 | 16 | 10 | 15 | 8 | 16 | 3 | 5 | 12 | 8 | 16 | 8 | 15 |
| 138 | 4 | 3 | 7 | 13 | 9 | 5 | 13 | 4 | 9 | 4 | 3 | 7 | 16 | 9 | 4 | 13 |
| 133 | 3 | 5 | 21 | 9 | 15 | 5 | 13 | 5 | 15 | 3 | 4 | 21 | 12 | 15 | 5 | 13 |
| 128 | 2 | 4 | 11 | 10 | 16 | 6 | 4 | 7 | 16 | 2 | 5 | 11 | 10 | 16 | 7 | 4 |
| 123 | 6 | 8 | 17 | 10 | 11 | 3 | 4 | 5 | 11 | 6 | 6 | 17 | 13 | 11 | 5 | 4 |
| 118 | 8 | 3 | 10 | 7 | 5 | 2 | 4 | 5 | 5 | 8 | 8 | 10 | 18 | 5 | 5 | 4 |
| 113 | 4 | 7 | 10 | 3 | 11 | 1 | 0 | 2 | 11 | 4 | 5 | 10 | 5 | 11 | 2 | 0 |
| 108 | 5 | 6 | 19 | 5 | 15 | 6 | 5 | 4 | 15 | 5 | 5 | 19 | 9 | 15 | 4 | 5 |
| 103 | 5 | 3 | 7 | 5 | 2 | 1 | 0 | 1 | 2 | 5 | 4 | 7 | 0 | 2 | 1 | 0 |
| 98 | 2 | 2 | 11 | 1 | 0 | 1 | 0 | 2 | 0 | 2 | 2 | 11 | 1 | 0 | 2 | 0 |
| < 96 | 3 | 3 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 3 | 5 | 3 | 2 | 1 | 0 | 0 |

Egocentric Literal Transitional Figurative Elaborative Egocentric Literal Transitional Figurative

**Notes: 1. High proportion numbers are in 12pt. Bold**

2. Close to high proportion numbers are in 10pt.

**3. # → # Advancing Developmental Pathway**

**4. # ← # Declining Developmental Pathway**

**5. School Leaving Age** -------- (192 Months – 16 years)

**Fig. 3.4** Two developmental patterns in one item

Finally, at the top-center there is a group of students who moved systematically from B*, the right answer to answer A, as in the 1968 study (see Fig. 3.1).

It is obvious that the transitions between stages, representing discrete shifts in thinking, occur between the age levels where the same developmentally appropriate answer is selected both times. As indicated in Table 3.6 (Appendix), the repeated choice of the right answer is sequential, accounting for a high proportion (98%) of the variability explainable by this sequence of cells.

However, for item 18, this sequence accounts for only 23.95% of the explained variability of the entire table. In contrast total variability explained by all answer pairs is 75.41% (using the þ $\leq$ 0.945 criterion), which is about three times the amount explained by the repeated right answers alone. Since each die has six sides and the coin only two, this increase is exactly what would be expected for a nonrandom distribution with two possibilities for giving a right answers.

For all 40 items the right–right association accounted for 30% while the sum for all answer pairs remained at 76%. A less stringent criterion will explain even more variability. These figures are based entirely upon within-item variability. The way to establish the between-item contribution has yet to be determined.

### *3.3.4 Associating Independent Tests*

This procedure can also be used to associate two different tests or any other variables that are discrete event frequencies that would be appropriate to consider. We turn to this application because this group was not interviewed and it was necessary to establish two categories of right answer to satisfy the model.

Since the RSE technique crosstabulates answer by answer, there are no constraints upon which data is cross-tabulated except that each set of events must be discrete, countable, and appropriate to the investigation. When working with a data set in excess of 1000 subjects, interviews are impractical. Alternative ways to get two categories of right answer were required.

Powell, Cottrell, and Lever (1977) developed a survey instrument to provide some interesting insights into people's worldviews. Scale 5 of this instrument captures something similar to Maslow's (1968) hierarchy of needs. This scale can be translated into Piaget's terms to fit the levels of classifications used here:

| | |
|---|---|
| ❖ Constrictive thinking | |
| ❖ **Piaget** | **Maslow** |
| • Egocentric → 8 year olds | Self-protective |
| • Concrete → 9 & 10 year olds (Literal) | Self-indulgent |
| ❖ Expansive thinking | |
| • Transitional → 11 thru 15 years olds (Figurative) | Self-growth |
| • Formal → 16 Year olds (Figurative) | Others Focused |
| ❖ Elaborative thinking [Not posited by piaget] | |
| • N-value logic → 18 + (About 1 in 20) | Self-actualized |

Maslow's basic needs parallel our definition of constrictive thinking, which requires paying close attention to the personal and immediate life issues, growth orientation at the second level and outside-the-box thinking at the third.

We gave this second instrument concurrently with the *Proverbs Test* to all our subjects from the fifth grade onward.[2] The results of this comparison are given in Fig. 3.5.

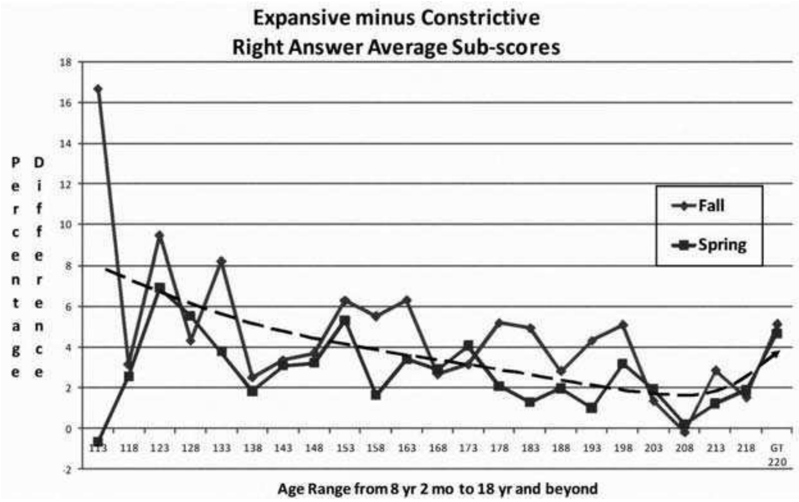


**Fig. 3.5** The impact of high-stakes schooling

We converted the averages into percentages by using the formula $(\sum C/23n - \sum E/17n)^{*}100$ (where $n =$ the number of students in the age-based subgroup) for every subgroup.

Notice that not only did constrictive thinking increase systematically and significantly from the third grade through to nearly the end of high school, but also, for the most part, the students were consistently more constrictive in their thinking in March than they were the previous October! Also observe the dramatic (20%) drop in expansive thinking among the 9 year olds. This is the fourth grade slump. The expansive thinking increased somewhat after school leaving age of 16 (203 months).

This school system has a long history of being a high-stakes operation.

Replacing $R_m$ and $R_u$ with $R_c$ and $R_e$, dice-roll model now has six observable facets: $R_c$, $R_e$, $W_1$, $W_2$, $W_3$, and $W_3$+ for each item derived empirically from these data set. The earlier study that provided the reasoning behind these answer selections now has 17 categories of performance complexity among answer clusters that form a strong age-based progression, (including a shift away from the right answers by the most profound thinkers.)

[2] Children younger than 10 years of age found this survey too difficult to answer.

These findings have been cross-validated in three studies:

1. With adults (Powell, 1968), where the reasoning predicted the answers;
2. With younger children (Powell, 1977), where a strong age-based progression was found;
3. And in this larger study (Powell & Shklov, 1992), where the points of change fell between the consolidated answering stages in the age sequence.

Admittedly, these observations come from only two tests and only one school system. However, Rasch (1960) scaling shows analogous progressions among the alternative answers for the best items.

Where does elaborative thinking fit the picture? The evidence of profoundly informed students choosing wrong answers came from the adult students, whose reasoning reports showed this trend (Powell, 1968). The same observation appeared among the older students (Fig. 3.4 above) who shifted from B* to A or stayed on A. To explore this concept further, we isolated the top 20% of scorers and combined them into elementary school, middle school, and high school groups (Fig. 3.6).

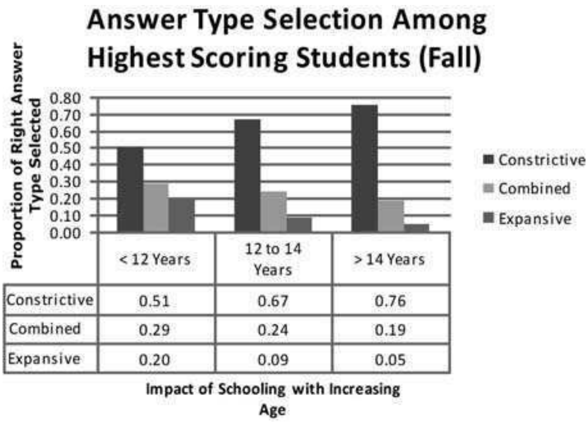


**Fig. 3.6** The impact on our best students

Three distinct groups of students emerge. Group 1 had high scores because they were high in the constrictive subset of the right answers. The proportion of these students systematically increased significantly across this time frame, adding 50% to their numbers.

Group 2 had high scores in the expansive thinking subtest of the right answer subtest. These students systematically decreased significantly in representative proportion across this same time frame, losing 75% of their group.

Finally, group 3 had high scores in both subtests, the proportion of membership in this group declined by about a third, retaining about 20% for the total age sequence.

It would appear that this particular school system is teaching constrictive thinking and the top student was using skills they did not learn in school.

As we will see in the next section, elaborative thinking is teachable and there is a level of thinking beyond this, whole-theme thinking, proposed by Iran-Nejad and Parizi (2008) that is also teachable.

## 3.4 A New Model for Assessing Learning

By summarizing the findings from this data-mining process, we can now infer a new learning model from these findings. Thus far we have shown that:

1. Giving right answers and understanding the concept may be unrelated events.
2. The choice of alternative answers on multiple-choice tests is not random (blind guessing) but is a systematic choice based upon the way in which the testee interpreted the question.
3. It is necessary to bypass linear dependency among test data to detect these transformational patterns. An adaptation of the multinomial statistical procedure has successfully achieved this bypass.
4. There is a strongly age-dependent discontinuous behavioral sequence underlying learning.
5. A number of thinking strategies have been identified and coded into this system.
6. These response characteristics have been found in three separate studies with different examinees using the same test.
7. The particular test employed in the study has provided 18 categories of discrete behavior. Recent work has added another category (not shown in Figure 8–11)
8. Two ways of associating one test with another test have been demonstrated:
    i. Test–retest.
    ii. Another test, administered concurrently, of an entirely different type, can be linked by cross-tabulation.
9. The age appropriateness of the stage changes does not seem to support the assumption that recall is interfering with answering the test.
10. It appears that the learning progression can best be described as multifaceted multidimensional changes in performance that may become progressively more open-ended and flexible, or the reverse.

### *3.4.1 Illustrations Using Actually Student Data*

In Fig. 3.7, we present a two-dimension version of the model just described. We will use this to examine the profile gains and losses we observed with individual students from our data. Actually, there appears to be two types of learning shifts. Piaget (Flavell, 1973) distinguishes between assimilation (adding to existing knowledge stock) and accommodation (shifting thought perspective). This second way of

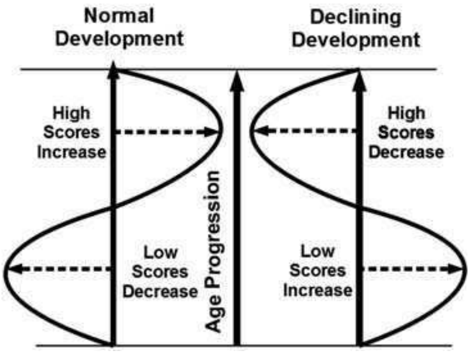


**Fig. 3.7** Simplified learning patterns

learning adds to the dimensionality of the thinking capability, as with the profound students changing from the right answer to alternative A in our example above (see Fig. 3.1).

For normal progress, we expect the scores on the higher cognitive skills to increase and the lower ones to decrease. The *sine* wave would be ascending the age scale. We would expect the reverse for declining performance. The bulges to the left indicate declines in subscores and the ones to the right indicate increases. To support this model, we will show that actual student behavior conforms to it.

### *3.4.2 Student Performance Change*

The following four illustrations were selected from a random subsample of 52 drawn from the 2810 students for whom the data was complete on both administrations. These figures have 17 levels shown. The top two are the constrictive and expansive score changes. The figures have appended to them the learning pattern model so that direct comparisons with the actual change events and the model can be made. Comparisons will also be made with the total-correct score interpretation, and suggestions for teacher about how to interpret and use these performance profile changes are also given.

#### **3.4.2.1 Student 2350**

In Fig. 3.8, the bars to the left indicate that the score on that subtest declined, with the opposite meaning to the right. The labels on the bars are the categories of the subtests. The numbers in parentheses are the modal ages and the freestanding numbers are the percentage change. The *sine* curve shows the developmental pattern and the horizontal double arrow gives the chronological age of this student.

By scaling and accumulating all of these changes (except for the total scores), this student seems to have gained about 8 months in five. However, this student's

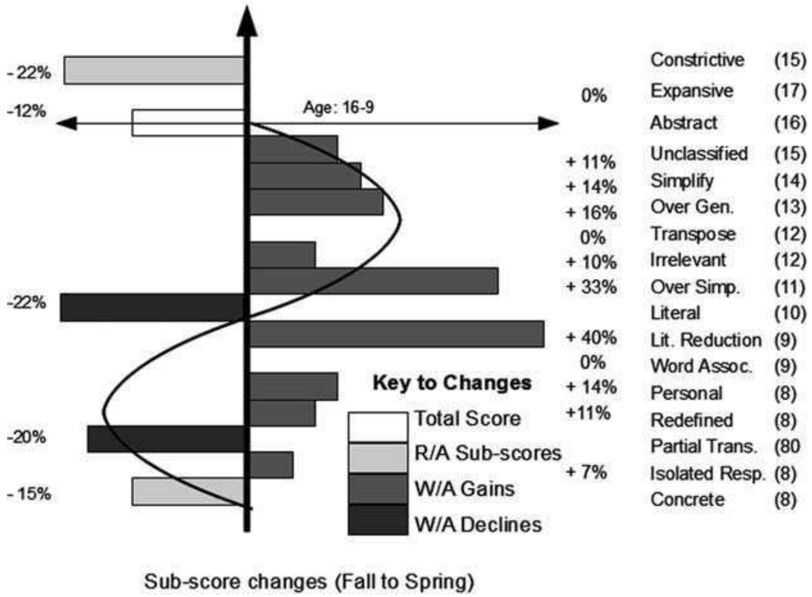


**Fig. 3.8** Student 2350 – age: 16–9

total scores (ABS; white bar near the top) declined by 12% on the strength of a decline in constrictive thinking. It appears that constrictive thinking behaves as we would expect right answers without understanding to behave, supporting the use of this alternative construct to complete the dice-roll model.

This student is behind the norms for his or her age by about two and a half years. For this reason, we need to look more closely at the particular subtests where the changes are occurring to be able to make recommendations to the teacher for appropriate interventions.

The largest proportional gain is in the literal interpretations (Lit), followed by the bimodal alternative subtest called "Irrelevancies" (Irr). This student is at the transition between concrete thinking and figurative thinking, a level of functioning that many students have difficulty escaping in a high-stakes setting, as indicated by the continuation of alternative D in item 18 through the end of high school.[3] Specific practice with metaphoric thinking has often broken this logjam.

### 3.4.2.2 Student 1660

Here, we observe a classic example of expected development from the model. Of particular interest here is the fact that this student made gains in both constrictive and expansive thinking, with an aggregate scaled gain (taking the declines in the lower levels as gains) of about 20 months in five.

[3]Notice the D to D stability continues vertically all the way to the top of the chart in Figure 3.4.

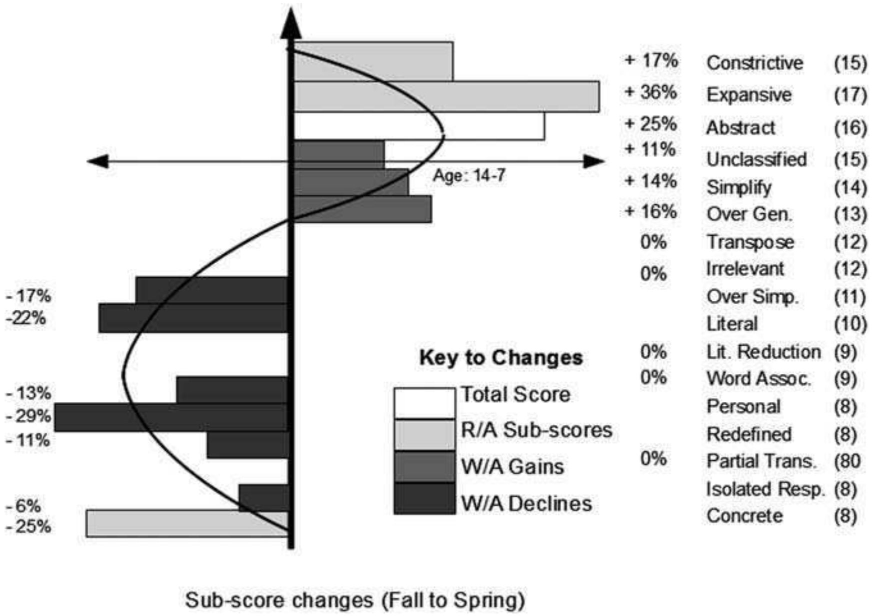


**Fig. 3.9** Student 1660 – age: 14–7

This student must have had an experience during this 5-month period that shifted him or her into elaborative thinking. Whether or not this was an in-school experience, this student shows that such transformations are possible and may be teachable with RSE informative support.

The best way to consolidate such rapid gains would seem to be to enlist this student as a tutor of others, such as the student in the previous example (Fig. 3.10).

### 3.4.2.3 Student 1150

This student has 6 of the 16 alternative answer subscores showing no change, implying that he or she has reached an impasse in learning, perhaps school related. The overall pattern suggests a major decline in performance of about 6 months during this 5-month interval.

Considering the right answer changes, we observe an increase in total score produced by an substantial increase in constrictive thinking and a decline in expansive thinking. This observation further supports the implication that constrictive thinking represents the mind-closing process.

The three areas of gain (Over Simplifications – OS; Word Associations – WA and Isolated Responses – IR) suggest a collapse in this student's ability to read effectively.

The teacher would need to look closely at this student to see whether this is a result of a lack of motivation to take this test, a loss of motivation because of

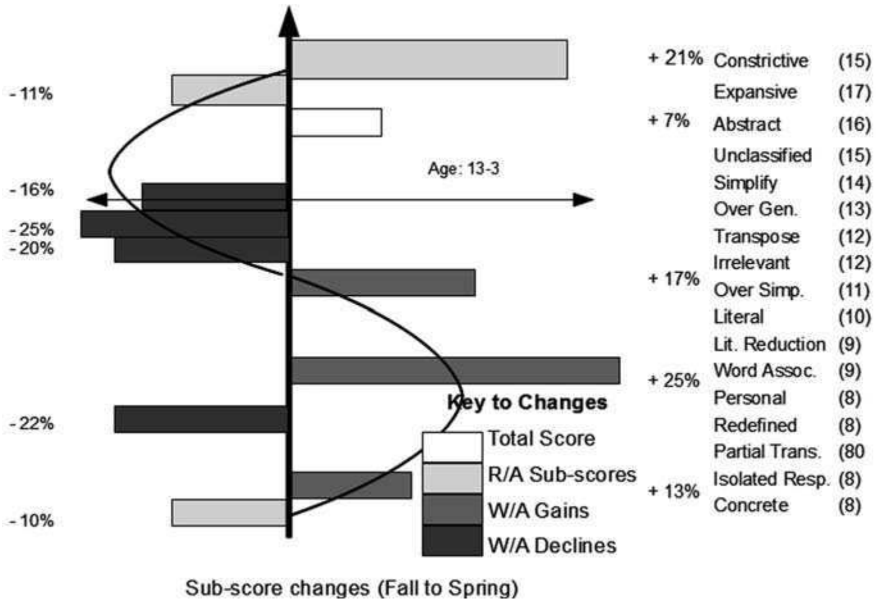


**Fig. 3.10** Student 1150 – age: 13–3

personal trauma (such as divorce in the family), or a school-related turn-off. Each of these possibilities requires a different intervention.

The need for such an intervention could easily be missed if the only information the teacher had is a gain in total scores.

#### 3.4.2.4 Student 160

Looking at the right answer subtests suggests that this test was too difficult for this student. He or she had three answers correct in October and five in March. Since the norms suggest that a gain of 3.2 answers represents a year's gain, this change for a half year is not too far off the mark, but the scores are low for a 9-year-old.

Alternatively, the double-headed arrow at this student's chronological age shows a performance gain near this age level. In fact, the greatest gain of Oversimplification (OS) is selection behavior characteristic of 11-year-olds. This student appears to be making the transition from concrete thinking to figurative thinking a bit more than a year early. This pattern illustrated the ladder-climbing effect on the model.

Once again, this student should be flagged so that the teacher can look more closely at emerging skills. The short and simple suggestion is to encourage reading, but if already a voracious reader, other approaches could be explored.

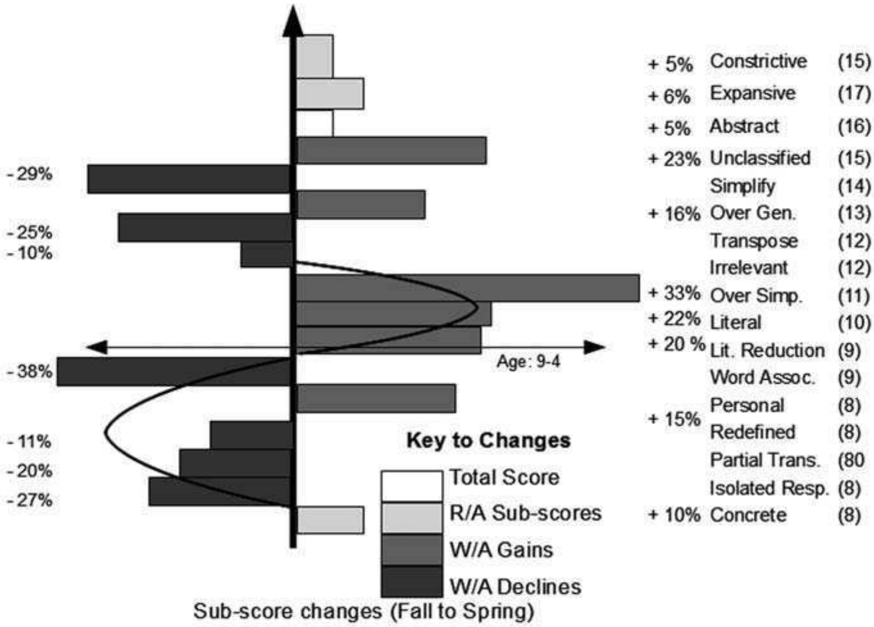


**Fig. 3.11** Student 160 – age: 9–4

In all, these four examples fit the general results but are insufficient by themselves to be conclusive. On the other hand, these commentaries show that a 40-item survey-type test can be used diagnostically when RSE scoring is employed.

## 3.5 Summary, Conclusions, and Implications

In summary, we have observed the following:

1. To the three purposes for large-scale testing, we have added a fourth to inform teaching.
2. RSE can add sufficient detail to assessment data, including tracking changes, that it can serve both summative and formative purposes.
3. Current right–wrong scoring practices diminish the available observable diversity of student behavior to the point where the distinction between answering from rote and from understanding is lost.
4. Students give the best answer they can from what they know and the way they interpreted the question. This information appears in the wrong answer they select.

5. The reason why these observations have not been made earlier is that these data disappear during scoring and cannot be recovered using linear analysis models because of the linear dependency among answers.
6. RSE is a nonlinear scoring approach built upon the multinomial procedure, which is described in the chapter.
7. The procedure has uncovered systematic, age-dependent developmental sequences among the alternative answers selected by students.
8. A number of interpretation-process strategies have been identified among wrong answers in 40-item four-option reading-comprehension multiple-choice test.
9. The stage changes occur age appropriately, suggesting that familiarity with the test from taking it more than once may not be an issue.
10. RSE therefore proposes a dice-roll model to replace the coin-toss model for describing answer selection strategies.
11. Two learning pathways have already been found, one progressive and one regressive.
12. RSE not only can be used for repeated use of the same test, but also be used to associate two quite different instruments as long as the answers can be crosstabulated.
13. When associating an achievement test with a personality survey, evidence for a generalized decline in performance was found in a school system using high-stakes testing.
14. The decline effect was more severe for the highest performing students, except for small, identifiable subgroup.
15. Emerging from this work is an expanded model for learning that adds conceptual and process shifts to the current accumulative functioning approach.
16. Intervention suggestions for teachers can be drawn directly from the profile changes observed among the students used to illustrate the process
17. Tests that appear too difficult for a young child, based upon total score, may still provide developmental status information among the wrong answers.

RSE has shown consistent results, capturing close to 80% of the variability in the tests studied, in three separate studies, both from cross-validation and replication standpoints. It has shown many outcomes of schooling that have been long suspected but which lacked research evidence.

The observation of dynamic shifts to higher levels of cognitive complexity suggests that we should be teaching students how to think and how to learn using the subject matter as an exploratory vehicle. Focusing on information transmission seems to stultify the learning process.

Whatever the final outcome of this scoring procedural shift (from score accumulation to profile analysis using pattern matching), RSE appears to be a promising alterative to current practice, deserving a thorough investigation of its nature and possibilities.

# Appendix

**Table 3.6** Complete data for item 18

| Ages | **A to A** | A to B* | A to C | A to D | B* to A | **B* to B*** | B* to C | B* to D | C to A | C to B* | **C to C** | C to D | D to A | D to B* | D to C | **D to D** | Age Group Totals | Meaningful Count |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| < 96 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 3 | 1 | 3 | 5 | 3 | 24 | 16 |
| 98 | 0 | 1 | 1 | 1 | 2 | 0 | 4 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 11 | 31 | 17 |
| 103 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 2 | 3 | 5 | 3 | 5 | 3 | 4 | 7 | 38 | 17 |
| 108 | 15 | 6 | 4 | 9 | 4 | 5 | 3 | 2 | 6 | 0 | 5 | 6 | 5 | 7 | 5 | 19 | 101 | 81 |
| 113 | 11 | 1 | 3 | 5 | 2 | 0 | 1 | 3 | 4 | 0 | 4 | 7 | 3 | 4 | 5 | 10 | 63 | 27 |
| 118 | 5 | 2 | 7 | 18 | 5 | 4 | 3 | 3 | 5 | 1 | 8 | 3 | 7 | 3 | 8 | 10 | 92 | 58 |
| 123 | 11 | 3 | 0 | 13 | 5 | 4 | 2 | 2 | 4 | 0 | 6 | 8 | 10 | 8 | 6 | 17 | 99 | 75 |
| 128 | 16 | 6 | 2 | 10 | 7 | 4 | 3 | 4 | 6 | 4 | 2 | 4 | 10 | 3 | 5 | 11 | 97 | 31 |
| 133 | 15 | 5 | 1 | 12 | 5 | 13 | 4 | 6 | 4 | 0 | 3 | 5 | 9 | 8 | 4 | 21 | 115 | 90 |
| 138 | 9 | 5 | 3 | 16 | 4 | 13 | 1 | 0 | 3 | 4 | 4 | 3 | 13 | 7 | 3 | 7 | 95 | 50 |
| 143 | 16 | 10 | 3 | 8 | 8 | 15 | 0 | 6 | 1 | 6 | 3 | 3 | 16 | 5 | 5 | 12 | 117 | 96 |
| 148 | 10 | 8 | 4 | 5 | 5 | 16 | 3 | 5 | 1 | 3 | 2 | 3 | 7 | 5 | 4 | 9 | 90 | 63 |
| 153 | 11 | 3 | 2 | 11 | 5 | 14 | 1 | 5 | 4 | 2 | 0 | 3 | 4 | 5 | 3 | 14 | 87 | 67 |
| 158 | 10 | 8 | 0 | 5 | 9 | 20 | 2 | 6 | 4 | 2 | 5 | 2 | 10 | 6 | 4 | 5 | 98 | 57 |
| 163 | 10 | 5 | 1 | 4 | 4 | 16 | 1 | 4 | 3 | 1 | 1 | 1 | 6 | 1 | 4 | 11 | 73 | 63 |
| 168 | 11 | 8 | 3 | 7 | 5 | 33 | 2 | 6 | 3 | 2 | 0 | 3 | 9 | 5 | 2 | 11 | 110 | 78 |
| 173 | 16 | 17 | 3 | 7 | 6 | 60 | 5 | 8 | 1 | 3 | 3 | 2 | 13 | 17 | 5 | 22 | 188 | 144 |
| 178 | 15 | 17 | 3 | 14 | 5 | 54 | 4 | 9 | 2 | 7 | 3 | 3 | 12 | 20 | 3 | 22 | 193 | 153 |
| 183 | 9 | 20 | 2 | 10 | 15 | 70 | 2 | 10 | 4 | 5 | 1 | 2 | 10 | 20 | 3 | 18 | 201 | 163 |
| 188 | 16 | 14 | 0 | 6 | 15 | 63 | 4 | 5 | 1 | 4 | 2 | 1 | 5 | 17 | 6 | 18 | 177 | 157 |
| 193 | 15 | 14 | 0 | 7 | 10 | 56 | 8 | 5 | 0 | 3 | 0 | 4 | 8 | 12 | 1 | 17 | 160 | 151 |
| 198 | 7 | 18 | 4 | 10 | 9 | 48 | 1 | 9 | 1 | 2 | 1 | 3 | 6 | 9 | 2 | 14 | 144 | 114 |
| 203 | 9 | 11 | 1 | 4 | 12 | 38 | 2 | 6 | 0 | 3 | 0 | 1 | 7 | 7 | 3 | 13 | 117 | 92 |
| 208 | 3 | 8 | 0 | 1 | 7 | 38 | 4 | 6 | 0 | 0 | 0 | 1 | 3 | 9 | 1 | 7 | 88 | 80 |
| 213 | 9 | 5 | 1 | 2 | 6 | 38 | 1 | 3 | 0 | 1 | 1 | 0 | 1 | 7 | 2 | 7 | 84 | 77 |
| 218 | 3 | 4 | 1 | 6 | 4 | 16 | 5 | 3 | 2 | 2 | 1 | 0 | 3 | 2 | 1 | 5 | 58 | 39 |
| >220 | 3 | 5 | 1 | 1 | 5 | 35 | 2 | 4 | 0 | 1 | 1 | 0 | 3 | 4 | 0 | 5 | 70 | 63 |
| Totals | 258 | 205 | 51 | 194 | 165 | 673 | 68 | 124 | 62 | 61 | 66 | 76 | 187 | 198 | 96 | 326 | 2810 | 2119 |
| Totals | 196 | 158 | 0 | 151 | 124 | 669 | 34 | 85 | 20 | 13 | 50 | 42 | 130 | 136 | 60 | 244 | 2112 | |

**Acknowledgments** A previous version of this chapter was presented at the IADIS International Conference on Cognition and Exploratory Learning in the Digital Age (CELDA 2008), Freiburg, Germany.

## Notes for Appendix

1. *Source:* Composite of Tables 3.4 and 3.5 from Powell and Shklov (1992).
2. The results of the analysis of the two administrations of item 18 from the *Proverbs Test.*
3. The shaded columns represent the meaningful changes. Row 168 gives the data from which the sample calculations were developed.
4. The **bold-faced** larger numbers are frequencies using our adaptation of the *multinomial* procedure that explain at least 95% of the variability that can be contributed by that cell.
5. The zeros in square boxes represent no more than 5% of the variability in that cell. Of all the zeros (0s) in the table, only three were exclusively disjunctive. With such a strong skewing of these data means that they cannot be described to be random.
6. The column labels identify the pairs of answers from the rows and columns of the 4-by-4 tables used to establish event in each of the 27 different 5-month age intervals. Reordering of the columns reveals two full-length pathways (Fig. 3.4) discovered in this one item.
7. The full data set is available (for professional acknowledgment) upon request. Contact the author at jpowell@tir.com.
8. The students in the sample diagnosis section were drawn randomly from this entire data set.
9. The proportion of contribution to the total variability of the repeated right answers is (673/2810)*100 or 23.95%, while the total explained variability for the entire table is (2119/2810)*100 or 75.41.
10. A book that tells the story of this discovery and presents educational implications anecdotally is in press (Powell, 2009).

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# Chapter 4
# Enhancing Learning from Informatics Texts

**Alexandra Gasparinatou, Grammatiki Tsaganou, and Maria Grigoriadou**

**Abstract** Previous studies have demonstrated that high-knowledge readers learn more from low-coherence than high-coherence texts in the domain of Informatics and specifically in the domain of Local Network Topologies. This study explored deeply the research hypothesis that this characteristic is due to the use of knowledge to fill in the gaps in the text, resulting in an integration of the knowledge of the text with background knowledge. Participants were 65 eighth semester undergraduate students of the department of Informatics and Telecommunications, University of Athens, who had been taught and successfully completed the "Data Transmission and Networks Communications" course in the fourth semester of their studies, so they were considered as high-knowledge readers. Participants' comprehension was examined through free-recall measure, text-based questions, elaborative-inference questions, bridging-inference questions, problem-solving questions, and a sorting task. We found that readers with high background knowledge performed better after reading the low-coherence text. We support that this happens because the low-coherence text forces the readers with high background knowledge to engage in compensatory processing to infer unstated relations in the text.

## 4.1 Introduction

The literature indicates that the more a reader knows about the domain of a text, the more likely the reader will comprehend and learn from the text (McNamara, Kintsch, Songer, & Kintsch, 1996; Means & Voss, 1985). It has also been demonstrated that readers with greater background knowledge employ more effective reading strategies (Lundeberg, 1987) and express more interest in the reading material (Tobias, 1994).

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There are also studies which show that text comprehension can also be improved by rewriting poorly written texts in order to make them more coherent and to provide the reader with all the information needed for reading comprehension (Beck, McKeown, Sinatra, & Loxterman, 1991; Beyer, 1990; Britton & Gulgoz, 1991; McKeown, Beck, Sinatra, & Loxterman, 1992; McNamara et al., 1996). Text coherence refers to the extent to which a reader is able to understand the relations between ideas in a text. This is generally dependent on whether these relations are explicit in the text. The general approach to increasing text coherence is to add surface-level indicators of relations between ideas in the text. Such modifications range from adding low-level information, such as identifying anaphoric referents, synonymous terms, or connective ties, to supplying background information left unstated in the text. However, increasing text coherence is not necessarily the best condition for learning. Making readers participate more actively in the comprehension process can help memory and learning. In many research domains, it has been shown that learning can be improved by making the learner's task more difficult (Healy & Sinclair, 1996; Mannes & Kintsch, 1987; McDaniel, Blishak, & Einstein, 1995). Consequently, the findings for facilitating the reading and comprehension process are contradictory.

Beyer (1990) used a computer manual as his learning material. He revised the original manual by making its macrostructure explicit by means of titles and subheadings and by improving the comprehensibility of the instructions contained in the manual with illustrative examples. The revised text proved to be significantly better than the original version, but the improvement was restricted to problem-solving tasks. Beck et al. (1991), working with fourth- and fifth-grade students who studied a text about the American Revolutionary War, significantly improved performance on open-ended questions and recall by adding explanatory coherence to the text, especially emphasizing causal relations. A more systematic approach to filling in the local coherence gaps in a text was employed by Britton and Gulgoz (1991), who used a history text as their learning material that described the US air war in Vietnam.

McNamara and colleagues (1996) approached the previous contradictory findings in terms of Kintsch's model of text comprehension (Van Dijk & Kintsch, 1983; Kintsch, 1988). This model assumes that there are at least two levels of text understanding, text base understanding and situational understanding, and consequently that memory of a text is not the same as learning from the text (Kintsch, 1994). Because a good text base understanding relies on a coherent and well-structured representation of the text, facilitating the reading process by presenting a coherent and well-structured text, it should indeed improve text base understanding. In contrast, a good situation model relies on different processes, primarily on the active use of long-term memory, or world knowledge, during reading (Kintsch, 1994). Links between the text base and world knowledge must be activated in the reader's mental representation of the text. If motivated readers encounter a gap in the text, an attempt will be made to fill in this gap. Doing so requires accessing information from the readers' world knowledge, which in turn results in the text information being integrated with long-term memory. This gap-filling process can only be successful if readers have the necessary background knowledge. Therefore, for a good situational understanding, a single text cannot be optimal for every reader: low-knowledge readers should benefit more from an easier, coherent text, whereas high-knowledge readers should be allowed to do their own inferencing with harder, less coherent texts.

McNamara and colleagues (1996) examined students' comprehension of one of four versions of a biology text, orthogonally varying local and global coherence. They found that readers who know little about the domain of the text benefit from a coherent text, whereas high-knowledge readers benefit from a minimally coherent text.

Gasparinatou, Tsaganou, and Grigoriadou, (2007) investigated the effects of background knowledge and text coherence on learning from texts in Informatics and specifically in Wired Local Networks – Bus Topology. Fifty-nine first-semester undergraduate students of the Department of Informatics and Telecommunications, University of Athens, Greece, participated in the study. Participants were randomly separated into four groups and each group was given a text of different coherence. The same prior-knowledge questionnaire was given to these groups. According to their responses, participants were classified as "high" or "low" with regard to prior knowledge. The classification was made based on a median split procedure. The difference in knowledge between the high- and low-knowledge participants could partly be due to the fact that participants had different backgrounds and previous schooling in the subject. Before reading the text, participants had to answer a sorting task (pre-reading sorting task). They were given 14 concepts and were asked to categorize them into three groups. There were 2 nontext and 12 keyword concepts from the text; 5 related to "Categories of Transmission Medium," 5 to "Wired Topologies," and 2 to "Rules–Protocols that Determine the Transfer of Information." The purpose of selecting these concepts was to provide a group of concepts for which there were not only several rational sorting principles, but also clearly discernible, text-driven sorting principles. Participants completed this sorting task again after reading the text and answering all other required tasks. The post-reading sorting task was used to determine how strongly reading the text affected readers' conceptual structure concerning the information in the text.

Participants read the text twice. After the first reading, they had to recall a paragraph from the text when answering a set of eight open-ended questions afterward. They also had to recall a paragraph from the text and answer another set of eight open-ended questions after the second reading of the text. Thus, the measures used in the study were text recall, text-based questions, and situation model questions. Text recall is a measure of memory for the text itself; it is a text base measure, particularly useful when the task presented to the reader is simply to recall the text. Text-based questions require only a single sentence from the text in order to be answered; thus, understanding the relation between two sentences or text in whole is not necessary. Situation-model measures include problem-solving questions, bridging-inference questions, elaborative-inference questions, as well as the sorting task. Problem-solving questions require applying information from the text to a novel situation and, hence, depend on situational understanding.

Bridging-inference questions require linking information from two or more sentences in the text to answer the question. Inferring the unstated relation between sentences is also a process that relies on the situation model. Elaborative-inference questions require linking textual and outside knowledge information, which requires some, but not necessarily a deep, situational understanding. Finally, the sorting task measures the reader's understanding of the relation between concepts presented in the text, which reflects, at least in part, the situation model. The results showed that in the domain of Informatics, high-knowledge readers benefit from a text of minimally coherence contrarily to the low-knowledge readers who learn better with a maximally coherent text.

In this line of research, we explored the comprehension of students of high background knowledge while reading texts of high and low coherence in the domain of Informatics and specifically in the thematic unit "Tree-Ring and Star Topology." The participating students in the research were 65 eighth semester undergraduate students of the Department of Informatics and Telecommunications, University of Athens, who have been taught and successfully passed the course "Local Network Topologies" in the fourth semester of their studies. Consequently, they were characterized as "high-knowledge" readers.

The remainder of this chapter presents the Construction–Integration Model used in the study, followed by a discussion of the methods involved and findings. The chapter concludes with suggestions to improve informatics texts and with plans for future research.

## 4.2 The Construction–Integration Model

The construction–integration model was an extension of earlier models of comprehension (van Dijk & Kintsch, 1983; Kintsch & van Dijk, 1978), primarily specifying computationally the role of prior knowledge during the comprehension process. This framework has been applied successfully to numerous aspects of text and discourse comprehension (Kintsch, Welsch, Schmalhofer, & Zimny, 1990; Kintsch & Welsch, 1991; Otero & Kintsch, 1992) as well as to more complex domains such as expert-novice differences in problem-solving tasks (Kintsch, 1988; Weaver & Kintsch, 1992). Within the construction–integration framework, processing occurs in two stages. In the first stage – *construction* – concepts from the text as well as syntax, semantic, and world knowledge are activated without taking into account global constraints to produce a network of activated concepts. In the second stage – *integration* – activation flows through the network of activated concepts according to connectionist principles of constraint satisfaction. Concepts that are compatible with the overall context mutually enhance the activation of one another, while concepts that are not compatible with the context lose activation. Thus, comprehension arises from an interaction and fusion between text information and knowledge activated by the reader. The final product of this construction and integration process is referred as the reader's mental representation of the text.

The levels of understanding that are most relevant to our purposes are the text base and situation model. The text base consists of those elements and relations that are directly derived from the text itself. The text base is what would be obtained if the text is to be translated into a propositional network and then integrate this network cycle by cycle but without adding anything that is not directly cued by the text. Typically, this procedure results in an incoherent or incomplete network. The reader must add nodes and establish links between nodes from his/her own world knowledge and experience in order to make the structure coherent, to complete it, to interpret it in terms of the reader's prior knowledge, and to integrate it with prior knowledge. The situation description that a reader constructs on the basis of a text as well as prior knowledge and experience is called the situation model. Thus, the text base comprises those nodes and links in the mental representation of the text that have direct correspondences in the text itself. The situation model includes not only the text base, but also the nodes and links that have been added on the basis of world knowledge.

Analogous to the distinction between text base and situation model is the distinction between the micro- and macrostructure of the text. Microstructure refers to local text properties; macrostructure refers to the global organization of text. Microstructure is generally cued by the text via explicit indicators of relations between concepts and ideas in the text (e.g., connectives, argument overlap, and pronominal reference). Microstructure can also be constructed on the basis of the reader's knowledge when there are details or relations left unstated in the text. A text's macrostructure can be cued directly in the text via topic headers and sentences.

In the general case, the situation model that a reader generates from a text is a mixture of text-derived (the text base) and knowledge-derived elements. If the reader has no relevant background knowledge or does not employ it in understanding a text, text representation will be dominated by text base (Moravcsik & Kintsch, 1993). On the other hand, if rich relevant background knowledge is available and the text itself is poorly written and disorganized, the reader's knowledge elaborations may dominate the mental representation of the text and a good situation model may be obtained at the expense of the text base (Bransford & Franks, 1971).

### *4.2.1 Text Coherence*

Coherence is a fundamental property of text, discourse, and comprehension; the notion of coherence was covered extensively by van Dijk and Kintsch (1983). McNamara et al. (1996) manipulated both local and global coherence. Local coherence was increased by replacing pronouns with noun phrases, adding descriptive elaborations to link unfamiliar concepts with familiar ones, adding sentence connectives and replacing words to increase argument overlap. Global coherence was manipulated by adding topic headers and macro propositions that linked each paragraph to the rest of the text and overall topic. Consider, for example, a paragraph concerning bus topology.

The low-coherence text is:

Bus topology supports broadcasting emission. The message which is sent from one node to another contains the address of the recipient. As soon as the node receives the message, checks the recipient's address to determine if the message is intended for this node. If it is so, the recipient copies the packet and afterward sends it to the other nodes.

The high-coherence text is:

Bus topology supports broadcasting emission. *Networks that use broadcasting emission allocate only one common means of transmission which is shared by all the nodes connected to the network. As a result of this connection, each message which is sent from each node is received by all users connected to the network.* The message which is sent from one node to another contains the address of the recipient *and is received by all nodes which are connected to the network.* As soon as the node receives the message, it checks the recipient's address to determine if the message is intended for this node. If it is so, the recipient copies the packet *which means that it creates a copy of the original packet* and afterward sends it to the rest of the nodes.

### *4.2.2 The Measurement of Learning*

As the levels of understanding are not separate structures and the situation model, by definition, involves both the text base and long-term memory, a comprehension measure cannot exclusively tap into one level of understanding. Some measures are more indicative of text memory (e.g., recognition, text-based questions, and reproductive recall), whereas other measures are more sensitive to learning (e.g., bridging-inference questions, recall elaborations, problem-solving tasks, and keyword sorting tasks). The former are referred to as text base measures because all that is required for good performance is a coherent text base understanding. The latter are referred to as situation model measures because, in order to perform well on them, the reader must have formed a well-integrated situation model of the text during the comprehension process (Kintsch, 1998).

Recognition tasks are considered as a text base measure because all of the information is contained in the question and it is merely a matter of recognizing the text. Text-based questions are considered as text base measures because only one segment of the text must be comprehended or accessed and it is not necessary to have understood the relations between different segments of the texts. Text recall is also considered as a text base measure because it is possible to access and reproduce separate segments of a text without understanding or reproducing the relations between them. The degree to which recall is a text base or situation model measure is on a continuum. Some aspects of a reader's text recall, such as inferences and elaborations, are more indicative of the situation model level understanding. Under some conditions, inferences and elaborations occur infrequently in participants' recall protocols. In laboratory experiments, recall sometimes is almost purely reproductive, as are summaries. They may involve some semantic knowledge, as in generalizing one concept to another or paraphrasing, but that still remains primarily at the text base level. Recall and summaries can also be perfectly good indicators of well-developed situation models when, and if, they go beyond the text. In this study recall doesn't go beyond the text, and hence it is taken as measure of the text base (Kintsch, 1998).

A measure is assumed to tap primarily into the situation model level of understanding if: (a) information in the text must be integrated with prior knowledge (e.g., recall elaboration, problem solving), (b) the organization of the information in the text must be discerned (e.g., keyword sorting), or (c) more than one segment of the text must be accessed and the relation between the separate segments must be understood (e.g., bridging-inference questions). One caveat is that a bridging-inference question is only a situation model to the extent that comprehension of the text segments, and therefore of the question, requires world or situational knowledge. Bridging-inference questions often involve only syntactic or semantic knowledge. To the extent to which the latter is true, these types of questions are tapping into the reader's text base level of understanding (Kintsch, 1998).

## 4.3 The Study

This study was designed to address the issues mentioned in our previous study (Gasparinatou et al., 2007) with high-knowledge readers. The research question was whether the results of Gasparinatou et al. (2007) with high-knowledge readers of first semester undergraduate students of Informatics and Telecommunications are also applicable to high-knowledge readers of eighth semester undergraduate students of Department of Informatics and Telecommunications.

Thus, students were separated randomly in four groups and each group was given a text of different coherence. The participants in this study had been taught the "Data Transmission and Networks Communications" course in the fourth semester of their studies. Consequently, they were considered as "high-knowledge" readers. In the present study, it is very important to confirm the interactive effects of knowledge and text coherence we had on our previous study because we have a larger sample of high-knowledge readers (65), whereas in the previous study the respective sample was limited to 27.

### *4.3.1 Method*

#### 4.3.1.1 Participants

Our research was conducted with the participation of 65 eighth semester undergraduate students of the Department of Informatics and Telecommunications, who had successfully completed the "Data Transmission and Networks Communications" course that is taught in fourth semester. Participants were assigned randomly to one of four groups and given a different coherence text. Seventeen students participated in the group with the maximally coherent text. The texts were presented following the pretest matching activity. Participants' reading time was recorded for each text. We included two text base comprehension measures (i.e., recall and text-based questions) and three situation model comprehension measures (i.e., matching activity, bridging-inference questions, and problem-solving questions) as our dependent variables. We also included reading times as a dependent measure.

#### 4.3.1.2 Procedure

The order of the experimental tasks was as follows: (1) pre-reading matching activity, (2) first text reading, (3) first text recall, (4) first set of assessment questions, (5) second text reading, (6) second text recall, (7) second set of assessment questions, and (8) post-reading matching activity. All the tasks were paper-and-pencil tasks. The session lasted about 2 h.

After the first reading of the text, the students answered a set of assessment questions and after the second reading they answered another set of assessment questions. The two sets of questions were different. Students read the text and completed the comprehension measures twice in order to ensure as complete an understanding of the text as possible.

### *4.3.2 Materials and Tasks*

#### 4.3.2.1 Matching Activity (Pre-reading and Post-reading Test)

Nine figures were created illustrating simple and complex local network topologies. The participants were asked to match each figure with one of the wired local network topologies and to justify their choice. The matching data in the post-reading test is used to determine how strongly reading the text affected readers' conceptual structure concerning the information in the text. We are not interested in how well participants match the items, but in the degree to which the information presented in the text influences matching. The evaluation of this task, expressed as percentage correct, was performed by two course teachers.

#### 4.3.2.2 Texts

The experimental texts were based mainly on a chapter concerning "Local Network Topologies" (Walrand, 2003). By varying the coherence of the original text, according to rules described below (McNamara et al., 1996), we obtained four texts with the same content but different in coherence, which was orthogonally manipulated at the local and global levels, by adding or deleting linguistic coherence signals. This process resulted in four text versions: (a) a maximally coherent text at both the local and the macro levels (LG), (b) a text maximally coherent at the local level and minimally coherent at the macro level (Lg), (c) a text minimally coherent at the local level and maximally coherent at the macro level (lG), and (d) a minimally coherent text at both the local and the macro levels (lg).

The following three types of rules were used to maximize local coherence: (1) replacing pronouns with noun phrases when the referent was potentially ambiguous (e.g., in the phrase "It is the critical node," we replace "it" by "the root"). (2) Adding descriptive elaborations that link unfamiliar concepts with familiar ones (e.g., "The network topology determines the way in which the nodes are connected" is elaborated to "The network topology determines the way in which the nodes are connected, which means the data paths and consequently the possible ways of interconnecting any two network nodes"). (3) Adding sentence connectives (however, therefore, because, so that) to specify the relation between sentences or ideas.

In the global macro coherence versions of the text (lG and LG), macro propositions were signaled explicitly by various linguistic means (i.e., macro signals) (McNamara, 1996): (1) adding topic headers (e.g., Ring Topology, Access control methods in the Medium) and (2) adding macro propositions serving to link each paragraph to the rest of the text and the overall topic (e.g., "Afterward the advantages and the disadvantages of star topology will be discussed").

The texts were presented following the pretest matching activity. Participants read the entire text two times. They were not told in advance that they would be able to read the text twice.

#### 4.3.2.3 The Propositional Representation of Text

The part of the text that concerns "Tree Topology" in the four text versions was propositionalized according to the principles specified in Van Dijk and Kintsch (1983). After the prepositional representation of text, we found that there were 20 micro propositions and 3 macro propositions concerning tree topology, common to all text versions. For example, the phrase "The root transmits the signal in the all network" was propositionalized as follows:

TRANSMITS [ROOT, ALL [NETWORK], SIGNAL]

### *4.3.3 Text Recall*

After reading the text, participants were asked to recall as much of the text as they could by writing it down. In this study, text recall is considered as a text base measure because it is possible to access and reproduce separate segments of a text without understanding or reproducing the relations between them (Kintsch, 1998).

### *4.3.4 Assessment Questions*

We included two text base comprehension measures (i.e., recall, text-based questions) and three situation model comprehension measures (i.e., matching activity, bridging-inference questions, and problem-solving questions) as our dependent variables. We also included reading times as a dependent measure.

There were created two questionnaires containing eight open-ended questions of short answer that concern the content of the text. The questions were categorized in four different categories (two per category). After the first reading of the text, the participants answered in the first questionnaire and after the second reading in the second questionnaire: (1) Text-based questions: The necessary information to answer the question contained within a single sentence of the minimally coherent lg text (e.g., “From what the network in the ring topology is constructed?”), (2) Elaborative-inference questions: Linking text information and information from outside knowledge is required in order to answer the question (e.g., “What is the distinction between a local network and an Internet?”), (3) Bridging-inference questions: The information is contained in the text but requires linking two or more sentences to answer the question (e.g., “What are the disadvantages in ring topology; How can they be avoided?”), (4) Problem-solving questions: Linking information from separate sentences within the text and applying this information to a novel situation is required (e.g., “Let us assume that you want to make your own local network in order to communicate with your fellow students. What characteristics you will take into consideration in order to choose the topology that you will use?”).

The evaluation of each question, expressed as percentage correct, was performed by the two course teachers.

### *4.3.5 Data Collection*

Reading and task completion times were recorded. They were collected data that afterward they were analyzed in order to study the text base and the situation model that a reader develops while reading a text in the domain of Informatics and consequently the comprehension achieved.

## 4.4 Results

### *4.4.1 Matching Activity*

The results of this analysis are shown in Table 4.1. Participants were randomly assigned to the four text versions and the differences in the scores of matching activity according to the version of the text weren’t statistically significant ($p = 0.482$). As expected, after the reading of the texts the participants who read the minimally

**Table 4.1** Matching activity scores (%)

| | LG | Lg | lg | lG |
|---|---|---|---|---|
| Pre-reading test | 88 | 69 | 78 | 71 |
| Post-reading test | 91 | 75 | 94 | 89 |

coherent text (lg) performed better in matching activity, but the results weren't statistically significant ($p = 0.318$). Consequently, the high-knowledge readers developed a better situation model with the minimally coherent text.

#### 4.4.1.1 Reading Rates

Participants recorded the time required to read the text. Reading time was divided by the number of words in each text, yielding the average time spent per word. Participants read the text twice, yielding two reading time scores. The results are presented in Table 4.2.

**Table 4.2** Reading rates (words per minute)

| Text version | Words per minute (first reading) | Words per minute (second reading) |
|---|---|---|
| lg | 87 | 141 |
| lG | 84 | 104 |
| LG | 132 | 191 |
| Lg | 131 | 201 |
| *M* | 108 | 159 |

As we can see from Table 4.2, readers read the text much more slowly at the first time ($M = 108$ words/min) in relation with the second ($M = 159$ words/min). There was a statistically significant difference between the reading rates of four texts ($p = 0.002$ and $p = 0.003$, respectively). Readers read more quickly the text with the maximum local coherence. The Bonferroni test showed that the factor local coherence is statistically significant between texts lG and LG ($p = 0.015$), whereas it isn't statistically significant between texts lg and LG. This result indicates that the minimally coherent text requires more inferencing than does the high-coherence text. Participants also read more quickly texts with the minimum global coherence (lg and Lg), but the factor global coherence wasn't statistically significant. These results demonstrate that readers with high background knowledge about the topic spent more time processing the low-coherence text. The results are in agreement with the results of previous study for high-knowledge readers (Gasparinatou et al., 2007).

#### 4.4.1.2 Text Recall

Participants recalled the part of the text concerning tree topology twice, once after the first reading of the text and again after reading the text a second time. They were asked to remember from the text as much information as they could. The part of the text that concerns Tree Topology in the four text versions was propositionalized according to the principles specified in van Dijk and Kintsch (1983). The two results for each participant were pooled and scored collectively. One-way ANOVA was performed on proportional recall including the factors local coherence, global coherence, and proposition type. The results are presented in Table 4.3.

**Table 4.3** Text recall

| Text | Micro propositions (%) | Macro propositions (%) |
|---|---|---|
| lg | 53 | 67 |
| lG | 56 | 59 |
| LG | 44 | 62 |
| Lg | 45 | 53 |

Participants reproduced texts well enough. The observed differences in the recall of the micro propositions are statistically significant, whereas the differences in the recall of macro propositions aren't statistically significant. Apparently, they were able to construct a good text base with or without the help of explicit linguistic signals. These results are in agreement with the results of previous study (Gasparinatou et al., 2007).

#### 4.4.1.3 Assessment Questions

Participants answered eight open-ended questions after each of the two readings of the text. First or second assessment questionnaire completion times were combined, as they were similar. There were no significant differences between the four text conditions in terms of the total amount of time spent answering questions ($M =$ 12 min, $F(3,61) = 0.476$, MSE $= 0.47$, $p = 0.7$). The questions were scored for percentage correct. Participants answered two sets of questions and the scores derived by averaging individual scores from the two questionnaires for the relative question. ANOVAs, both by participants and items, were performed on the assessment reading question percentage – correct scores, with the factors of local coherence, global coherence, and question type. Results are presented in Table 4.4.

Participants performed better in bridging questions ($M = 0.83$) and problem-solving questions ($M = 0.81$). Readers who read the minimally coherent text performed better in all types of questions. According to these results, the high-knowledge participants developed a text base model (text-based measures, $M =$ 0.67, MSE $= 0.020$, $F(3,61) = 1.293$, $p = 0.285$) independent from the coherence of the text. Contrarily, they developed a situation model (bridging-inference measures, $M = 0.83$, MSE $= 0.02$, $F(3,61) = 4.092$, $p = 0.010$), (elaborative-inference measures, $M = 0.66$, MSE $= 0.02$, $F(3,61) = 4.877$, $p = 0.004$), and (problem-solving

**Table 4.4** Proportion of correct responses to the assessment reading questions for the four text conditions by question type

| Text | LG | Lg | lg | lG | $M$ | $p$ |
|---|---|---|---|---|---|---|
| Text based | 0.70 | 0.61 | 0.72 | 0.65 | 0.67 | 0.285 |
| Bridging | 0.88 | 0.76 | 0.93 | 0.78 | 0.83 | 0.010 |
| Elaborative | 0.68 | 0.52 | 0.76 | 0.66 | 0.66 | 0.004 |
| Problem solving | 0.74 | 0.80 | 0.92 | 0.75 | 0.81 | 0.001 |

measures, $M = 0.81$, MSE $= 0.018$, $F(3,61) = 7.150$, $p = 0.001$) that depends strongly from the coherence of the text. This occurs because the text with coherence gaps forces the readers with high background knowledge to engage in active processing, leading to a better situation model of the text information.

## 4.5 Conclusions and Future Plans

These results confirm the findings of previous studies, such as McNamara et al. (1996) in the domain of biology and Gasparinatou et al. (2007) in the domain of Informatics. They also enrich our understanding of what it means to learn from a text in Informatics. McNamara et al. claim that a maximally coherent text in Biology may be counterproductive for students who have the necessary knowledge background to understand low-coherence texts on their own. We confirmed this claim in the domain of Informatics. Letting students make their own inferences, both to achieve local coherence and to understand the structure of a text, yields the best results. However, there are two important qualifications to this claim. First, the students must be capable of performing the inference work that is required to understand a low-coherence text, which means that they must possess a minimal level of background knowledge so that this work can be done. Second, the assessment of the students' performance must focus on their learning, not merely on their text memory.

We have assumed that low-coherence text requires extra processing on the part of the reader. The reading times obtained have supported this assumption. Participants' average reading times per word were greater for the low-coherence than for the high-coherence text. We also might expect that participants who possess the necessary knowledge for this extra processing would be more likely to show increased reading times for the low-coherence text. Our study supported this hypothesis: We found that high-knowledge participants spent more time processing the low-coherence text. This result indicates that high-knowledge participants attempted to fill in the gaps of the low-coherence text. We had predicted that these inference processes would only be successful for participants who possessed the necessary background knowledge. Our assessment questions confirmed this hypothesis.

Ideally, a text should contain the new information a reader needs to know, plus just enough old information to allow the reader to link the new information with what is already known. Texts that contain too much that the reader already knows are boring to read and, indeed, confusing (e.g., legal and insurance documents that leave nothing to be taken for granted). Hence, too much coherence and explication may not necessarily be a good thing (Kintsch, 1988).

Based on our results, we propose an approach by which the educational text can be presented at the level of coherence that is appropriate for each student according to his/her background knowledge. This demands the construction of several versions of a text and it can be assisted from the development of an authoring tool. This authoring tool supports authors while constructing texts of different coherence accompanied by activities, which are designed to support students' comprehension on line. In this way, students will be activated to use their background knowledge while reading, and more students will have the opportunity to achieve better results in learning from Informatics texts than reading a single textbook in Informatics targeted at an average reader.

Our studies of text coherence and background knowledge point to the importance of considering background domain knowledge in conjunction with active processing strategies in order to determine the most advantageous learning methodologies for individual students. Understanding the ways and directions in which text structure, individual differences, and comprehension measures interact is vital for a complete theoretical account of text comprehension, as well as an educational approach to using texts in a classroom. Kintsch's (1988) model of text comprehension has provided us with a framework to approach these issues and for the most part, this framework has been both useful and successful for understanding these issues. Future research should be directed at examining the effects of background knowledge on other methods for enhancing learning from text. With regard to our research in the field of comprehension of text in Informatics, we also intend to (a) examine whether open-ended questions provide a more sensitive measure of the reader's situation model than multiple-choice question and (b) examine long-term effects by including a delayed retention test.

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# Part II
# Knowledge Representation and Mental Models (Ifenthaler)

# Chapter 5
# Model-Based Knowledge Mapping

## A New Approach for the Automated Graphical Representation of Organizational Knowledge

**Andreas Lachner and Pablo Pirnay-Dummer**

**Abstract** One of the core tasks of knowledge management is knowledge assessment. Conducting knowledge assessment within organizations is considerably demanding because it is time and cost intensive and the results are often subjective and not very amenable to validation. In this chapter, we present a new theory-driven approach to knowledge management which simplifies this task considerably: model-based knowledge management. Furthermore, we introduce a new and fully automated text-based technology for the assessment of organizational knowledge. Within this technology new computer linguistic techniques and associative networks are used for knowledge mapping. The results of the technological study and our validation study indicate that our methodology is an efficient time- and cost-saving alternative to common knowledge mapping approaches.

## 5.1 Introduction

Due to economic and technological changes, primary factors of production have lost significant ground and human factors like knowledge acquisition and dissemination have gained great importance for economic success. This has led to the development of a variety of new knowledge management and organizational learning approaches (Argyris & Schön, 2002; Nonaka & Takeuchi, 1997; Probst & Raub, 1998; Senge, 1990). Thus, the core tasks of knowledge management (KM) are monitoring, controlling, and evaluating knowledge construction in addition to knowledge generation, storage, and distribution (Christmann-Jacoby & Maas, 1997, Wilke, 1998).

What all of these approaches have in common is that they concentrate primarily on the organizational aspect of knowledge management and thus tend to

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ignore cognitive aspects of constructing and sharing knowledge. Therefore, it is necessary to develop a new theoretically based approach to knowledge management. Pirnay-Dummer and Lachner (2008) propose a new model of knowledge management designed to fulfill this need, *model-based knowledge management.* According to this approach and in accordance with other knowledge management models, one of the central tasks of KM is to visualize knowledge for knowledge management interventions such as structuring communication and interaction processes (Wilke, 1998).

However, knowledge mapping is considerably time-consuming and expensive. Therefore, we introduce a new automated methodology for visualizing knowledge in this chapter, *model-based knowledge mapping*.

First, we introduce the theoretical foundations of this new knowledge mapping approach. Second, we present a technological study which confirms the feasibility of our methodology. We then present a validation study of our methodology and discuss possible applications of these results for knowledge management.

## 5.2 Theoretical Background

In this section, we describe the theoretical background of our knowledge mapping technique. First, we introduce the Montague Grammar (Montague, 1974), a theory about formal semantic interpretation of natural languages which provides the foundation for our automated semantic clustering and network visualization. Second, we describe the theory of mental models and the distributed cognition theory and synthesize them for our model-based knowledge management approach.

### *5.2.1 Semantic Interpretation and Categorization*

Semantic interpretation is one central aspect in model and knowledge construction. While constructing a mental model or interpreting states of the world, a cognitive system operates on objects derived from semantic interpretation (Pirnay-Dummer, 2006; Seel, 1991). However, semantic interpretation is independent of the model construction but essential for this process. We state that the semantic interpretation provides the bits and pieces which are arranged during the model building process. Moreover, a model-based semantic interpretation yields the right formats for later model composition. Accordingly, we connected model-based semantic interpretation and mental model building. The synthesis will form a comprehensive theory on how the composition process may be carried out within any system.

According to the Montague Grammar (Montague, 1974), the semantics of a statement can be interpreted by means of a certain interpretation structure $\langle M, D, G \rangle$, where $M$ denotes a certain model structure, $D$ an evaluation function, and $G$ a set of assignments of variables to values. The model structure $M$ consists of the following elements (Montague, 1974):

$M = E$ : a set of individuals which are elements of the model
$W$ : a set of possible worlds where the conditions are possible
$T$ : a set of times at which the conditions are possible
$\{1, 0\}$ a set of truth values

For the interpretation of a statement, a set of different models of time and worlds is possible. In order to elicit the semantics of a statement, categorization is necessary. Therefore, Montague (Montague, 1974) introduced a hierarchy of so-called TYPES which structure the different models. This categorization can then be interpreted via truth values.

As can be seen, categorization is the central method for interpreting the semantics of a statement. This approach can also be broadened in order to analyze the semantics of entire text corpora of an organization, e.g., with the help of the latent semantic analysis approach (Landauer, Foltz, & Laham, 1998).

### 5.2.2 Mental Models and Model-Centered Instruction

So far, semantic interpretation has been considered as an essential but independent operation of mental models. Mental models are knowledge structures which are constructed ad hoc depending on the situation and the cognitive system's knowledge (Ifenthaler, 2006; Pirnay-Dummer, 2006; Seel, 1991). People construct them when they experience assimilation resistance (Piaget, 1976; Pirnay-Dummer, 2006), meaning that new information from the external world is not in accordance with the preconceptions of a cognitive system. This information cannot be simply integrated into the knowledge structures. Rather, the cognitive system has to reconstruct and reorganize its cognitive structures (accommodation) until the model is subjectively plausible for the cognitive system, i.e., until the estimated effect of a reasoning-based act is satisfactory to the system. Due to their ad hoc (on the fly) construction, mental models are, in contrast to schemata, not stable. Anything which is stable and like a mental model is a schema.

The powerful naturally occurring circumstance raised from the demand for equilibrium can be used in learning and instruction because cognitive systems will have to construct models until they reach equilibrium between the internal representation and the outside world.

In learning situations, learners construct mental models in order to explain and understand real situations and processes (Seel, 2003). Therefore, the goal of model-centered instruction is to support the construction of mental models externally by providing learners with an instructional model which – as a model in general – is meant to simplify, visualize, and simulate complex phenomena. Furthermore, models support the learner's analogies (Seel, 2003).

### 5.2.3 Distributed Cognition

Hitherto, individuals have usually been considered to be cognitive systems. Distributed cognition (Hutchins, 1995), whose roots lie in the investigation of socio-technical systems like cockpits, considers groups and its environment as an entire cognitive system. Therefore, the knowledge representation and the cognitive processes operating upon it are distributed among a social group and externalized artifacts in its surroundings and also through time. Additionally, operations of the cognitive system must be coordinated between external and internal representations. This does not mean that this system has any kind of consciousness or a shared knowledge representation but that it is distributed internally in the individual's mind and in the externalized artifacts. However, cognitive processes – especially reasoning – can be distributed throughout the system. In extreme cases, the system may make decisions which result in concrete acts (highly desirable, e.g., in a cockpit) without a single individual having the whole decision model in his or her mind at the time of decision. For our further theoretical framework, we used the powerful explanations from distributed cognition to explain decision-making processes within organizations more precisely.

### *5.2.4 Model-Based Knowledge Management*

According to the theory of "distributed cognition" (Hutchins, 1995, 2000), an organization may be considered as a complete cognitive system. Thus, the knowledge base of an organization is distributed among its artifacts, agents, and actions. For model-based knowledge management, we propose a three-layer generic model of knowledge representation (Pirnay-Dummer & Lachner, 2008) (see Fig. 5.1). The first layer represents stable schemata within the individuals. These individual schemata can be externalized in organizational standards and routines. Individual ad hoc constructed mental models are represented by the second layer (Seel, 1991). These mental models operate upon the individual schemata and support organizational flexibility and adaptivity. Hence, these individual models deviate from each other, although they are part of the same subject domain (Pirnay-Dummer & Lachner, 2008). The third layer maps the organizational model. This model also deviates from the individual models. Additionally, it cannot be considered to be the set union of all individual models because of its system dynamics (Bossel, 2004; Pirnay-Dummer & Lachner, 2008). This organizational model can evoke direct actions and decisions.

Normally, the organizational model is implicit and not visible at all. By nature it cannot be externalized by single experts or even groups of them, e.g., in a consensus process. In fact, if any individual (other than the organization itself) does the interpretation, it will be an individual model again. Hence, we have to develop methodologies to assess the organizational model directly to some possible extent. However, in order to be applied on an everyday basis, the organization has to implement fast and holistic assessment methodologies which do not require for knowledge to be assessed individually or with a lot of manual effort. The purpose of all interventions of model-based knowledge management is to visualize the organizational model for structuring decision processes, needs assessment (Pirnay-Dummer & Nußbickel, 2008), quality assurance or meeting support.

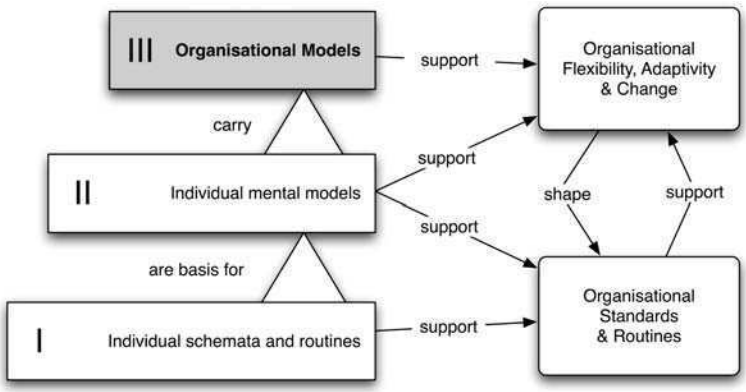


**Fig. 5.1** Three layers of model-based knowledge management

## 5.3 Conventional Knowledge Mapping

As mentioned above, the first step in knowledge management is to visualize the organizational knowledge. A conventional knowledge assessment technique is the construction of organizational knowledge maps. Some of the available techniques concentrate on meta-information on the knowledge rather than showing the knowledge itself. Such assessments are important for all kinds of organizational procedures (see Eppler, 2001). When it comes to conceptual knowledge, knowledge maps can be seen as graphical re-representations of organizational models which are supposed to enhance knowledge elicitation and dissemination (Eppler, 2001). Knowledge maps are usually constructed in five steps (Eppler, 2001):

1. Knowledge analysis of the diverse departments by way of interviews with stakeholders
2. Knowledge modeling
3. Knowledge visualization
4. Implementation
5. Update

These conventional knowledge mapping techniques implicate some tremendous discrepancies. The construction of a specific knowledge map is very time-consuming because stakeholders of diverse departments have to be interviewed and these interviews have to be transferred to a knowledge model (Eppler, 2001).

In the described way, the recent (ad hoc) knowledge can never be re-represented because knowledge is always a dynamic construction process (Seel, 1991). Additionally, the costs of a knowledge map are significantly high because several experts have to collaborate to construct one (Eppler, 2001), both experts on knowledge maps and experts on the given task or domain. Finally, the output of a knowledge map will raise validity issues because the overall knowledge of the whole organization cannot be assessed when the assessment is conducted through interviews with individual stakeholders and a lot of confounding variables distort the results of the knowledge map, especially within the key positions in the process of interpretation. This makes it necessary to use or create other valid methodologies. Therefore, we propose a new knowledge mapping methodology in the next section which may help to address some of the still existing problems.

## 5.4 Model-Based Knowledge Mapping

Instead of interviewing certain stakeholders, one can assess the *database* of the individual organization whenever it contains the significant parts of knowledge. This will work even if a company only uses parts of the available modern information infrastructure – even if there is simply and only a document management system available and no further technologies have yet been applied at the company. Typically, each department of an organization documents its processes in order to allow decision-making processes to be reconstructed. Therefore, sufficient text corpora which represent organizational information are usually available as a powerful data source, and they can be used to assess the organizational models directly with the help of computer linguistic techniques.

The model-based knowledge mapping methodology consists of three main modules: a preprocessing component which parses the ad hoc organizational text corpora, a semantic clustering component which prestructures the organizational knowledge base, and a visualization component which visualizes the prestructured text corpora as a model (see Fig. 5.2).

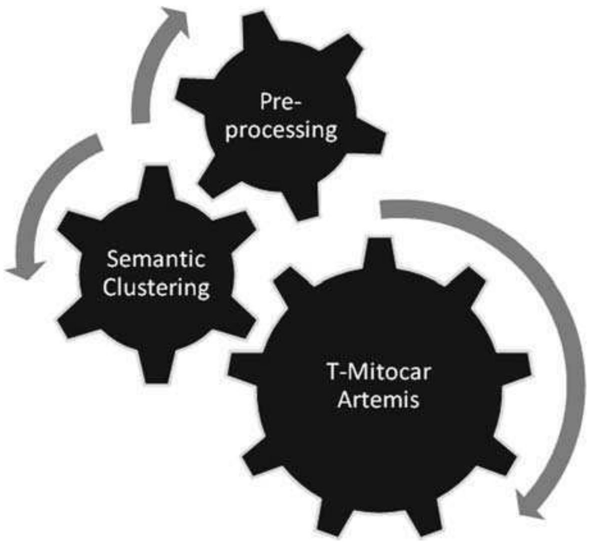


**Fig. 5.2** Modules of model-based knowledge mapping

### 5.4.1 Preprocessing

The task of this module is to preprocess the text corpora with computer linguistic techniques and to store the preprocessed text corpora in an organizational knowledge base. First of all the documents are tokenized. This means that a list of all words in the documents is generated in order to make them machine readable. Afterward, a stop word filter is applied in order to eliminate unnecessary words such as pronouns or adverbials. Additionally, a Porter stemmer (Porter, 1980) reduces all words to their word stem in order to enhance the precision of the clustering algorithm by eliminating suffixes and prefixes.

### 5.4.2 Semantic Clustering

The semantic clustering module structures the organizational knowledge base concerning a specific knowledge domain. Therefore, a structuralist approach is applied. First, the organizational database is analyzed according to a query for a knowledge domain. Then, the detected text corpora are converted into a term-document frequency matrix ($X$), where each row represents a single word of the whole text corpus, the columns represent all of the documents on the database, and the cell entries represent the frequency of the individual words per document (see Table 5.1).

**Table 5.1** Example for a text-document frequency matrix

| | Doc 1 | Doc 2 | Doc 3 | Doc 4 |
|---|---|---|---|---|
| Philosophy | 2 | 1 | 4 | 4 |
| Mind | 1 | 0 | 3 | 2 |
| Permutation | 8 | 1 | 2 | 2 |
| Analysis | 3 | 3 | 3 | 2 |
| Lisrel | 1 | 1 | 7 | 4 |
| Cognition | 2 | 3 | 4 | 1 |
| Cancer | 0 | 2 | 3 | 3 |
| Problem | 1 | 1 | 1 | 5 |
| System | 0 | 4 | 7 | 9 |
| Model | 8 | 3 | 5 | 1 |

Afterward, a logarithmically weighted tf-idf-term document matrix ($X'$) (see Table 5.2) is computed, with a local weighting function term frequency:

$$\text{tf} = (\text{freq}_{ij})/(\max_l(\text{freq}_{l,i}))$$

and a local weighting function for inverse document frequency,

$$\text{idf} = \log N/n$$

where $N$ corresponds to all text corpora in the matrix and $n$ to the text corpora in which $j$ occurs.

**Table 5.2** Weighted tf-idf-term-document matrix $X'$

| | Doc 1 | Doc 2 | Doc 3 | Doc 4 |
|---|---|---|---|---|
| Philosophy | 1.09 | 0.69 | 1.61 | 1.61 |
| Mind | 0.98 | 0 | 1.96 | 1.55 |
| Permutation | 2.19 | 0.69 | 1.09 | 1.09 |
| Analysis | 1.38 | 1.38 | 1.38 | 1.09 |
| LISREL | 0.69 | 0.69 | 2.07 | 1.60 |
| Cognition | 1.09 | 1.38 | 1.61 | 0.69 |
| Cancer | 0 | 1.55 | 1.96 | 1.96 |
| Problem | 0.69 | 0.69 | 0.69 | 1.79 |
| System | 0 | 2.27 | 2.94 | 3.25 |
| Model | 2.19 | 1.38 | 1.79 | 0.69 |

These local weighting scores are multiplied and replaced in $X'$ in order to enhance the categorization and to evaluate and emphasize important documents within the text corpus (Salton & McGill, 1983).

Then, an $n$[1]-dimensional singular value decomposition over the text matrix is computed in order to detect latent relations between words and documents and to eliminate noise (Landauer, Foltz, & Laham, 1998). First, the matrix $X'$ is decomposed into three submatrices, such that $X' = T_0 * S_0 * D_0$.

$T_0$ and $D_0$ are orthogonal. The values of $S_0$ are arranged in a rank order and the $n$ largest values remain. This method gives us an approximation of the original matrix $X'$ with enhanced latent relations and reduced noise. Table 5.3 illustrates the approximation matrix $X''$ with $n = 4$.

**Table 5.3** Approximate SVD Matrix $X''$

| Doc 1 | Doc 2 | Doc 3 | Doc 4 |
|---|---|---|---|
| –0.32 | 0.91 | –0.13 | 0.21 |
| –0.40 | –0.06 | 0.87 | 0.23 |
| –0.63 | –0.05 | –0.09 | –0.76 |
| –0.57 | –0.39 | –0.44 | 0.55 |

Afterward, the $k$-means clustering algorithm is applied to the approximate text matrix, which assigns the individual documents to a predefined number of categories (Lloyd, 1982). In order to detect a valid number of categories, the SSI index (Weingessel, Dimitriadou, & Dolnicar, 1999) between $[2...k]$ is computed and the category number with the highest ssi value is selected for the number of categories.

[1] $n$ depends on the tf-idf weighted matrix.

## *5.4.3 Data Visualization with T-MITOCAR Artemis*

After the clustering, the knowledge map is constructed.

### 5.4.3.1 Prior Work

MITOCAR (Model Inspection Trace of Concepts and Relations) can visualize knowledge from groups of experts. Its technology uses natural language expressions and several subsequent tests which the experts work on individually. The group's knowledge is aggregated by the methodology. The whole process of knowledge elicitation has shown itself to be homogeneous, highly reliable, and valid (Ifenthaler, 2007; Pirnay-Dummer, 2006, 2007). MITOCAR automatically generates interpreted reports on group knowledge and on its comparison.

T-MITOCAR (Text-MITOCAR) is based on MITOCAR and can visualize knowledge structures on the basis of written text. It uses several tagging and parsing techniques similar to semantic web algorithms based on association psychology to represent model structures within text as an associative network (Pirnay-Dummer & Spector, 2008).

### 5.4.3.2 Knowledge Mapping with T-MITOCAR Artemis

T-MITOCAR Artemis (Lachner & Pirnary-Dummer, 2008) is a further development which uses the core modules of T-MITOCAR to generate knowledge maps. It has multicluster text corpora as input from multiple possible sources. Thus, an automatically preclustered corpus which resembles the written knowledge of a work group, a department, or even a whole company can be used without further formatting (e.g., tagging) and without any manual work. Each cluster is graphically visualized by Artemis and becomes a "continent" on the knowledge map. Each continent is represented in a different color. The whole process takes from 2 min to several hours, including the time for clustering (usually 0.5–3 min) and for graphical representation (between 1 min and several hours depending on the amount of text material). Compared to classical manual knowledge mapping techniques this is still fast, but the computing power is still beyond what is feasible in real time on a web server. Therefore, in contrast to T-MITOCAR, which is an online tool, Artemis can only be run offline.

#### Input Formats and Interface

There are three interfaces (input formats) available for T-MITOCAR Artemis at the moment. The first one is a ZIP file which contains each text cluster as a separate plain text file, utf-8 encoded. This format is suitable if Artemis is used as part of our model-based knowledge mapping methodology. The second interface is also a ZIP file, but it contains further ZIP files, one for each continent of the knowledge map. The further ZIP files contain at least one MS Word format file (.doc) each. They may each contain more than one Word file. In the process, the Word files within each

ZIP file are treated as one cluster (one individually colored continent). This format is suited for manual clustering from multiple sources when Word files are available. The third interface links Artemis directly to Wikipedia. Artemis needs at least one term as input and constructs the map using the text from Wikipedia as a corpus. Each term builds a continent on the map. This technology could easily be used to process documents from the web onto the knowledge map. Unfortunately, the APIs (Application Programming Interface) to search engines are far from available. Some good API services have even been practically discontinued, e.g., the Simple Object Access Protocol, SOAP, from Google, which stopped providing new access codes in 2006.

### Output Format of the Knowledge Map

As output, T-MITOCAR Artemis first generates a list form of the graph (Pirnay-Dummer, 2007) and then a bitmap in the Portable Network Graphics format (PNG) using GraphViz (Ellson, Gansner, Koutsofios, & North, 2003). A miniature of this map can be seen in Fig. 5.3.

Usually these maps are printed in much larger formats. Figure 5.4 shows details of the intersections between continents at the center of the map. The complete image of the knowledge map derived from the preclustered text corpora can be downloaded at the following URL: http://elena.ezw.uni-freiburg.de/pic/km_full.png.

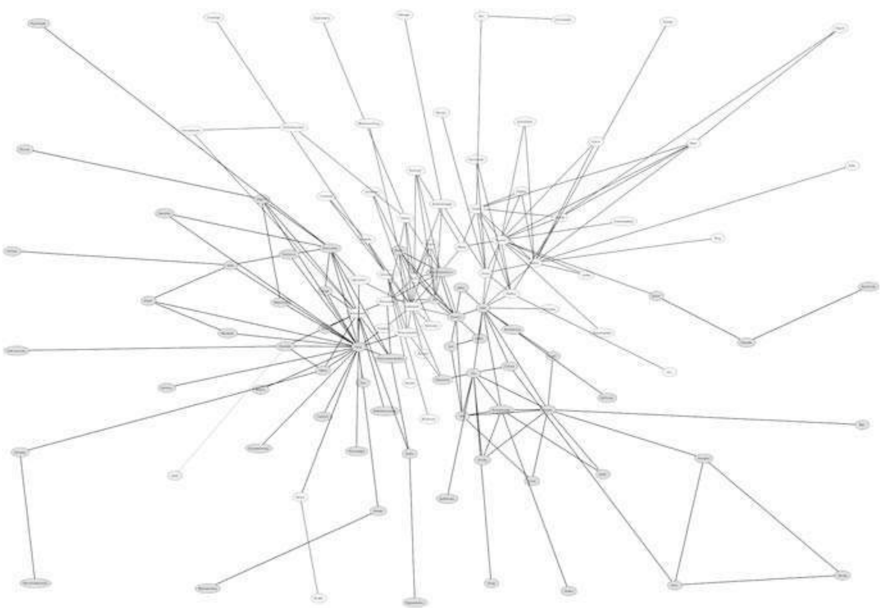

**Fig. 5.3** Miniaturized knowledge map

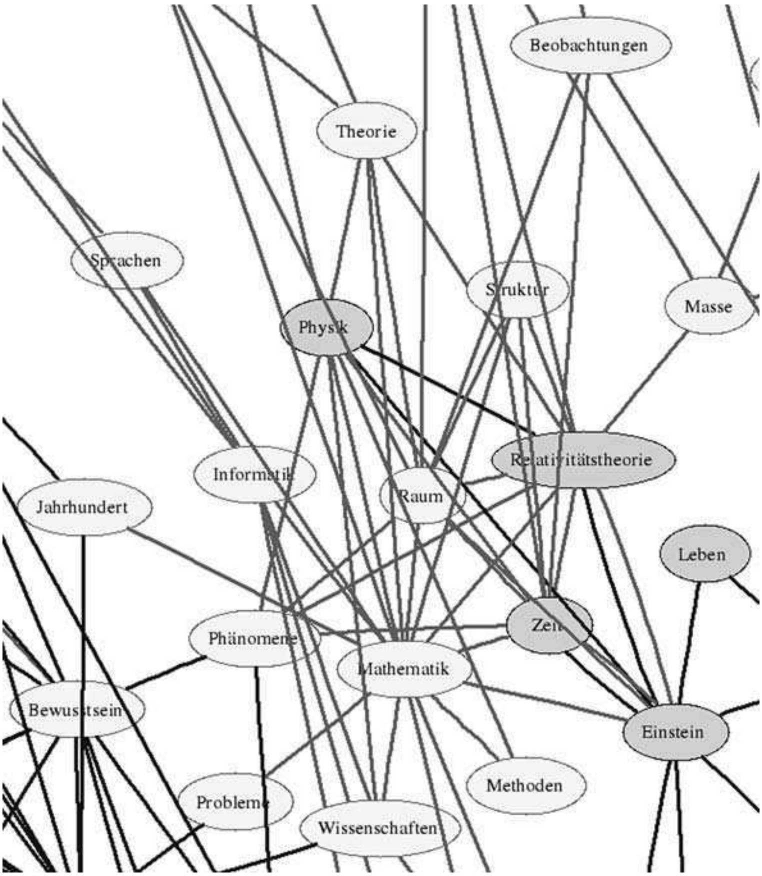


**Fig. 5.4** Detailed knowledge map

## 5.5 Technological Study

To test the assumption that our model-based knowledge mapping methodology is capable of clustering untagged and unstructured text corpora semantically without exact annotations, we constructed a small-scale database with 28 texts derived from the German Wikipedia (http://de.wikipedia.org). The topics of the documents were human and natural science and geography. Via our semantic clustering technology, four distinct categories were found (see Table 5.4).

The results indicate that our methodology can find suitable and valid categories. As can be seen, cluster 1 ($N = 9$) contains topics from cognitive science and physics with a strong relation to mathematics. Cluster 2 ($N = 3$) can be interpreted as a representation of philosophical issues. In contrast, cluster 3 ($N = 9$) represents documents with a strong focus on the United States, and Cluster 4 ($N = 6$) emphasizes topics concerning planets. Also, the cluster centroids indicate that the different clusters represent distinct categories.

The results also affirm our hypothesis that untagged and unstructured text corpora can be clustered semantically without exact annotations. Thus, this semantic clustering approach seems to be appropriate for knowledge assessment within organizations.

**Table 5.4** Results from the technological study

| Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 |
|---|---|---|---|
| Attention | Consciousness | USA | Mercury |
| Theory of relativity | Philosophy of mind | Bill Clinton | Milky way |
| Mental models | Mind | Florida | Pluto |
| Theory of mind | | Software | Neptune |
| Physics | | Albert Einstein | Planet |
| Brain | | California | Sun |
| Metacognition | | Hardware | |
| Computer science | | Galaxy | |
| Mathematics | | Alaska | |
| Total | | | |
| 9 items | 3 items | 9 items | 6 items |
| Cluster centroids | | | |
| (–0.15; –0.09) | (–0.31; –0.36) | (–0.08; 0.01) | (–0.257; 0.278) |

## 5.6 Validation Study

So far we have tested the feasibility of our methodology. In order to prove the validity of our model-based knowledge mapping methodology, we also conducted a cross-validation study with real subjects.

### *5.6.1 Hypotheses*

The following set of hypotheses was tested in our experimental study. In order to understand the strengths and weaknesses of our methodology, we compared the clustering results from the technological study (TCL) with human clustering results (HCL).

For the cluster comparison, we derived the following hypothesis:

$H_{1.0}$ The TCL[2] differs from HCL[3]
$H_{1.1}$ The TCL does not differ from HCL

[2] Technological Clusters derived from our methodology.
[3] Human Clusters made by the subjects.

In order to ensure that the clustering derived from our methodology was an admissible categorization which fit the subjects understanding, we made the following hypothesis:

$H_{1.0}$ Subjects disagree that the TCL is an admissible categorization.
$H_{1.1}$ Subjects agree that the TCL is an admissible categorization.

## 5.6.2 Method

### 5.6.2.1 Participants

Twenty-one students (12 female and 9 male) from the University of Freiburg, Germany, participated in the validation study. Their average age was 23.90 (SD = 2.76).

### 5.6.2.2 Procedure

The experiment was conducted in our research lab and consisted of three phases. In the first phase (15 min), the subjects were asked to open and scan the 27 documents already used in the technological study according to their topic and structure. In the second phase (10 min), the subjects had to categorize the documents in four categories. There were four folders (ws_*n*-cl1 – ws_*n*-cl4[4]) on their Microsoft Windows desktop for this purpose, which they had to fill with the most similar documents. The premises were that the subjects could only assign one document to one folder, i.e., no multiassignments of documents were allowed. Second, it did not matter which folder the subjects started with. However, the most similar documents had to be situated in one folder. In the third phase (5 min), the subjects were asked to assess the TCL. They were thus given the original TCL (see Table 5.4). Additionally, they had to prove the TCL and afterward to fill out a questionnaire.

### 5.6.2.3 Instruments

In order to compare the TCL and HCL (phase two), we compared each HCL cluster with the TCL cluster via the Tversky similarity (Tversky, 1977) because it is a similarity measure for sets (where $s = 0$ means complete exclusion and $s = 1$ complete identity of sets). The Tversky similarity measure is calculated in the following way:

$$s = \frac{f(A \cap B)}{f(A \cap B) + \alpha \cdot f(A - B) + \beta \cdot f(B - A)}$$

In phase three, we used a self-constructed questionnaire (Cronbach's $\alpha = 0.69$). It consisted of nine items which were supposed to measure the adequacy of the TCL. The answers were collected on a 5-point Likert scale.

[4] *n* denotes the subject number.

### *5.6.3 Results*

#### 5.6.3.1 Cluster Comparison

To answer our first research question, namely whether the technological categorization differs from the human categorization, we compared each subject's cluster with the technological cluster (Table 5.5).

As shown in Table 5.5, the similarities between cluster 1, cluster 3, and cluster 4 are significant. Therefore, we can accept our hypothesis that the technological clusters do not differ from the human clusters. However, cluster 2 was not significant.

**Table 5.5** Results from the comparison of TCL-HCL

| Subject number | Similarity with TCL 1 | Similarity with TCL 2 | Similarity with TCL 3 | Similarity with TCL 4 |
|---|---|---|---|---|
| ws_1 | 0.59 | 0 | 0.71 | 0 |
| ws_2 | 0.59 | 0 | 0.71 | 0 |
| ws_3 | 0.59 | 0 | 0.31 | 0.75 |
| ws_4 | 0.59 | 0 | 0.71 | 0 |
| ws_5 | 0.59 | 0 | 0.38 | 0.92 |
| ws_6 | 0.59 | 0 | 0.38 | 0.83 |
| ws_7 | 0.59 | 0 | 0.47 | 0.92 |
| ws_8 | 0.59 | 0 | 0.71 | 0 |
| ws_9 | 0.59 | 0 | 0.71 | 0 |
| ws_10 | 0.46 | 0.67 | 0.71 | 0.71 |
| ws_11 | 0.59 | 0 | 0.71 | 0.92 |
| ws_12 | 0.53 | 0 | 0.71 | 0 |
| ws_13 | 0.67 | 0.67 | 0.53 | 0 |
| ws_14 | 0.59 | 0 | 0.71 | 0 |
| ws_15 | 0.59 | 0 | 0.71 | 0 |
| ws_16 | 0.59 | 0 | 0.71 | 0 |
| ws_18 | 0.6 | 0 | 0.71 | 0 |
| ws_19 | 0.67 | 0.25 | 0.71 | 0 |
| ws_20 | 0.59 | 0 | 0.71 | 0.92 |
| ws_21 | 0.59 | 0 | 0.71 | 0.92 |
| ws_22 | 0.59 | 0 | 0.71 | 0.92 |
| MEAN | 0.59*** | 0.08 | 0.64*** | 0.37* |
| SD | 0.04 | 0.20 | 0.13 | 0.44 |
| t | 3.93 | 0.33 | 4.72 | 1.88 |

*$p < .05$
***$p < .00$

#### 5.6.3.2 Adequacy

In order to test whether the technological categorization was an admissible categorization, we had the subjects fill out the adequacy questionnaire (1 = totally agree, 5 = totally disagree). The results can be seen in Table 5.6.

**Table 5.6** Results from the questionnaire

| Question | Means | SD |
|---|---|---|
| 1. The categorization is understandable. | 3.05 | 1.05 |
| 2. I can imagine that this categorization was made by an expert. | 3.15 | 1.03 |
| 3. The documents are clearly assigned to topics by the categorization. | 3.4 | 1.02 |
| 4. The documents of the individual categories do not overlap. | 3.9 | 1.26 |
| 5. The categorization seems arbitrary. | 3.55 | 1.07 |
| 6. There are connections between the content of the documents in Category 1. | 3.05 | 1.10 |
| 7. There are connections between the content of the documents in Category 2. | 1.55 | 0.84 |
| 8. There are connections between the content of the documents in Category 3. | 3.3 | 1.23 |
| 9. There are connections between the content of the documents in Category 4. | 1.2 | 0.42 |

As Table 5.6 shows, the subjects could not clearly assess whether the technological categorization was an admissible categorization. Nevertheless, they assumed that the categorization was not arbitrary and rated the documents in categories two and four as being well connected to each other.

## 5.7 Discussion

As the results of the technological study and the validation study indicate, our model-based knowledge mapping approach can be seen as a valid automated methodology for the categorization and visualization of organizational knowledge. This automation is also necessary because organizational databases are usually considerably large and often unstructured. When implemented using the methodological process discussed in this chapter, our approach for knowledge assessment is an efficient and precise alternative for knowledge mapping in situations in which documents are available that correspond to the knowledge of an organization. One of the striking arguments for our approach is that the organizational models can be directly assessed with only the text documents at hand. The process model for our knowledge mapping approach can be seen in Fig. 5.5:


**Fig. 5.5** Process model

First of all, a preprocessing component converts the document into a computer-readable format. Afterward, the semantic clustering component is applied, which prestructures the text corpora. Then, the text visualization component T-MITOCAR

Artemis is used in order to construct a knowledge map directly from the prestructured text corpora (see Fig. 5.4). This convenient methodology can be used for a variety of knowledge management interventions, such as for needs assessment (Pirnay-Dummer & Nußbickel, 2008), quality assurance, or meeting support.

Compared to the core modules of MITOCAR and T-MITOCAR, classical knowledge maps are by far less precise. They usually rely on single judgments of experts which have to be interpreted by nonexperts (nonexperts in the investigated subject domain, e.g., knowledge engineers) in order to be integrated into the map (Huijsen, Driessen, & Jacobs, 2004; Vail, 1999), which is constructed like a mind map or concept map. If a fitting corpus that resembles the organizational knowledge exists, maps can be generated automatically in a very short amount of time. Our methodology has shown how the different well-validated heuristics available today can help to pave the way from completely untagged text and files to semantically clustered graphical knowledge maps. All of the intermediate steps can be processed automatically with existing heuristics from computer linguistics and model-based knowledge assessment strategies. Our current and future studies concentrate on the implementation and evaluation of the automatically generated maps in practical applications, e.g., in meetings and decision-making processes in companies. This research will also help to improve on the algorithms and organizational processes involved in model-based knowledge management.

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# Chapter 6
# Prototype for the Knowledge Representation Supporting Inter-institutional Knowledge Flow Analysis

**Ieva Zeltmate, Marite Kirikova, and Janis Grundspenkis**

**Abstract** Each academic year the changes caused by different knowledge levels of the learners and changing teaching standards in educational institutions create a necessity to make adjustments in the educational process. The learner is an important member of the educational process affected by the knowledge flow between institutions. The learner-acquired knowledge characterizes the teaching result and is an essential criterion for the teaching staff to be able to adapt to the frequently changing learning situations. This chapter identifies potential inter-institutional knowledge flows in the context of educational system. The solution that helps to identify the student knowledge level and provide consistent knowledge flow support is described. The development of the prototype and its role in the educational system is discussed, too. The proposed solution gives an opportunity to overcome the challenges of teaching domain complexity with respect to time and scale dimensions.

## 6.1 Introduction

It is well known that knowledge sharing and dissemination is crucial at educational institutions. At the same time, the existence of differently structured knowledge areas at various educational institutions leads to differences in knowledge interpretation and representation and, as a consequence, also to differences in the understanding of the domain. During their studies, learners pass through several educational institutions and obtain knowledge based on each institution's structured presentations of knowledge they encounter. Each year a new contingent of students enters the university, and it is important to adapt and find optimal requirements and teaching strategies in changed teaching situation. The prior knowledge level of the learners determines the amount of information that first-year students are

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capable to absorb and process. To establish how learner knowledge complies with standards and university requirements, it is necessary to acquire, analyze, and evaluate prerequisite knowledge level of each freshman. In this chapter, we propose to accomplish the given task by considering inter-institutional knowledge flows in the educational process and by creating inter-institutional knowledge flow supporting prototype implemented in digital form (further PIIKFS).

The objective of this chapter is to describe the solution that helps to analyze students' knowledge and the actual knowledge flows between educational institutions. Exploration of knowledge flows allows to predict students' knowledge in the future, to set adequate entry requirements at the university, and to adjust these requirements to the changes of the prerequisite knowledge level. The solution incorporates the requirements (domain, complexity, roles, and appropriate representation) that are common in the knowledge dissemination and that are implemented in the prototype.

Authors acknowledge that they have not found similar solutions that are specific for inter-institutional knowledge flow processing and analysis in the educational institution context. The conceptual structure that was made for a specific knowledge area, namely, knowledge schema, serves as the starting point of knowledge identification. The knowledge schema was saved within the knowledge representation shell called Frame System (Zeltmate, 2007).

This chapter is structured as follows. In Section 6.2, the application domain specifics are described. Section 6.3 reflects requirements and challenges for digitalized knowledge flow support. In Section 6.4, the solution that takes into account significant aspects of teaching complexity, time and scale, is discussed. The PIIKFS is described in Section 6.5. Conclusions and some trends of future work are presented in Section 6.6

## 6.2 Application Domain Specifics

Knowledge transfer in the field of Informatics was chosen as the specific knowledge area (application domain) and explored in terms of the analysis of inter-institutional knowledge flows (Zhuge, Guo, & Li, 2007). Identification, storage, and analysis of knowledge flows are needed to improve and to understand the activities, roles, and related information associated with educational process. Differently structured knowledge like speaking one language but different dialects overcomplicates the communication between the members of educational process and shows that there exist particular conceptual gaps between participants' knowledge variations. It is necessary to create structured schema that serves as a guideline and is common, shared, and acceptable in all knowledge flows. The analysis of inter-institutional knowledge flows can help to determine the conformity and gaps between the university program requirements and the student knowledge levels. The growing necessity to find a digital solution for the student knowledge assessment is also one of the reasons why the knowledge flows must be analyzed.

Secondary school students enter the university with different levels of acquired knowledge, depending on the school, teachers, available technologies, and personal qualities. The differences between knowledge content and amount which is offered at the university and which a first-year student is able to acquire are quite significant. The knowledge coordination using knowledge flows in educational system (i.e., the interrelated institutions that are involved in educational process) can be useful to meet student contingent needs and efficiently respond to changes in educational process.

The educational system may include several members, i.e., institutions as shown in Fig. 6.1: (a) University, (b) School, (c) Ministry of Education, (d) Teacher's educational institution, (e) Science, and (f) Industry. The knowledge transfer between the institutions is represented with the knowledge flows.

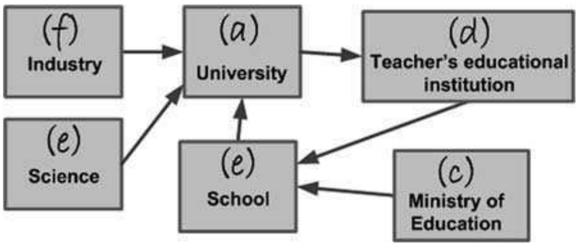


**Fig. 6.1** Sketch representing the flows between institutions

There may exist four knowledge flows between the University and other institutions. One flow from the University to the Teacher's educational institution and three flows to University: from the Science, from the Industry, and from the School. Two more flows may also exist between School and other institutions: one from the Ministry of Education and one from the Teacher's educational institution. More discussion of these knowledge flows is presented in the authors' previous paper (Zeltmate, Kirikova, & Grundspenkis, 2008). In this chapter, only a small part of educational system is surveyed. The authors of the chapter are interested in two educational system members, namely, University and School that have the largest number of the flows to or from other institutions and have substantial role in the learners' education.

Previously mentioned knowledge flows in directly or indirectly include information about the educational standard in Informatics (Ministry of Education, 1993). The standard of general secondary education in Informatics in Latvia is used to create the course structure or knowledge schema that includes the description of competences and skills that a learner must achieve in the subject of Informatics. Knowledge schema is relatively common for all schools in Latvia because the development of Informatics courses for secondary schools is standardized.

In order to choose the knowledge representation approach suitable for knowledge gaps and knowledge flow analysis, the following two requirements were set:

1. The scheme should preserve those structures of concepts that are explicitly represented in the document regulating knowledge scope in Informatics for secondary schools (e.g., standard in Informatics)
2. The scheme should not impose the structures which are not explicitly reflected in the regulations.

Several knowledge representation forms were considered (class diagrams, process diagrams, etc.); however, none of them proved to be useful. The class diagram did not allow linking procedural knowledge with declarative one outside the boundaries of one class, process diagrams imposed relationships between concepts which were not present in the regulations. Therefore, the frame-based representation was chosen. It allowed using all structures from the regulations and did not require establishing artificial knowledge constructs just for the sake of the mechanism of knowledge representation. As a result of the analysis of the standard, fundamental concepts of the domain and logical relationships between the concepts were acquired and a clearly structured knowledge schema created (see Fig. 6.2). Concepts of domain were classified and organized in one structure where each concept represents one knowledge element. A knowledge element either can be part of or can

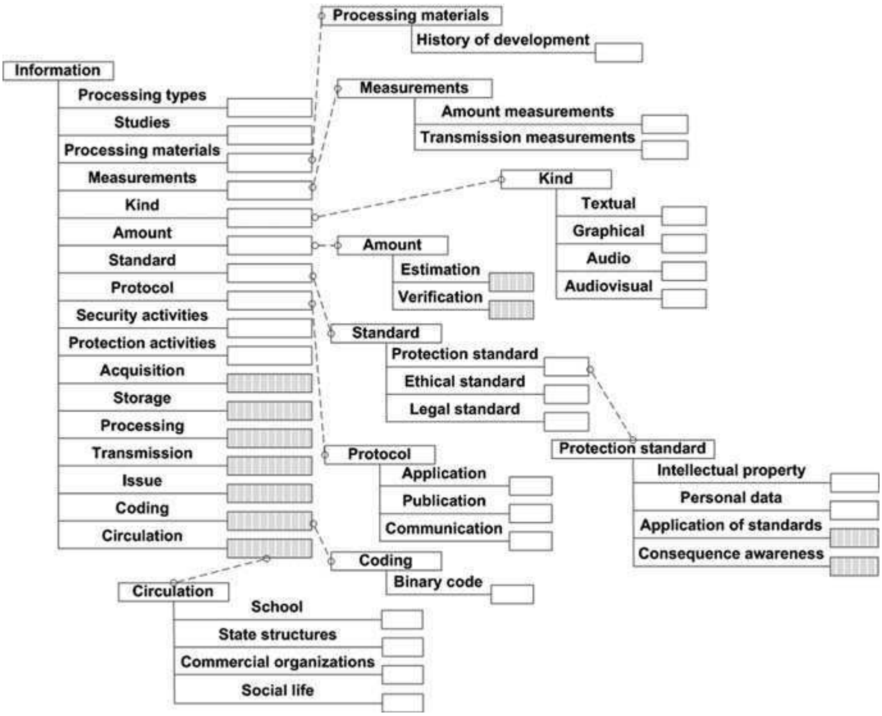


**Fig. 6.2** Example of knowledge schema

include another knowledge element. Each knowledge element can have properties that describe the details of concept and relations that allow understanding the concept's significance and location in the whole schema. It means that the context and logics of knowledge elements are acquired identifying the relationships with other elements. A knowledge element can be connected with elements that are located somewhere in the structure creating horizontal hierarchy. Concepts can be decomposed in two different types of subordinate concepts as shown in Fig. 6.2:

- The first describes knowledge or learning results that are associated with remembering and understanding. Concepts are reflected with lightened shading.
- The second describes skills or learning outcomes associated with the ability to apply, analyze, and evaluate. Concepts are reflected with darkened shading.

To show a decomposition example, the concept Information from Fig. 6.2 is used. The concept includes 10 subconcepts that refer to understanding: Studies, Processing Types, Processing Materials, Measurements, Kind, Amount, Standard, Protocol, Security Activities, and Protection Activities. Seven subconcepts that refer to skills are also mentioned: Acquisition, Storage, Processing, Transmission, Issue, Coding, and Circulation.

The knowledge schema is a structured, combined collection of concepts, relations, and additional attributes. We assume that the created structure is the normative standard for the specific knowledge area and each student is able to reach some knowledge level in this area. After defining knowledge schema, we use it to choose a solution that can be implemented in the PIIKFS to provide intuitively clear knowledge representation, acquisition, storage, and maintenance. The solution that complies with clearly defined knowledge schema may contribute to the data acquisition from the students, interpretation of knowledge area context, statistical analysis and generalization of acquired data, identification of students' knowledge levels, and knowledge fluctuation analysis.

## 6.3 Requirements and Challenges Concerning the PIIKFS

Several aspects that are important in consistent knowledge acquisition, storage, representation, processing, and maintenance were taken into consideration when the requirements for the prototype were made. PIIKFS was created in compliance with the stated requirements:

- Processing of incomplete information,
- knowledge acquisition and storage based on the created schema,
- two different types of concepts, associative relations, and decomposition hierarchy representation,
- all necessary aspects about the chosen concept consistent representation – describing concept-related additional information,

- visualized knowledge acquisition and representation to guide a considerate knowledge acquisition from students. Structured, but expressible to display everything that is necessary at a certain moment,
- development of statistics, knowledge that we are interested in is acquired in continuous time (over years) from numerous individuals (first-year students),
- the representation of knowledge of numerous students. One shared structure is used for many instances with similar knowledge in the prescribed domain,
- acquired knowledge analysis, evaluation, and potential entrant's knowledge prediction, and
- finally, an important requirement: the tool must be easily accessible, applicable, and adaptable for the knowledge schema and information reuse.

The identification of the requirements allowed detecting challenges (see Fig. 6.3) that affect the development of the PIIKFS.

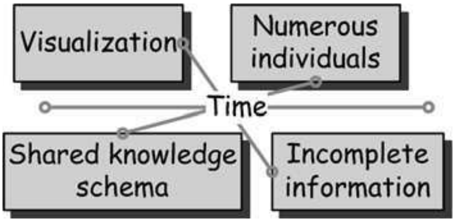


**Fig. 6.3** The challenges

It is evident that there cannot be any knowledge processing without representation. In this chapter, the challenge of the visualization is understood in the context of the knowledge representation. The provided knowledge representation as well as all represented information in the PIIKFS is visualized in a simple and coherent manner to promote easiness of the context understanding and the use of prototype. Visualization also is an instrument that makes possible the interactivity in the PIIKFS.

To acquire and represent concepts of a specific knowledge area is as important as to acquire and maintain student-represented knowledge about this specific knowledge area. Additional information about concepts that are specific to each case in the context of student knowledge must be considered as well. Here, the requirements meet the challenge of handling numerous individual knowledge cases. The educational process involves not only a large number of students but also many courses and lecturers interconnected in continuous time. To deal with the large amount of data about them and to be able to analyze and to create statistics of represented knowledge, appropriate data management technologies are to be used.

The knowledge models are made using shared knowledge schema thus reducing potential mistakes or differently structured knowledge area representations. The challenge of incomplete information can arise because of the gaps in student knowledge and lack of a specific course understanding. If a student indeliberately has not provided data for the prototype, it can lead to an incomplete knowledge model and imperfect assessment of actual student knowledge. This, in turn, may create imprecision in the predictions of the potential freshmen knowledge. To deal with incomplete information, special controls of the represented knowledge and information are needed in the PIIKFS.

The knowledge schema is common for the lecturers and students in each course. As a consequence, there is a need to reuse and to share the created knowledge schema in the prototype, which is to a certain extent persistent in time. Students provide the values (knowledge) for schema and create knowledge models. Considering the domain characteristics, it is evident that each student has unique knowledge and in each case the knowledge schema is fulfilled differently. The knowledge model is a representation of individual student knowledge in a specific knowledge area. The values provided in the knowledge schema are changing each year with the change of students' contingent. At the same time, the existing values must be saved in the context of history (past). Implementation of the knowledge schema must be flexible in time. Without the retention of knowledge that is delivered in continuous time and from multiple individuals, it is hard to carry out the knowledge analysis, evaluation, and accumulation of statistics. Likewise, the prediction of the potential entrant's knowledge without the support of time and instance properties in the tool is a cumbersome procedure.

Obviously, the surveyed challenges require using of some integrating structure. Such structure is provided by the knowledge schema that is shared for all instances and is to be defined relatively rarely. If the content of the knowledge schema is changed, it is also necessary to change the representation of the schema in the tool for all instances. To represent multiple instances of a particular knowledge schema that correspond to each student, the instance dimension (see Fig. 6.4) of knowledge representation was introduced. Within the instance dimension the properties that characterize the specific features of the instance are defined.

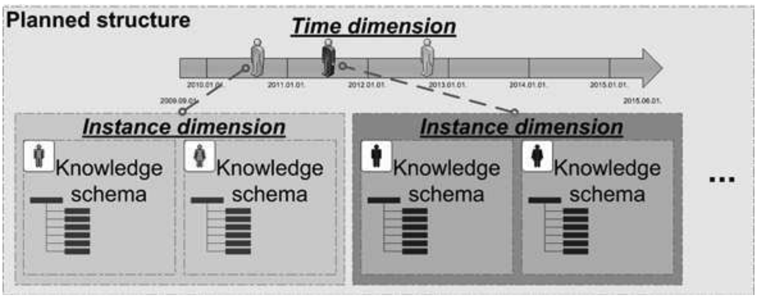


**Fig. 6.4** The planned knowledge representation structure

To include and represent time properties, the time dimension (see Fig. 6.4) is proposed. The time dimension helps to represent knowledge models in time. Every time dimension provides the knowledge representation at one moment of time. Since information about student knowledge is obtained in discrete time, each year there is some abstract state in time that is described. In the planned structure, one time dimension allows to represent 1 year. Additional time properties such as a month and a day can be varied for each instance dimension.

Both dimensions are implemented in one structure and only the distinct characteristics are defined within the time and instance dimension properties. The structure represented in the Fig. 6.4 is used to create the database for the prototype.

## 6.4 Meeting the Requirements and Challenges

Time and scale impose constraints on the choice of knowledge representation techniques. Considering identified requirements and the existing resources, the tool Frame System was chosen as the solution for knowledge schema representation and retention. However, to fulfill all requirements and four consequential roles: acquisition, representation, analysis, and sharing, additional technologies must be used. Thus, the Frame System was used together with specific database application and PIIKPS.

### *6.4.1 Usage of Frame System*

The Frame System is a tool (Valkovska & Grundspenkis, 2005) that is developed in the object-oriented programming language (C++ builder) and integrated with a database (MS Access). The Frame System is the frame-based knowledge representation system that uses Minskys' frame idea (Minsky, 1975) and the Structural Modelling Approach (Grundspenkis, 1997). The Frame System was developed at Riga Technical University; therefore, it is easily accessible to the authors. Within the Frame System it is possible to represent and store knowledge using the features of the knowledge representation structure called a frame. Frame-based knowledge representation is a well-known schema of the knowledge representation (Karp, 1993).

In the Frame System, a tree structure (hierarchy) is used to represent a hierarchy of concepts. A horizontal hierarchy that is more complex can also be used to demonstrate the relations between concepts. Visualized representation that allows intuitively represent the knowledge is an advantage of the Frame System. The basic element in the Frame System is a frame. A frame encapsulates small information chunks. A frame has a name, slots with labels describing the concept's attributes or features, and possible values for each attribute (Karp, 1993). Designing the Frame System, a novel structure called a Frame Set was created and implemented to provide full (more complete) representation of concepts (Zeltmate, 2007). The Frame Set consists of several correlated components: attribute frame, contact frame, behavior frame, and procedure frame. Within the Frame Set the names of concepts, properties, procedures, behavior, and relations between concepts can be defined. In the solution proposed in this chapter, a two-level hierarchy of frames are used: a class and a subclass. A class frame specifies information that is typical for a concept that represents a knowledge element; a subclass frame specifies a subordinate concept that is a part of class.

The Frame System allows representing the knowledge schema concepts (see Fig. 6.5) and provides easy retention for the structured representation of concept relations in the database. Within the Frame System full concept names are visible instead of the incomprehensible identifiers – knowledge is represented in the tool in the same manner as it is provided. The created and represented knowledge schema can be used to acquire someone's knowledge. If something is changed in the real world, it is possible to make changes also in the representation within the Frame System. Besides, it is possible to work with knowledge in the situation of incomplete information, providing a comprehensive description of domain.

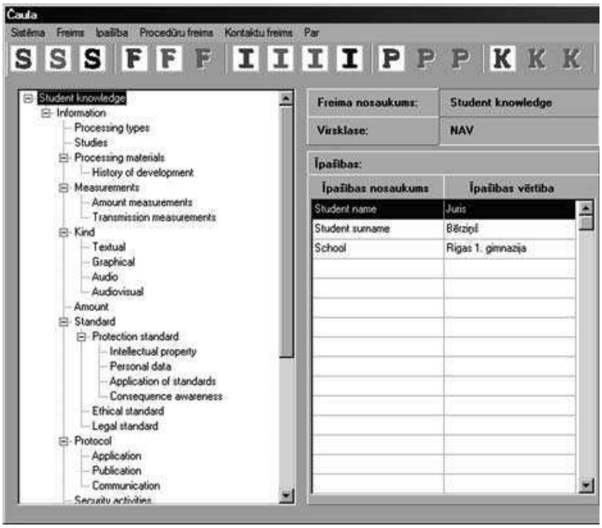


**Fig. 6.5** Insight the frame system

The representation form available in the Frame System is suitable for the knowledge schema representation and knowledge identification and maintenance, but unfortunately the tool lacks functionality that guarantees the storage of multiple student representations simultaneously in one shared database. Furthermore, the students' knowledge can be represented only at one state of time, i.e., at one moment of time only one knowledge schema and corresponding values can be represented. The representation can be changed in time within the tool, but there isn't provided the retention for the history of the knowledge changes. The time and multiple instances are complex characteristics of domain that affect the existing solution. The chosen tool serves as a link between the domain schema and PIIKFS. The Frame System was adapted and integrated with other tools to deal with technical problems produced by the complexity and to create PIIKFS.

### 6.4.2 Created Solution

Due to their complexity problems that are introduced by the time and the large number of instances (scale), the decision was made to use the Frame System, the database, and the Web-based prototype (see Fig. 6.6).

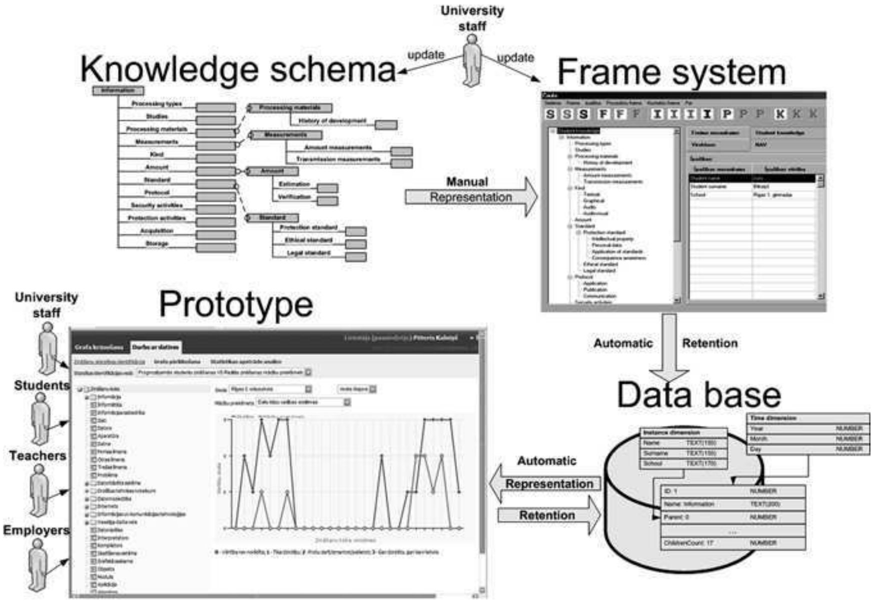


**Fig. 6.6** The proposed solution

The Frame System serves as a tool for the specific knowledge area representation and knowledge schema retention and maintenance. Frame System is used also as a design template for the knowledge area representation part in the prototype. If changes occur in the knowledge schema, then the changes in the mirroring knowledge schema within the Frame System are made by the university personnel. It is necessary to use some knowledge representation schema in the database to provide corresponding semantics for the gained knowledge. Without the schema the knowledge retention is a time-consuming procedure. For the existing database structure that is designed for the Frame System, the time and instance dimensions were added to create a new shared database that supports the functionality of the prototype.

Information from the Frame System database to the database is transferred automatically. The database technologies are used for the knowledge, information retention, and processing (knowledge analysis and evaluation). The database technologies used to support the prototype provide storage, revision, analysis, and also the multiuser facility for a large amount of data.

To acquire the student knowledge that is stored in the database, the PIIKFS Web-based prototype is created. Every student can access his/her page where the provided knowledge and the knowledge analysis results are represented. The analysis of student-represented knowledge is made by comparing the anticipated and acquired knowledge (the predicted knowledge versus existing knowledge). All the necessary information is represented and shared to provide consistent knowledge flow support. The knowledge sharing allows organizing feedback to other educational institutions (Strazdina, Stecjuka, Andersone, & Kirikova, 2008). It is possible to provide the analysis and comparison of different individual knowledge in the prototype. Aggregation of student knowledge is made by bar charts. In addition, analysis and comparison of individual student answers at different moments of time are possible in the prototype. The prototype can help to anticipate changes in student knowledge on the basis of the analysis of data about knowledge schemas of different educational institutions involved in educational process.

## 6.5 The Prototype

The created prototype (see Fig. 6.6) PIIKFS is used for the knowledge acquisition from students, knowledge representation, and, therefore, supporting inter-institutional knowledge flows. The focus of the prototype is to support inter-institutional knowledge flows; therefore, PIIKFS plays an important role for participants in the educational process from several institutions, namely, for the university staff, teachers of informatics in schools, secondary school students, university students, and employers.

University staff can see which parts of their courses should be modified in order to fit the course to the defined student contingent. Lecturers can use the prototype to obtain feedback from students about the courses. For lecturers, the prototype serves also as an assessment tool and tool of knowledge acquisition about the student individual and average knowledge levels. The PIIKFS is useful not only for the student knowledge assessment but for the course assessment, too. By analyzing the course knowledge schemas, it is possible to get a view of the university courses to see which course themes overlap themes in other courses.

Teachers of informatics in schools can be informed about the situation in schools thus providing benchmarking. Secondary school students can get information about the university (requirements, courses, and study materials) to be better prepared for studies. Employers can review the knowledge schemes to understand what kind of knowledge the university students have and can give the feedback of their opinion on what could be changed or improved in the university study programs. Employers can also find information about the average level of student knowledge and the predicted student profile.

Knowledge schema of a particular subject is to be implemented in the prototype with the purpose to evaluate student knowledge level in a specific domain. Students' answers produce values for attributes related to concepts in the given knowledge schema that allow to process the stored knowledge. The knowledge schema helps to automate the knowledge management to some extent. For students the prototype is a knowledge assessment tool – they can verify their knowledge themselves and also share their opinion and knowledge level with the lecturer. Students use the knowledge schema to represent their knowledge in a certain structured way. After students have represented their knowledge in the prototype, the assessment and analysis of knowledge can be provided.

## 6.6 Discussion and Conclusion

Educational system lacks regular analysis of existing knowledge and therefore there exist gaps between the university program requirements and student knowledge and ability to adjust to university requirements. Research efforts described in this chapter were motivated by two main goals. The first was to understand and evaluate what students actually know in the concrete domain as well as to obtain descriptive, though structured view about educational process results that are achieved after secondary school and to provide feedback to educational institutions. The second goal was to anticipate (predict) student approximate knowledge in the following years, analyzing the collected information that includes multiple educational aspects. One of main objectives of this work is to adapt to circumstances provided by existing educational process and standards. The course standard was used to build the knowledge schema and to find knowledge that is worth to be represented and analyzed. The knowledge schema was used as standard solution for equivalent knowledge acquisition that allows collecting essential information about student knowledge.

The Frame System was inspected in connection with provided requirements and implementation of a new solution that provides domain-required functionality. Ideally, the obtained information about student knowledge enables university to predict potential entrant knowledge for the next year and to identify the right educational strategy. Analysis of inter-institutional knowledge flow provides knowledge needed to improve study process and to find inconsistencies or gaps that exist between the knowledge that a student really can have and the knowledge which is required in the university program.

The obtained results allow for the assessment of student knowledge, the identification of knowledge gaps, and adaptation to an appropriate level of knowledge. Thus, it is possible to provide prerequisite inter-institutional knowledge flows and to provide feedback to other institutions.

At the moment, PIIKFS is being tested in two universities of Latvia. The prototype facilitates analysis of the potential changes in the student knowledge and provides information for decision making about yearly adjustments to knowledge needs of freshmen. In the future, the prototype will serve as a tool not only for the student knowledge analysis but also for further research. It will be interesting to inspect how changes in standards, environment, and student knowledge will affect the necessary knowledge level in specific knowledge areas.

**Acknowledgment** This revised chapter is based on the paper (Zeltmate, Kirikova, & Grundspenkis, 2008) presented in the International conference on Cognition and Exploratory Learning in the Digital Age 2008 (CELDA 2008)

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# Chapter 7
# The Role of Supportive Information in the Development and Progression of Mental Models

**A. Aubteen Darabi, David W. Nelson, and Norbert M. Seel**

**Abstract** In learning a complex skill, creation and elaboration of learners' conceptual and causal models benefit from supportive information provided at the beginning of instruction. On the other hand, it has been documented that practicing problem solving leads to better performance and transfer of complex cognitive skills. Despite the essential role of problem-solving practice for integration and transfer of knowledge and skills, providing novice learners with supportive information before practice can contribute substantially to the progression of a learner's mental model toward an expert-like mental model. This progression process was examined before and after three phases of the instructional process: supportive information presentation, problem-solving practice, and test performance. Participants' mental models of the complex learning task were matched against an expert mental model at five observation points through an instructional troubleshooting session. The results indicated a significant change in participants' mental models after receiving the supportive information and no change after practice or performance.

## 7.1 Introduction

In this chapter, we will examine how learners build the foundation for learning in complex domains. We will discuss theoretical explanations of the interaction of supportive information and practice for the progressive development of learners' mental models. We will describe an empirical study that illustrates the importance of supportive information in the progression of mental models toward those resembling experts, and we will attempt to explain why instructional practice, though essential

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for developing the ability to perform complex tasks, is not as effective as supportive information for developing mental models.

Individual learners come to unfamiliar problem-solving tasks with fragmentary preconceptions of the problem space, elements of which might include the goal state, initial state, operators, constraints, or control knowledge about which operator to employ (Newell, 1994). Based on the elements presented, learners construct mental models of the situation and potential solution paths (Seel, 2001). This fragmentary construction is all novice learners have at the initial introduction of a complex problem to solve. We call these constructions mental models.

In complex subject domains, the expert's mental model usually constitutes the standard against which a novice's mental model is compared (Snow, 1989). Thus, for learners to acquire complex cognitive skills, a primary aim of instructional designers is to specify the instructional strategies that contribute to a learner's development of mental models that further learners' mental model progression toward those of an expert. Presenting appropriate supportive information and practice challenges during instruction is presumed to develop an expert-like mental model in a complex learning situation. Given the essential roles of both supportive information and practice in the acquisition of complex cognitive skills, the question arises how supportive information and practice influence the progression of learners' mental models.

Supportive information provided prior to practice is critical to the creation and elaboration of learners' conceptual and causal models (van Merriënboer, 1997). On the other hand, Darabi, Sikorski, Nelson, and Palanki (2006) argued that problem-solving practice is more beneficial to the performance and transfer of complex cognitive skills than providing supportive information by direct instruction. We suggest that, despite the essential role of problem-solving practice for integration and transfer of knowledge and skills, providing novice learners with supportive information before practice can contribute substantially more to the progression of a learner's mental model toward an expert-like mental model than providing instructional practice does.

### *7.1.1 Model-Oriented Instruction and Mental Model Progression*

Instructional psychology defines the development of mental models, as well as their external representations, as learning-dependent transitions between different states of knowledge on the basis of the learners' interactions with the environment and its significant features. Accordingly, it is possible to distinguish different kinds of model-oriented instruction that are based on divergent conceptions of the autonomy and adaptability of learners. From an instructional psychology perspective, the suggestion has been made (Greeno, 1989) that mental models are acquired with significant properties of external situations (such as the learning environment) and the subject's interactions with them. This corresponds with the verdict of constructivism that the learning environment is an important resource that can be used in a strategic manner to extract the information needed to create subjective plausibility and solve learning tasks and problems. Consequently, tasks are required that enable learners to explore the environment in dynamic interaction with the context as if they were really there. Furthermore, embedded supports and scaffolds can be provided to assist problem solvers in operating successfully within the learning environment. Our overall experience is that learning environments enable students to focus explicitly on the communication of problem understandings, in such a way that problems become more open for discussion and allow easier resolutions.

Thus, in general, three approaches of constructing mental models can be distinguished (Johnson-Laird, 1989; Seel, 1991, 2001). The individual's ability to construct cognitive artifacts either from a set of basic components of world knowledge or from analogous models that the individual already possesses (i.e., discovery learning), everyday observations of the outside world (in the sense of observational and imitational learning), and other people's explanations, especially in teaching–learning situations.

Johnson-Laird (1989) argues, "What is at issue is how such models develop as an individual progresses from novice to expert, and whether there is any pedagogical advantage in providing people with models of tasks they are trying to learn" (p. 485). This implies two basic instructionally relevant assumptions. First, in accordance with Snow (1990), we understand the learning-dependent progression of mental models as a specific kind of transition mediating between preconceptions that describe the initial states of the learning process and the causal explanations as the desired end state of learning. Second, we can adopt Mayer's (1989) argumentation that students given model instruction may be more likely to build mental models of the systems they are studying and to use these models to generate creative solutions to transfer problems. In this case, the construction of mental models presupposes the learner's ability to adopt other people's explanations in a semantically sensitive manner. Accordingly, the learner must be sensitive to characteristics of the learning environment, such as the availability of certain information at a given time, the way this information is structured and mediated, and the ease with which it can be found in the environment.

However, learning situations can also be designed in such a way that students may be involved in a process of discovery and exploratory learning by which they extract facts from data sources, look for similarities and differences between these facts, and thus develop new concepts (cf. Carlson, 1991). In this context, instruction is oriented to facilitate learning and to provide the students with opportunities to create their own solutions for given tasks and problems. In accomplishing given learning tasks, the learner examines continuously the given environment for information that can be used for creating and completing an initial mental model. Advocates of this approach, such as Penner (2001) and Seel (2003), argue that learning occurs as a multistep process of model building and revision.

The two approaches have in common an emphasis on relatively complex, semantically rich, computerized laboratory tasks, constructed to resemble real-life problems. The approaches, however, differ somewhat in their theoretical goals and methodology.

Until today, remarkably few investigations of complex learning tasks have carried on through the many hours or even weeks such learning takes to accomplish. What goes on during that time? Whatever it is, it is slow, effortful, continuous, often unconscious, sensitive, and fragile. There is no magic dose of knowledge in the form of a pill or lecture. Complex learning entails a lot of slow, continual exposure to the topic, probably accompanied by several bouts of restructuring the underlying mental representations and reconceptualizing the concepts, plus many hours of accumulating many facts. Accordingly, a central goal of our research is the investigation of the learning-dependent progression of mental models in the course of instruction. In a series of quasi-experimental studies, Seel has focused on the construction and revision of models intended for the explanation of complex phenomena as well for analogical problem solving (Seel & Dinter, 1995; Seel & Schenk, 2003; Ifenthaler & Seel, 2005; Seel, Darabi, & Nelson, 2006). Actually, a special focus in these studies was placed on measuring the stability and change of mental models in the course of learning.

The results of the different experiments indicate that learners "respond" adaptively to the learning environment and extract information in order to develop and stabilize a coherent understanding of the complex systems to be explained. However, at the whole, the results of the different studies show that mental models are strongly situation-dependent and idiosyncratic cognitive artifacts that are changed quickly in accordance with new information. This can be interpreted with the semantic sensitivity of the learners with regard to situational demands and new information (cf. Anzai & Yokoyama, 1984).

### *7.1.2 Instructional Situations That Support Learners' Adaptive Responses*

Overtime, an instructional experience has been described to include information presentation, practice with feedback, and performance testing. In van Merriënboer's (1997) four-component instructional design (4C/ID) model, the presentation of information plays a significant role in supporting skill acquisition in a complex learning environment. Learners need this supportive information to bridge the gap between their prior knowledge and the knowledge they need to successfully solve nonrecurrent problems (van Merriënboer & Kirschner, 2007).

Supportive information can include features such as text, still pictures, schematics, and dynamic visualization. The recent findings in instructional systems research suggest that these features, individually or in combination, are differentially effective depending on the learner's competence and characteristics (see Tversky, Bauer-Morrison, & Bétrancourt, 2002; Mayer, 2001, 2005). The multimedia principle (Mayer, 2005) recommends combining text and still pictures for effective instruction of novice learners. More experienced learners, on the other hand, benefit from more dynamic visualizations such as video or animated schematics developed according to the congruity principle (Tversky, et al., 2002).

Supportive information is either direct or responsive. Direct supportive information, provided during initial instruction, focuses on the organization of concepts as domain models, problems and their solutions, and procedural information to illustrate causal relationships. Responsive supportive information, provided as feedback during discussion or practice, may take the form of confirmation, correction, explanation, diagnosis, or elaboration of learner responses. According to Fleming and Levie (1993), confirmative feedback informs learners whether their answers are correct or incorrect; corrective feedback supplies the correct answer when needed; explanatory feedback provides the reason why the answer was incorrect; diagnostic feedback identifies the potential sources of misconceptions and provides remedial instruction; and elaborative feedback builds on the correct response to provide additional information related to that response.

Supportive information is important to the acquisition of complex cognitive skills, but so is practice (Darabi et al., 2006). Practice is obviously important for the acquisition of complex skills, whether those skills are recurrent (performed the same way on each incidence) or nonrecurrent (performed differently according to conditions managed by complex rules or contextual features [van Merriënboer, 1997]). But supportive information guides learners through decision-making processes that may be complex.

For instructional practice to help learners construct mental models similar to an expert's, it should be what Ericsson (e.g., Ericsson, Krampe, & Tesch-Römer, 1993) calls deliberate practice for a prolonged period. Deliberate practice is that in which one uses feedback from previous practice attempts to successively refine one's performance. Becoming an expert in a complex domain typically requires 10 years of deliberate practice (Ericsson & Charness, 1994). The construct of deliberate practice implies a metacognitive process similar to that of self-regulated learning (e.g., Winne & Hadwin, 1998; Zimmerman, 1989), in which one continually assesses and improves one's own strategy and performance through iterative feedback cycles including goal-setting, performance, self-observation, and self-reflection (Zimmerman, 2002).

Mental effort and its relationship to performance of complex learning tasks and problem solving have been investigated extensively. Researchers have documented this relationship in different learning environments for experienced and novice learners (see Carrol, 1994; Kalyuga, Ayres, Chandler, & Sweller, 2003; Kalyuga, Chandler, Tuovinen, & Sweller, 2001; Darabi, Nelson, & Paas, 2007; Paas, Tuovinen, Tabbers, Van Merrriënboer, & Van Gerven, 2003; Paas, Renkl, & Sweller, 2003; 2004). But, to our knowledge, learners' investment of mental effort in performing a task has not been examined in relation to the learner's progression of mental model compared with that of an expert. Thus, we explored the progression of mental models of those who invested high and low mental effort.

Similarly, the literature has identified cognitive flexibility as an indicator of "how the person represents the task and the set of strategies employed to deal with it" (Cañas, Quesada, Antolí, & Fajardo, 2003, p. 482). This flexibility should influence the learners' transition from one instructional phase to the next and how they adjust their mental models to accommodate the new information. More experienced individuals, research shows, are better at making this adjustment because of their more intricate mental representations of the domain (Spiro, Feltovich, Jacobson, & Coulson, 1991). Individuals' capacity to adapt their strategies to accommodate new conditions of complex tasks has shown to be dependent upon their level of performance of these tasks. (Reder & Shunn, 1999).

### *7.1.3 Exploring the Roles of Supportive Information and Practice*

Because of this documented relationship between cognitive flexibility, learners' level of performance, and the mental effort they invest in that performance, we conducted an experiment using a computer-based simulation of a chemical plant to examine the progression of learners' mental models throughout an instructional experience involving their performance of troubleshooting tasks. Participants were 26 undergraduate engineering students. We assessed learners' mental models before and after instructional episodes of supportive information delivery, problem-solving practice, and a performance test that involved troubleshooting and diagnosing malfunctions in the simulated plant. We assessed their mental models by eliciting their THEN conclusions to a series of 10 IF premises, resulting in five assessments of their causal reasoning about the functions of the chemical plant as external representations of their mental models.

In the instructional experience provided for this study, we employed a combination of instructional strategies to constitute direct and responsive supportive information for the learners. In the direct supportive information, the learners were provided with a combination of text, still pictures, and graphics of critical components of a complex system to explain the nonrecurrent aspects of problem solving in this domain. Following the direct supportive information, a dynamic, interactive simulation presented the learners practice and feedback sessions as responsive supportive information for meeting problem-solving challenges. The purpose of the study was to determine the changes that occurred in the progression of learners' mental models throughout this instructional experience.

The instruction presented supportive information that included a simulated performance environment in which the learners played the role of chemical plant operator. In this learning environment, as long as plant systems functioned normally, the operator's role merely involved observing the plant's automated operations. However, the gradual deterioration of the plant's components caused malfunctions that the operator had to diagnose quickly and repair efficiently. Figure 7.1 displays the simulation control panel interface.

The experts' mental model was established by using a series of 10 IF-THEN statements (Seel et al., 2006), the aggregate of which represented the experts' conception of causal relationships among the system components. A chemical engineering professor and two of his doctoral candidates, after familiarizing themselves with the simulation, provided responses to the IF premises in the form of THEN conclusions about conditions in the plant. Their THEN conclusions on

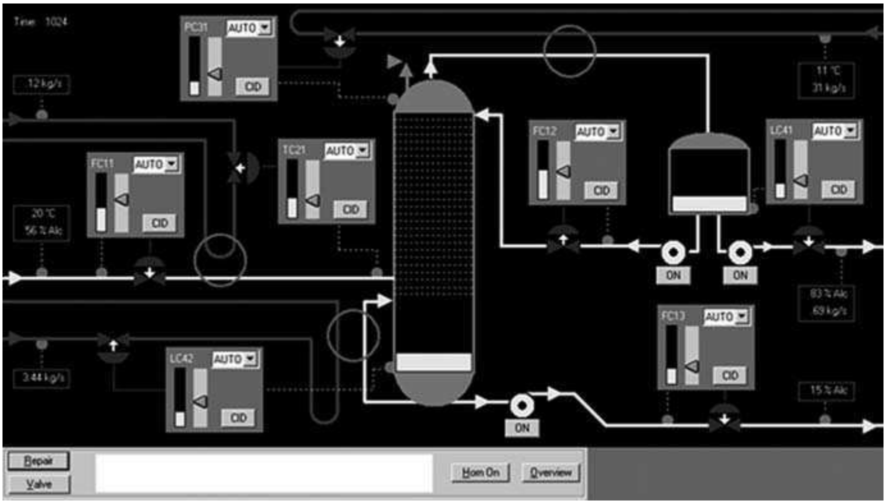


**Fig. 7.1** Simulation control panel interface

10 hypothetical system conditions comprised the expert mental model of the simulation system, against which learners' THEN statements were rated.

The learners' THEN conclusions to the IF propositions were collected by pencil on paper, after each instructional event to capture a representation of participants' mental models about the system. The trait of cognitive flexibility was measured using Martin and Rubin's (1995) Cognitive Flexibility Scale (CFS). This trait was of interest due to the dynamic nature of the learning tasks and the cognitive restructuring necessary to change initial preconceptions to later causal explanations. At the completion of each troubleshooting task in practice and performance, the simulation recorded whether the participants correctly diagnosed the fault presented in that task. For the purpose of this study, the total number of correct diagnoses was used as the performance measure. The nine-point Mental Effort Scale (MES) introduced by Paas and van Merriënboer (1994) was used as a measure of participants' investment of mental effort.

To focus the learners' attention on the complex domain of the distillation processes, they were shown a photograph of a real distillation plant. This event was followed by the first administration of the IF-THEN participant mental model instrument (Observation 1). The learners' mental models were later assessed at four different points, using the same instrument, following the introduction of supportive information (Observation 2), practice (Observation 3), performance (Observation 4), and 2 weeks later for an indication of participants' retention of their mental model (Observation 5).

Following the initial assessments, the participants began the three subsequent phases of the experiment through which they eventually operated the computer-based simulation. They started with an initial introduction to the simulation system and its inner working principles. The content of the introduction was instructionally designed to provide the participants with supportive information required for performing the complex tasks involved. Applying the multimedia principle (Mayer, 2005), the introduction phase consisted of complementary computer-based text and graphics designed to teach learners about the components, features, and troubleshooting processes required for flawless operation of the simulation. (See Fig. 7.2 for an example of combining text and graphics in supportive information and introductory discussion of how the system works and can be operated.)

As part of the introduction, learners had the opportunity to manipulate the system's controls. At the completion of this introductory phase, the Mental Effort Scale was administered and the participants' mental models of the plant operation were assessed for the second time.

During the practice phase, the simulation system was programmed to present the learners with four consecutive fault conditions, each of which required learners to use their troubleshooting skills to diagnose the problem and return to the distillation plant in its normal functioning state. After each diagnosis, learners were provided with confirmative feedback informing them of the results of their diagnosis. They were then asked to rate the mental effort they invested in making that diagnosis. This exercise constituted the practice phase of the experiment which was followed by the third assessment of learners' mental model of the system's operation.

The performance phase of the experiment consisted of diagnosing and repairing eight system malfunctions. Participants were presented with eight faults different from those they had diagnosed during the practice phase. They were expected to

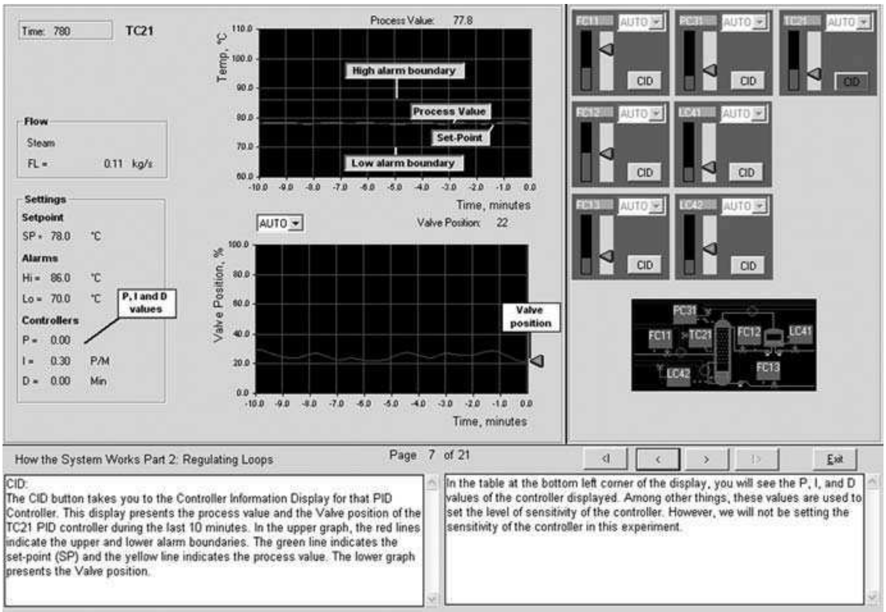


**Fig. 7.2** A sample screen of introduction and supportive information

make the correct diagnosis according to their understanding of system operation. They were asked to rate the mental effort they invested in making each diagnosis. The performance session was followed by the fourth administration of the mental model instrument.

Two weeks after the performance phase, the participants were given the mental model instrument for the fifth time. The purpose of this follow-up was to examine participants retention and changes in the mental model they had constructed as a result of their experience with the simulation. Table 7.1 graphically displays the design of the experiment by highlighting the treatment and observation phases.

Following the collection of the IF-THEN statements from learners, five doctoral students in instructional systems received training on the features and functions of the simulated plant and how the IF-THEN statements applied to the conditions of the system. Then they rated the match between learners' statements and the expert mental model for each observation using a three-point scale (no match = 0, partial match = 1, and full match = 2). This resulted in a total of 6500 ratings (5 raters X 10 statements X 26 learners X 5 observations). The inter-rater reliability was found to be a coefficient alpha of .93. The five ratings for each of the 10 statements were averaged and used as individuals' mental model match scores for each observation. Given the 10 statements included in the instrument, the maximum possible score for a match between learner and expert mental models on a single observation would have been 20.

The progression of match of participants' mental models with the expert mental model was analyzed in a one-way repeated measures analysis of variance to examine changes in mental model match assessed at the introduction and after each phase of the instruction. Means and standard deviations for each observation are presented in Table 7.2.

A significant overall difference among match observations was revealed, Wilk's Lambda = 0.36, $F$ (4, 22) = 11.94, $p < 0.001$, multivariate eta squared = 0.69. To identify the change that was statistically significant, we examined the differences between successive observations by conducting tests of within-subjects contrasts.

**Table 7.1** Treatment and observation design

| | 1st session | | | 2nd session | | | | 3rd session | | 4th ses-sion |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatments (X) and observations (O) | O | X | O | X | O | X | O | X | O | O |
| Session events | CFS[a] | Show picture[b] | 1st MM[c] | Intro-duction | 2nd MM 1st MES[c] | Practice solving[d] prob-lems | 3rd MM 2nd MES | Perfor-mance Test 8 Faults | 4th MM 3rd MES | 5th MM |

*Note*. [a]Cognitive Flexibility Scale (Martin & Rubin, 1995)
[b]The picture showed a still photograph of a distillation plant.
[c]The participants' mental models (MM) were assessed by having them answer open-ended questions (e.g., IF A and B, THEN ____).
[d]Mental Effort Scale (Paas et al., 1993)

**Table 7.2** Ratings of learners' mental model match with expert mental model ($n = 26$)

| Observe 1 | | Observe 2 | | Observe 3 | | Observe 4 | | Observe 5 | |
|---|---|---|---|---|---|---|---|---|---|
| M | SD | M | SD | M | SD | M | SD | M | SD |
| 3.12 | 1.29 | 5.21 | 1.80 | 4.62 | 1.85 | 4.82 | 2.12 | 5.18 | 1.78 |

The results showed a significant change in participants' mental models match between the first and second observations, $F\ (1, 25) = 41.16$, $p < 0.001$, partial eta squared = 0.62, and between the fourth and fifth observations, $F\ (1, 25) = 8.53$, $p = 0.007$, partial eta squared = 0.25. Figure 7.3 graphically displays the progression of the match between participants' mental models and the expert mental model over the five observations.

Given these significant changes, we decided to examine the role of our mediating variables in this progression. To differentiate among the participants in terms of those variables, we classified the participants into two groups of high and low scorers on cognitive flexibility, mental effort, number of correct diagnoses for practice, and the number of correct diagnoses for performance test. The median scores were used to dichotomize these variables and categorize participants. Then, for each measure, we examined the difference between the two groups regarding their match with the expert mental model. The descriptive statistics for this analysis are presented in Table 7.3.

The multivariate analysis compared the participants scoring high and low, above or below the medians, over the five repeated measures of mental model match, for

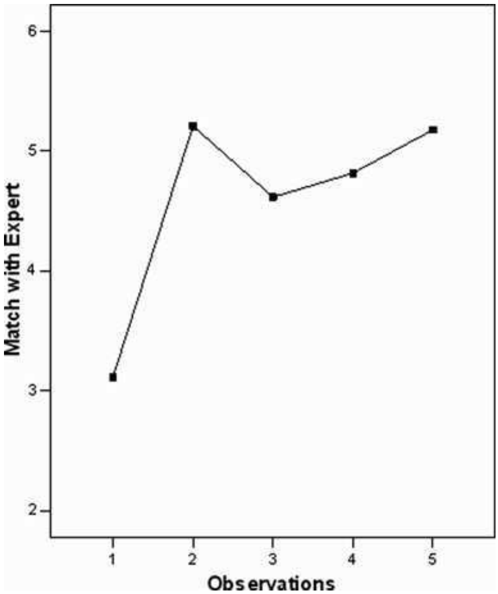


**Fig. 7.3** Progression of match between learners' mental models and the expert mental model over five observations

**Table 7.3** Means and standard deviations of participants' mental model match dichotomously differentiated by scores on mediating variables

| Observation | | 1st | | | 2nd | | | 3rd | | | 4th | | | 5th | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *M* | *SD* | *n* | *M* | *SD* | *n* | *M* | *SD* | *n* | *M* | *SD* | *n* | *M* | *SD* | *n* |
| CF | High | 3.60 | 1.29 | 13 | 5.93 | 1.60 | 13 | 5.28 | 1.68 | 13 | 5.67 | 1.49 | 13 | 5.80 | 1.87 | 13 |
| | Low | 2.63 | 1.13 | 13 | 4.47 | 1.73 | 13 | 3.95 | 1.82 | 13 | 3.95 | 2.35 | 13 | 4.55 | 1.51 | 13 |
| ME | High | 3.07 | 1.22 | 15 | 5.44 | 1.93 | 15 | 5.17 | 2.20 | 15 | 5.37 | 2.10 | 15 | 5.56 | 1.61 | 15 |
| | Low | 3.06 | 1.45 | 10 | 4.66 | 1.52 | 10 | 3.80 | 0.78 | 10 | 3.80 | 1.90 | 10 | 4.44 | 1.90 | 10 |
| P | High | 3.27 | 1.34 | 15 | 5.25 | 1.80 | 15 | 4.95 | 1.88 | 15 | 4.87 | 2.00 | 15 | 5.48 | 1.79 | 15 |
| | Low | 2.91 | 1.25 | 11 | 5.15 | 1.88 | 11 | 4.16 | 2.26 | 11 | 4.75 | 2.38 | 11 | 4.76 | 1.76 | 11 |
| T | High | 3.22 | 1.26 | 17 | 5.32 | 1.73 | 17 | 4.62 | 1.51 | 17 | 4.72 | 2.04 | 17 | 5.31 | 1.75 | 17 |
| | Low | 2.91 | 1.40 | 9 | 5.00 | 2.00 | 9 | 4.60 | 2.47 | 9 | 5.00 | 2.39 | 9 | 4.93 | 1.91 | 9 |

*Note*. CF = cognitive flexibility; ME = mental effort; P = practice performance; T = test performance the following measures. Cognitive flexibility revealed a significant overall difference, $F\ (4, 21) = 11.69$, $p < 0.001$, with a partial eta squared effect size of 0.69 (see Fig. 7.4, Part a); mental effort revealed a significant overall difference, $F\ (4, 21) = 9.80$, $p < 0.001$, with a partial eta squared effect size of 0.66 (see Fig. 7.4, Part b); practice performance revealed a significant overall difference, $F\ (4, 21) = 11.36$, $p < 0.001$, with a partial eta squared effect size of .68 (see Fig. 7.4, Part c); and test performance revealed a significant overall difference, $F\ (4, 21) = 10.25$, $p < 0.001$, with a partial eta squared effect size of .66 (see Fig.7.4, Part d).

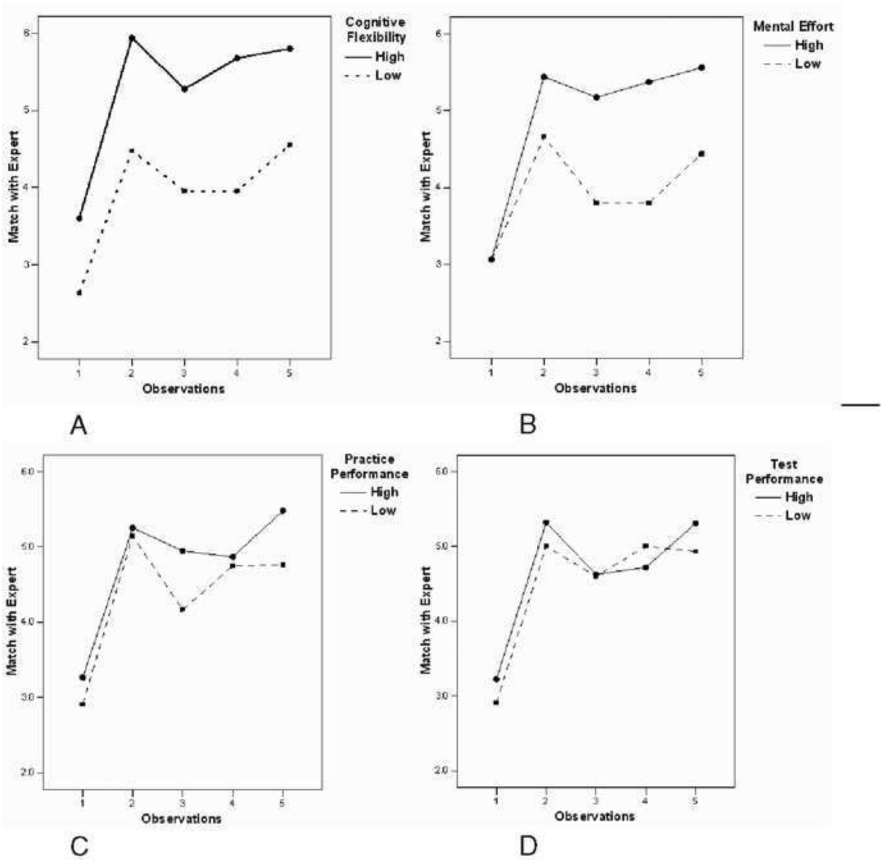


**Fig. 7.4** Comparisons of participants with high and low scores relative to medians on (**a**) cognitive flexibility, (**b**) mental effort invested in learning, (**c**) practice task performance, and (**d**) test performance, on the progression of the match of their mental models with the expert mental model

## 7.2 Conclusion

The results of this study point to several issues about the formation and progression of learners' mental models when dealing with complex systems. Overall, the findings align with the literature of instructional systems and learner expertise that emphasizes the importance of the whole task practice perspective, rather than a decontextualized, part-task practice perspective, and adopts a system perspective for problem solving. The main point of interest in these results was that the greatest change in learners' mental model match with the expert mental model occurred after the introduction of the supportive information, whereas practice at troubleshooting was not particularly influential in the progression of learners' mental models.

We observed that supportive information provided prior to problem-solving performance benefited novice learners' mental model matches with experts more than instructional practice. This effect was observed regardless of individual differences we expected to affect problem-solving ability (van Merriënboer, 1997). The results of this study seem to indicate that supportive information is also important for developing mental models that match, or at least progress toward, those of experts. The theoretical foundations of the 4C/ID model (van Merriënboer, 1997) also indicate that supportive information and declarative knowledge are more important than problem-solving practice and procedural knowledge in creating initial mental models.

While researchers have emphasized that whole task practice contributes to the learners' integration of information for transfer task performance (van Merriënboer, 1997), we found that instructional practice may not play such a crucial role in development and progression of their mental models. This finding seems plausible, given the time constraints of typical instructional programs and the 10 years of deliberate practice necessary to gain expertise, as the expertise literature suggests (Ericsson & Charness, 1994; Ericsson, Krampe, & Tesch-Römer, 1993). Moreover, research on cognitive load and learner characteristics has indicated that explicit descriptions of problem-solving processes are beneficial to novice learners but can be inhibitory to learning for advanced learners (Kalyuga et al., 2001, 2003), as in the expertise reversal effect. Our synthesis of these disparate conclusions suggests that, although whole task practice is essential for transfer of procedural knowledge, supportive information presented prior to practice is essential to facilitating the construction and the progression of learners' mental models. Further research is needed to replicate these findings, investigate the sequence of practice and supportive information presentation – to test primacy effects – and to find whether the effects suggested here are domain specific or universal.

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# Chapter 8
# The Qualitative Study on Contents Analysis/Construction Method for e-Learning

## Focusing on the Semantic Relationship Among Represented Media

**Naomi Nagata and Toshio Okamoto**

**Abstract** The aim of this study is to develop a method of qualitative analysis for extracting features/characteristics from e-learning contents, in consideration of the semantic relationship between figures and sentences. In order to extract the features/characteristics, we propose a method of contents analysis for "characteristics on frames" and "sequences of frames." On the basis of this analysis, we propose a method for contents construction. In comparison with previous research on the subject, our research is aimed to the synergy effect in the meaningful relationship among figures, sentences, and sound narrations; we take a qualitative analysis approach from the point of view of cognitive and linguistic semantics. As a result of that, we extracted three patterns: "Progressive pattern," "Regressive pattern," and "Spiral pattern" from the characteristics on analyzed frames. Also, we extracted two patterns for chunked frame sequences: "liner/branch/binding" and "Liner/nonbinding." Moreover, we try to test "synergy effect" for the compounded contents among figures, sentences, and sound narrations. Also, we propose the concept of "Dance of understanding" from the point of the semantic relationship among those media. We define that "Dance of understanding" is internal behavior to make harmony in brain for understanding a series of learning/instructional materials, accompanied with the several represented media. We assume the degree of this harmony "synergy effect."

## 8.1 Introduction

e-Learning is a relative newcomer to the education area, yet it already holds a noticeable share of the learning market. In general, e-learning contents are composed of some representative media such as sentences/figures and tables/video/sound

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narrations/animations/simulations. While any multimedia is being used, instructor is doing various devices to improve sustainability.

Moreover, as representation recourse, Bruner proposed a representation model (Bruner, 1967). In this research, we take up the problem of the frame construction based on combination of sentences (with narration) and figures and tables. Then, we try to explore how to construct frames/contents (its sequences as contents) from the point of semantic relationship among those media for the purpose of enhancing learning effect. We set up the elaborative learning environment and produce e-learning contents under several theoretical hypotheses in consideration of Bruner's representation of thinking theory (Bruner, 1967). The first stage (enactive) is the representation of knowledge in actions. The second stage (iconic) is the visual summarization of images. The third stage (symbolic) is the symbolic representation. Thinking theory refers to the use of words and other symbols to describe experience. Instruction should be represented in terms of the learners way of viewing the enactive, iconic, or symbolic.

In the research, development, and practice of e-learning, it seems to be five aspects which are (1) hardware, (2) software, (3) courseware, (4) useware (Instructional/Learning Design), and (5) *managingware*. In real educational organizations, we need to integrate those systematically and manage for the purpose of heightening educational effectiveness.

In this study, we focus on the aspect of courseware development. Especially, in this chapter, we try to propose the analytical methodology of extracting the semantic relationship between instructional sentences and figures in a frame. Moreover, we also try to propose the analytical methodology of extracting the features/characteristics on frame sequences. In consideration of those analytical methods, we examine methodologies of effective contents construction for e-learning.

Our study on contents construction of e-learning is based on Bruner's model, which consists of enactive, iconic, and symbolic learning media. For the purpose of assuring learning quality, we have dealt with the methodologies of analysis and constructions on e-learning contents. Especially, we address the task of compound "semantic relationship" as multimedia between "figures and tables" and "explanatory sentences" in a frame as well as the task of frame sequences. It is important to focus on the technological benefits of rich multimedia to improve the quality of e-learning contents.

Figure 8.1 shows the framework of the course management in Webclass-RAPSODY which we have developed and named as our LCMS (Learning and Contents Management System). (Okamoto, Cristea, & Kayama, 2000) We provide with "The structured Database of Learning Resources," which consist of two modules. Those are (1) Relational and Logical information of course structure and (2) Repository of Learning materials. The former has hierarchical structure, and "course," "units," "instructions/Q&As," and "frames." One unit consists of "a set of instructions/Q&As." One course consists of "a set of units." Teachers can reuse "instructions (Learning Objects)" and "questions (Test Items)" by this framework of the course management in Webclass-RAPSODY.

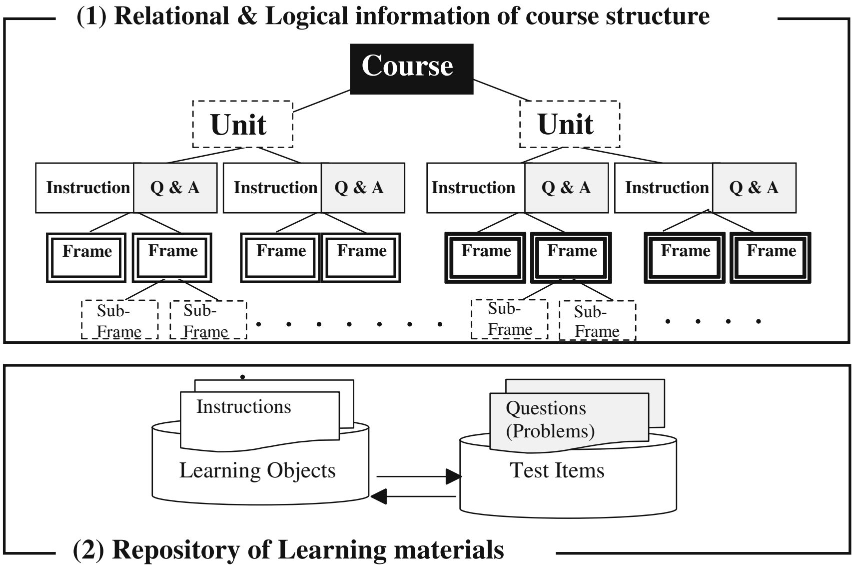



**Fig. 8.1** The structured database of learning resources in webclass-RAPSODY

We focus on "frame" for contents analysis on e-learning. We define the concept of "frame" as the follows. A frame is the coherent unit of instruction which consists of a few topics with semantic connection to learn. In e-learning, a frame is usually displayed on one screen (sometimes including scrolling function). This terminology is derived from the theory of "Programmed Learning" by Skinner (Skinner, 1958), the theory of "Good Frame and Bad" by Susan (Susan, 1964), and, the theory of "Component Display Theory" by Merrill (Merrill, 1983). We also define semantic chunking of frames as a frame sequence. Then we regard a set of frame sequences as an e-content.

## 8.2 The System Configuration of e-Learning Environment

The most important issue in the establishment of e-learning environments is to start by defining the educational objectives (instructional/learning goals) and then to develop/classify the learning contents that are best equipped to build the required learning environment (Collins, 1999). Moreover, research into appropriate methods is required to build the asynchronous collaborative learning contents. Further research should be devoted to the study of learning environments with the virtues of individualized learning and collaborative learning. In this case, the transmission of real images and voice data is required.

### 8.2.1 The Structure of Webclass-RAPSODY

The fundamental environment components for e-learning systems include the whole information system related to e-learning environments, which consist of several management functions, such as curriculum/learning materials management, learners' profile/log-data management, learning support as the core framework, LMS (Learning Management System), and LCMS (Learning and Contents Management System) (Fig. 8.2). To construct such educational management systems, several data/file processing modules are required, such as a distributed file system, synchronous data communications, etc (Nieminen, 2001). If any applications and tools related to e-learning can be plugged into the core framework, we can build an integrated e-learning environment where learners can share/operate this software/data in real time. In addition, the total management system of e-learning is required for implementation in a real educational project/practice, which means a requirement for research project management, learning schedule management, courseware development, etc. The modes of contents are text/video-based tutorial, drill and practice, simulation and gaming, data analysis package for experiments, and collaborative contents.

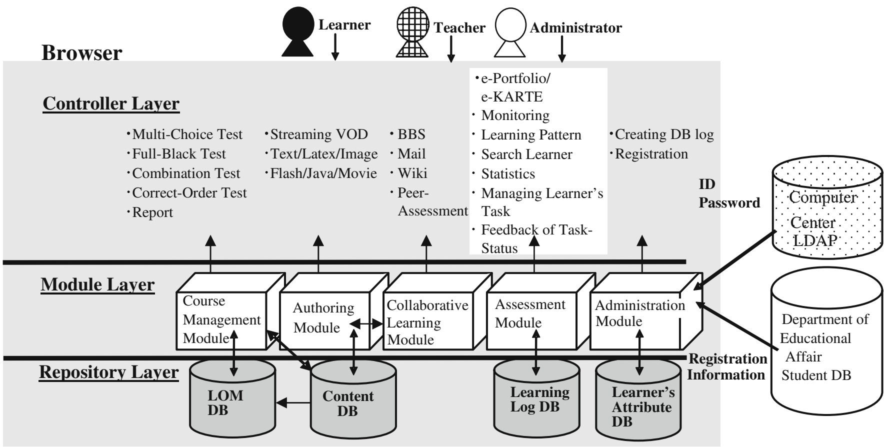



**Fig. 8.2** LCMS (Webclass-RAPSODY)

### 8.2.2 The Students e-KARTE and Mentoring Functions

The main theme of our research and development is to provide "e-learning services with mutual interaction between students' learning activities and RAPSODY (Nagata, Anma, & Okamoto, 2008)." We emphasize the mentoring functions in order to guarantee students' learning sustainability and support the achievement of specified learning goal online – real time. So we provide e-KARTE with the functions of formative/summative evaluation for an individual learner. By this e-KARTE, the students can check and confirm their learning status/progress (understanding level) as self-evaluation from the subjective/objective points of statistical data analysis.

As mentioned above, our e-learning center provides students and teachers with e-learning services such as information related to formative/summative evaluation with the diagnosing information online – real time. In this project, we focus on the following aspects.

#### 8.2.2.1 Use of Digital Portfolio (e-KARTE)

This is related directly to our theme. We integrated grade information currently stored in the Instruction Section database with learner information stored in LMS. This enables teachers to give students some appropriate suggestions.

Our LMS includes

- subjects of reports and submitted reports
- status of submission and its date
- status of credits
- grades
- past history of mentoring with summaries
- degree of achievement for goal and teachers' comments

Figure 8.3 shows e-KARTE including the mentoring function. Each student can see and check his/her learning status/achievement in order to prompt a learning plan of progress again. In e-KARTE, there are learning time, times of lesson access, degree of achievement per section/chapter in a course, and diagnosed messages. The students' learning log data are also analyzed by some statistical methods, then those results are shown to students.

#### 8.2.2.2 Mentoring and Coaching

Only preparing the digital portfolio is not sufficient to assure a student's learning progress. It is necessary to provide the function of mentoring/coaching like Fig. 8.3. In addition, we prepared several tutorial classes for teachers.

Mentoring/coaching items are about

- questions about contents
- recommendation of courses for students
- know-how of proceeding learning
- providing curriculum suitable for students
- advices for learning progress

These comments are made by teachers with reference to the learners digital portfolio. By supporting learners in mentoring/coaching appropriately, we believe that even the advanced courses can be learned by e-learning.

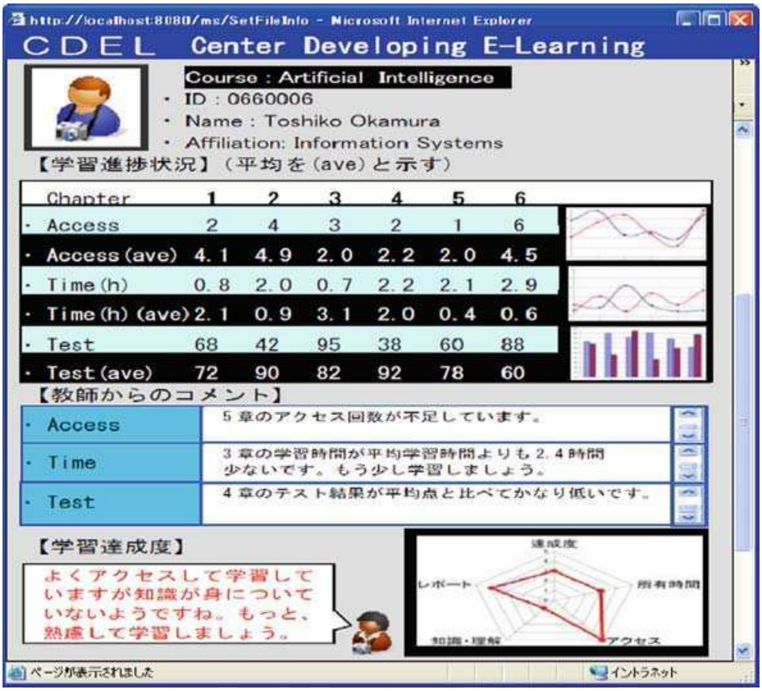



**Fig. 8.3** A displayed example for mentoring

## 8.3 Instructional Design and Learning Design

There are two conceptual approaches, Instructional Design and Learning Design, for performing the effective teaching/learning activities. The concept of Instructional Design emphasizes to optimize teaching environments such as instructional materials/tools/equipments, teaching methods, etc., for the purpose of maximizing learners' achievements for the instructional goal. On the other hand, the concept of Learning Design emphasizes to assign dynamically learning resources/environments for learners' learning needs/goals.

### *8.3.1 The Aspect from Instructional Design*

For the purpose of assuring learning quality, we have wrestled with the construction method of e-learning contents based on instructional theory. Especially, we address the task of compound "semantic relationship" as multimedia among "figures and tables," "explanatory sentences," and "sound narrations" in a frame as well as the task of frame sequences. This research for frames-construction tasks and testing of learning effectiveness are cyclically based on "The structured Database of Learning Resources in Webclass-RAPSODY" of Fig. 8.1.

On conducting e-learning, the idea of instructional design is quite important for the purpose of assuring quality on teaching effectiveness. In general, the method of instructional design covers the following areas (William & Owens, 2003):

1. Need and Task Analysis
2. Objectives Hierarchy
3. Performance Standards
4. Instructional Strategies
5. Lesson Specification
6. Lesson Development
7. Student Evaluation
8. Lesson Validation

In consideration of those steps, we propose the method to design and analyze the frames and its sequence on e-learning contents construction. In general, e-learning contents are composed of some represent media such as sentence/figure and table/video/sound narration/animation/simulation. In this research, we take up the problem of the frame construction based on combination of sentences (with narration) and figures and tables. Then we try to explore how to construct frames/contents from the point of semantic relationship among those media for the purpose of enhancing learning effect. We set up the elaborative learning environment and produce e-learning contents under several theoretical hypotheses in consideration of Bruner's represent theory of thinking. Our theory on contents construction of e-learning is based on Bruner's represent model (Briggs, 1977) which consist of enactive, iconic, and symbolic learning media.

Instructional Design is the systematic process of applying general principles of learning and conducting plans for instructional materials (Dick, Carey, & Carey, 2001). Instructional Design as a process is the systematic development of instructional specifications using learning and instructional theory to ensure the quality of instruction (Briggs, 1977). Instructional Design as a science is the science of creating the detailed specifications for the development, implementation, evaluation, and maintenance of situations that facilitate the learning of units of subject matter at all levels of complexity (Gagne, Wager, Goals, & Keller, 2005).

However, there are not so much specific researches about contents construction method on e-learning. By the way, the aim of this study doesn't focus strictly on the problem of lesson development in Instructional Design, but takes up originally the problem of the semantic understanding of "frame" and "chunked frame sequence" from the view of cognitive and psycholinguistics.

In our project, we emphasize this authoring activity under the system building of Organizational Knowledge Management. This study is intended to specify e-learning contents features/characteristics in consideration of the semantic relationship between figures and sentences. In order to specify those features/characteristics, we propose the method of contents analysis for "characteristics of a frame" and "frame sequence." By this analysis, we try to propose the constructional method of contents. The problem of the contents construction is related to the technology of

Instructional Design. We also propose the methodology of Instructional Design to compose effective and adaptive contents from the points of educational psychology and linguistics in consideration of individual differences.

### *8.3.2 The Aspect from Learning Design*

The IMS Learning Design specification supports the use of a wide range of pedagogies in online learning. This paradigm emphasizes to satisfy with learners' learning needs/goals by providing a generic and flexible language. This language is designed to enable many different pedagogies to be expressed. The approach has the advantage over alternatives in that only one set of learning design and runtime tools then needs to be implemented in order to support the desired wide range of pedagogies. The language was originally developed at the Open University of the Netherlands (OUNL), after extensive examination and comparison of a wide range of pedagogical approaches and their associated learning activities and several iterations of the developing language to obtain a good balance between generality and pedagogic expressiveness.

## 8.4 LICAP-β Model

In consideration of the theoretical/practical issues of Instructional Design and Learning Design, we proposed LICAP-β model which stands for the framework of PLAN, DO, ANALIZE, and RECONSTRUCT for contents production/construction. According to this model, we construct e-learning contents in consideration of learners' needs/learning styles. Figure 8.4 shows the framework of

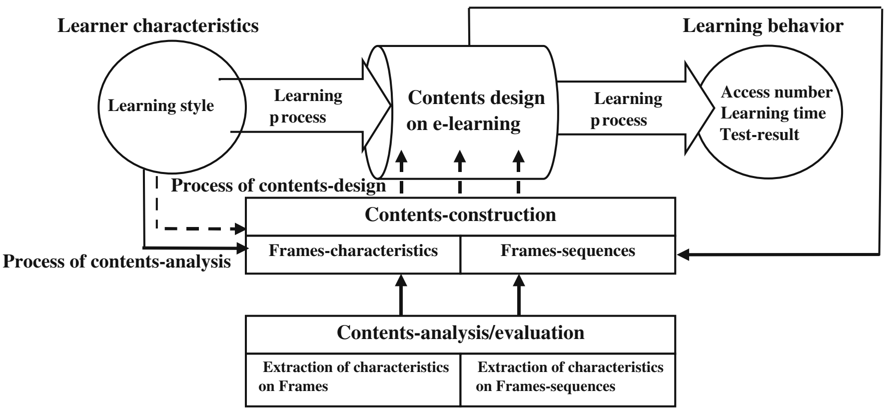



**Fig. 8.4** The LICAP-β model

LICAP-β. Based on this model, we propose the methodology of contents construction to compose more effective contents. This model is a redesign of the LICAP model by Okamoto (2000). LICAP model was originally designed as a decision-making model for developing CAI courseware, whereas LICAP-β model is focused on Contents Design on e-learning.

We propose the method to analyze and design the frames and its sequence on e-learning contents construction. This study is intended to develop e-learning contents features/characteristics in consideration of the semantic relationship between figures and sentences. In order to develop those features/characteristics, we propose the method of contents analysis for "characteristics of a frame" and "frame sequence." We also propose the methodology of Instructional Design to compose effective and adaptive contents from the points of educational psychology and linguistics in consideration of individual differences.

The LICAP-β model consists of four modules, which are (1) Learner characteristics, (2) Learning behavior, (3) Contents construction, and (4) Contents analysis/evaluation for designing/constructing e-learning contents. The inside factors/values of each module depend on the research purposes and the educational objectives. Therefore, this model is a kind of meta-knowledge representation for contents development of e-learning.

## 8.5 The Qualitative Analysis for Contents Construction Method

In this chapter, we mention the method of qualitative analysis for contents construction. We focus on some figures in a frame (Robinson & Kiewra, 1995). Moreover, we try to extract frame features/characteristics and frame sequence. Then, we expect to provide the contents designers with the patterns of analyzing the contents.

We provide with the study plan, which consists of three tasks (design, extraction, and analysis) as shown in Fig. 8.5.

Our study plan consists of 13 steps, which are as follows:

- Step 1: Analyzing e-learning contents.
- Step 2: Extracting figures/tables, semantic relationship figures and sentences, and frame sequence in e-learning contents.
- Step 3: Designing chart for contents analysis.
- Step 4: Analyzing *ordinability* for intuitive understanding about figures and sentences.
- Step 5: Extracting *ordinability* for intuitive understanding about figures and sentences.
- Step 6: Setting 2-dimensions.
- Step 7: Designing algorithm for extracting frame characteristics.
- Step 8: Extracting frame characteristics.
- Step 9: Analyzing frame characteristics.
- Step 10: Designing algorithm for extracting frame sequences.

- Step 11: Extracting frame sequences.
- Step 12: Analyzing frame sequences.
- Step 13: Analyzing contents with sound narrations in K-zone.

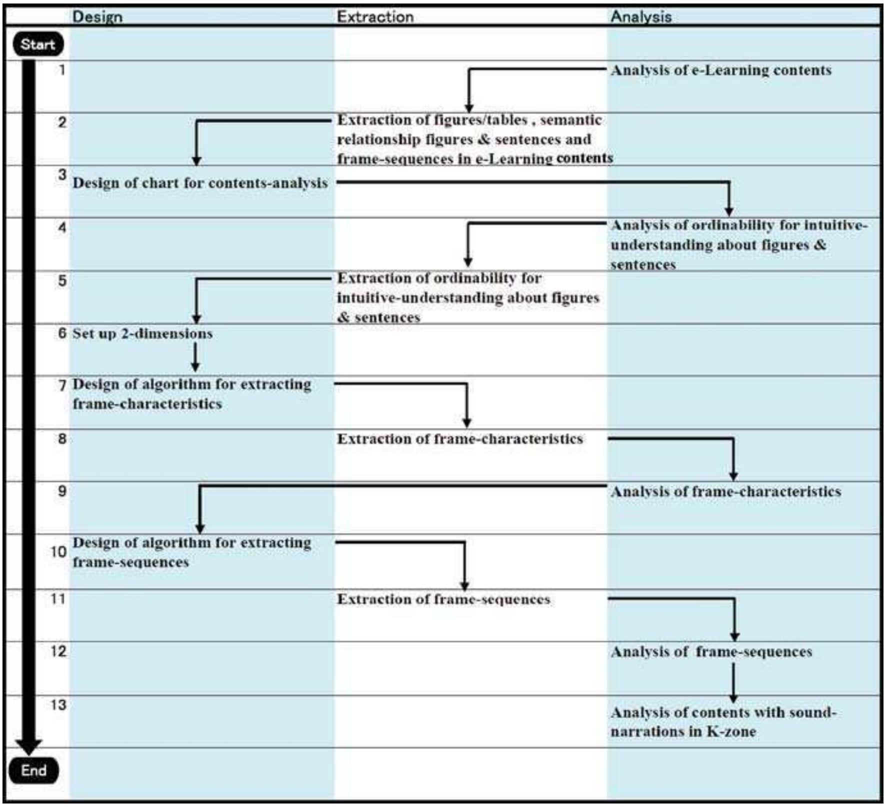



**Fig. 8.5** Study plan

## *8.5.1 Extraction of Features/Characteristics on Contents*

### 8.5.1.1 Semantic Relationship Between Figures and Sentences

In general, a frame of e-learning contents consists of some figures and sentences (Keiko, 2000; Levin, Anglin, & Carney, 1987). We focus on the semantic relationship between figures and sentences for a frame construction (Carrell, 1992). In this study, we regard "table" as a kind of "figures." We try to analyze the semantic relationship between figures and sentences, moreover extract a meaningful pattern of frame sequences.

We designed the elaborated chart for contents analysis. If a certain frame has any "characteristics of a figure"/"semantic relationship between figures and sentences"/"logical-story features on frame sequence," an evaluator checks (☑) in the chart. The figures were classified into four groups of "Link," "Array," "Area," and "Coordinates" (part of "Characteristics of a figure" in "frame characteristics" in Fig. 8.6). The semantic relationship between figures and sentences was classified into four groups of "Exemplification," "Copy," "Supplement," and "Condensation" (part of "Semantic relationship between figures and sentences" in "frame characteristics" in Fig. 8.6).

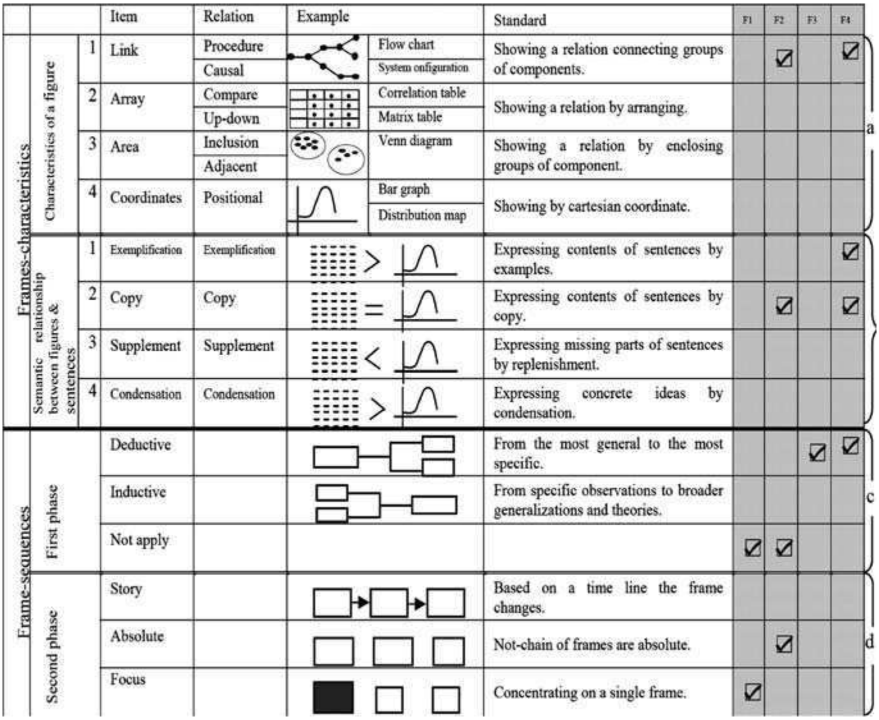



**Fig. 8.6** Chart for contents analysis

### 8.5.1.2 Ordinability for Intuitive Understanding About Figures and Sentences

Using Fig. 8.6, we extract the semantic features for each frame. Then we prepared two kinds of questionnaires as Tables 8.1 (for figures) and 8.2 (for semantic relationship) for the purpose of assuring the *ordinability* for each scale (X-axis: the degree of intuitive understanding for four figures, Y-axis: the degree of intuitive understanding for semantic relationship between figures and sentences) on the two-dimensions plane. All items for two kinds of questionnaires have the 5-rating scale.

The subjects are 10 students who were taking Study of "Information Education," one of the subjects for the teaching professional course in N University.

We present four figures (Link, Array, Area, and Coordinates) and four semantic relationship between figures and sentences (Exemplification, Copy, Supplement, and Condensation) to 10 subjects, and we use the question items about characteristics of figures (Table 8.1) and the question items about semantic relationship between figures and sentences (Table 8.2) to measure evaluation about effects and characteristics.

We try to assure the validity of *ordinability* for each by "testing method of combining the partial order." Figures 8.7 and 8.8 show the result of *ordinability* for the degree of intuitive understanding.

**Table 8.1** The question items about characteristics of figures

| The question items (5-rating scale) |
|---|
| 1. Can you understand the content when you see only figures/tables? |
| 2. Do figures/tables express the contents of the sentences? |
| 3. Do the sentences express the contents of the figures/tables? |
| 4. Do the contents of sentences and figures/tables match together? |
| 5. Can you understand the components of figures/tables? |

**Table 8.2** The question items about semantic relationship between figures and sentences

| The question items (5-rating scale) |
|---|
| 1. Can you understand what do express figures/tables? |
| 2. Can you construct the semantic information for a figure/table from a sentence? sentence? |
| 3. Can you understand the semantic relationship between figures/tables and sentences? |
| 4. Can you understand the characteristics of figures/tables from sentences? |
| 5. Can you understand concepts, relationships, and principles of figures/tables? |

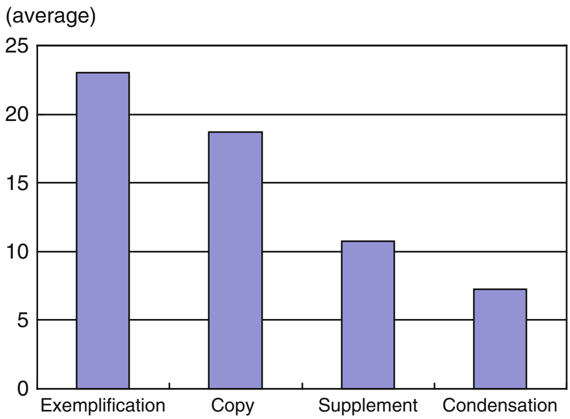



**Fig. 8.7** Ordinability for figures

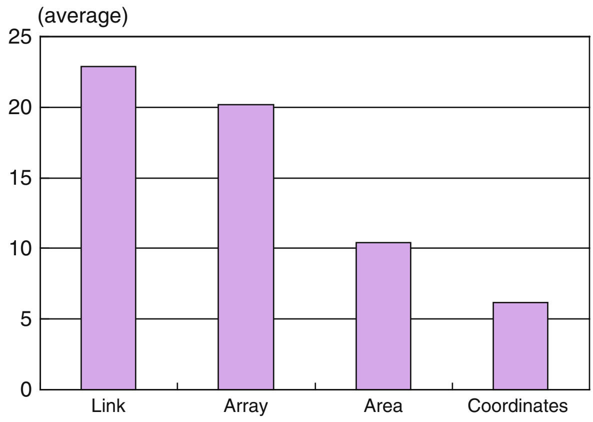



**Fig. 8.8** Ordinability of the semantic relationship between figures and sentences

As a result of that we set up *ordinability* which makes an ordering scale from high to low (Figs. 8.7 and 8.8).

*Ordinability* for figures:

Link (ave.22.9) > Array (ave.20.2) > Area (ave.10.4) > Coordinates (ave.6.1).

*Ordinability* of the semantic relationship between figures and sentences:

Exemplification (ave.23.0) > Copy (ave.18.7) > Supplement (ave.10.7) > Condensation (ave.7.2).

As the result of that, we provide 2-dimensions plane as Fig. 8.9. Based on this two-dimensions plane, we tried to extract the features/characteristics of "frame sequence" as Figs. 8.10, 8.11, and 8.12 according to the algorithm of Fig. 8.13.

We set up 2-dimensions as values of *ordinability*; X-axis consists of four categories, which are Link, Array, Area, and Coordinates, Y-axis consists of four

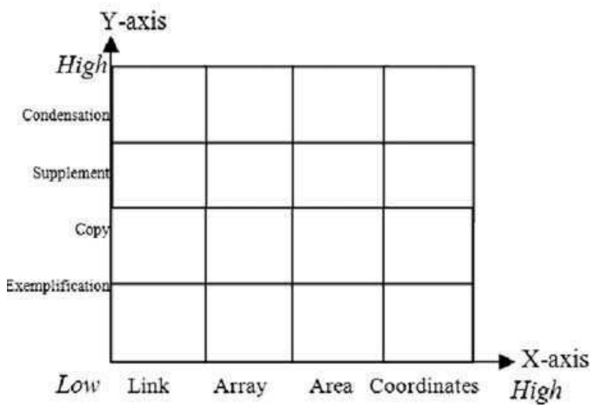
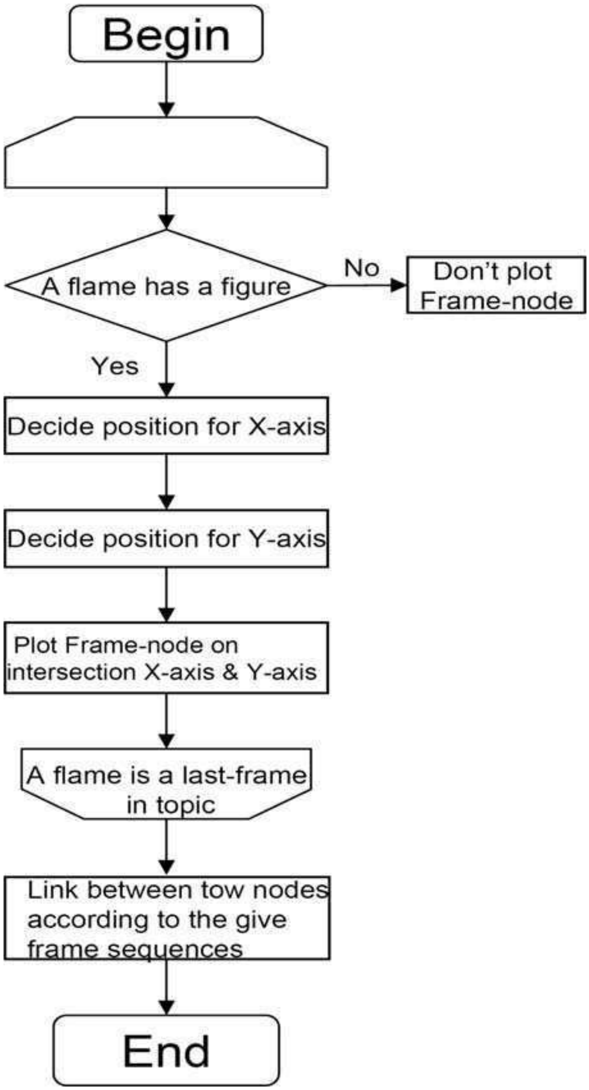



**Fig. 8.9** 2-Dimensions as ordinability

**Fig. 8.10** Procedure (frame characteristics)




categories, which are Exemplification, Copy, Supplement, and Condensation as the same way (Fig. 8.9).

From the result of experiments about *ordinability*, we mention the following facts: "Area" and "Coordinates" include too much essential information about figures. "Supplement" and "Condensation" do not explain much about the detail of figures. However, "Link" and "Array" include less essential information about figures. "Exemplification" and "Copy" explain much about the detail of figures.

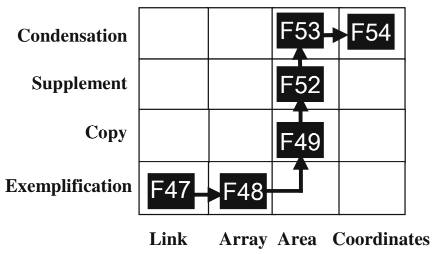



**Fig. 8.11** Pattern of progressive

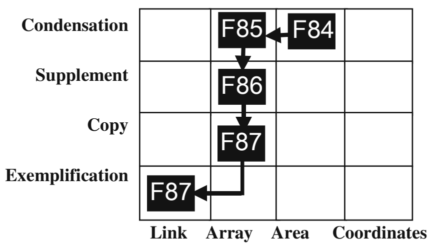



**Fig. 8.12** Pattern of regressive

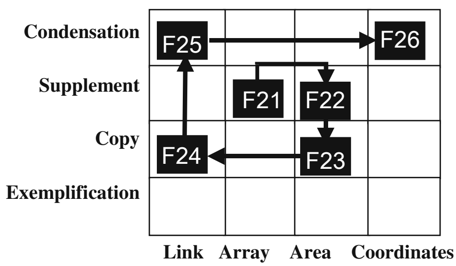



**Fig. 8.13** Pattern of spiral

## *8.5.2 Extraction of Features/Characteristics on Frames*

### 8.5.2.1 The Procedure for Extracting Frame Characteristics

We tried to find out the semantic relationship between figures and sentences in a frame according to the given frame sequences.

In the plane of 2-dimensions, we can show the profile of an e-learning content. If a certain frame has a figure, then we decide each position for X-axis and Y-axis. We repeat this procedure for all frames in the topic. We try to link between two nodes according to the given frame sequences. By this procedure, we can extract a peculiar pattern from a frame sequence.

By this method, features/characteristics of the extracting content are evaluated for the degree of understanding.

We extracted three patterns from this analysis as follows (see Figs. 8.9, 8.13 and 8.10).

1. Pattern 1: Progressive pattern (11 patterns)
2. Pattern 2: Regressive pattern (8 patterns)
3. Pattern 3: Spiral pattern (7 patterns)

#### 8.5.2.2 The Analysis for Frame Characteristics

We examined each of the test results for Progressive pattern, Regressive pattern, and Spiral pattern.

*Ordinability* of the average values for three patterns is as follows. Progressive pattern > Regressive pattern > Spiral pattern.

### *8.5.3 Extraction of Features/Characteristics on Frame Sequences*

#### 8.5.3.1 The Procedure for Extracting Frame Sequences

The patterns of frame sequences were classified. In the first phase, we classified into three groups: “Deductive,” “Inductive,” and “Not apply” (part of “First phase” in “frame sequences” in Fig. 8.6). In the second phase, we classified into three groups: “Story,” “Absolute,” and “Focus” (part of “Second phase” in “frame sequences” in Fig. 8.6).

We structured a set of the frame sequences into the integrated graph like Fig. 8.15 and Fig. 8.16 per one section. We utilize “figure template” in Fig. 8.6. If a figure in a frame corresponds with category of “focus,” an evaluator paints black. Otherwise, he/she paints white. If a frame corresponds with category of “story,” he/she adds an arrow line on the right side of the frame node. We repeat this procedure for all frames in the topic. Moreover, we link between two nodes. If a frame sequence is “Deductive,” it is diverged. If a frame sequence is “Inductive,” it is merged (Fig. 8.14).

By extracting features/characteristics on a frame sequence, we can evaluate the linkage degree among the frames in consideration of logical/story flow. In this extracting procedure, we emphasize the value of existence/nonexistence for liner/branch/binding. Accordingly, we can extract two patterns (see Figs. 8.15 and 8.16).

(1) Pattern 1: The pattern of “Liner/branch/binding” (15 patterns)
(2) Pattern 2: The pattern of “Liner/nonbinding” (11 patterns)

### *8.5.4 The Analysis for Extraction of Features/Characteristics on Frame Sequences*

We examined the test results for the pattern of “Liner/branch/binding” and the pattern of “Liner/nonbinding.” The pattern of “Liner/branch/binding” has higher

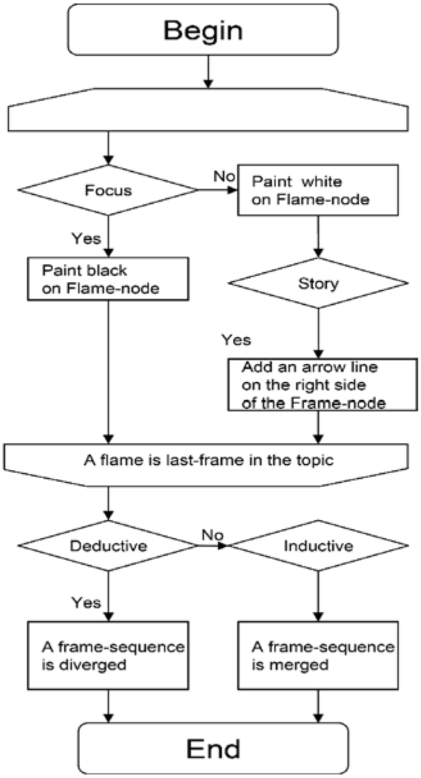



**Fig. 8.14** Procedure (frame sequences)

**Fig. 8.15** Liner/branch/binding

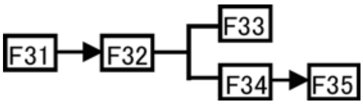
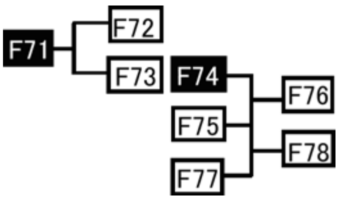



**Fig. 8.16** Liner/nonbinding




average than the pattern of "Liner/nonbinding." We could find out significant difference of t (26) = 7.33, $p< 0.01$, between the pattern of "Liner/branch/binding" and the pattern of "Liner/nonbinding."

## 8.6 "Synergy Effect" by Sound Narrations in Frames

In general, we can expect the higher degree of understanding the frame contents by adding some appropriate sound narrations. In this research, we examine this effect under some experimental conditions. Especially, we explore the method of the contents construction by adding sound narrations to each frame in K-zone we mentioned previously.

According to Brunner's representation model (1967), which consists of (1) enactive, (2) iconic, and (3) verbal/symbolic modes, we construct e-learning contents experimentally. Moreover, Mayer (2001) shows the effect of deep understanding by simultaneous presentation of visual and auditory media. Of course, those media should be integrated timely and appropriately in consideration of semantic relationship for content constructing. Based on those previous researches, we try to examine this phenomena from the semantic relationship among figures/tables, explanatory sentences, and auditory explanations.

Based on the previous analysis for frames in e-learning contents, we found out the parts for Area and Coordinates in X-axis and for Condensation and Supplement in Y-axis of Fig. 8.17 as the lower level of understanding degree for all of frames in the used content. Therefore, we define those parts as K-zone ("K" means "Kiken," which is a Japanese word, Dangerous in English). For those four parts, we tried to insert the blended explanation by "sound narrations" in each of the related frames for the purpose of investigating "synergy effect."

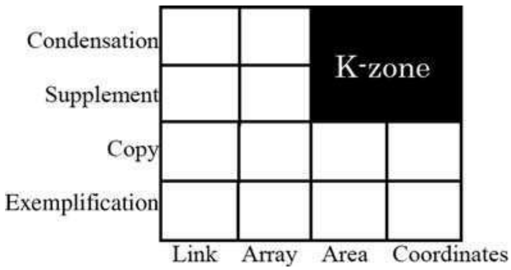



**Fig. 8.17** Definition of K-zone

As shown in Fig. 8.9, there are four kinds of figures/tables. The figures/tables of Area or Coordinate include much more information than those of Link or Array. On the semantic relationship between figures/tables and explanatory sentences, it is easier to understand the frame contents because of being able to mapping the explanatory sentences directly with Exemplification or Copy. On the other hand, it is more difficult to understand the frame contents because of not being able to mapping the explanatory sentences smoothly with Condensation or Supplement. By this reason, learners must understand the essential content in explanatory sentences in his/her brain, then must map explanatory sentences with the details in figures/tables. That is to say, the latter cases increase "cognitive load." In consideration of those fact findings, we explore the method of contents construction for the frames in

K-zone, which means the gap of semantic information between the tables/figures with much information and the explanatory sentences with less information.

### 8.6.1 Experiment I: The Effective Description of Explanatory Sentences for Understanding

#### 8.6.1.1 Procedures

Sound narrations were used to heighten the level of understanding for the frames belonged to K-zone.

In this experiment, we used the topic of "Digital information" and set up eight frames. The topic of four frames having the Area figures is described about "Logical operation for Venn diagrams." The topic of other four frames having the coordinates figures is described about "analog and digital." Moreover, we set up "supplement" or "condensation" for semantic relationship between the figures and the sentences.

Then three types of questionnaires were used to test the level of understanding by the use of the sound narrations. The types of questionnaires were "multiple-choice questions," "free recall questions," and "descriptive questions."

The subjects were 117 high school students. The frames were classified as (a) key sentences only (key sentence consists of several keywords), (b) key phrases only (key phrase consists of several key sentences), and (c) explanation (explanation is described about the details of figures).Then we made three experimental groups corresponding with the conditions A, B, and C.

#### 8.6.1.2 Test Results and Analysis

We analyzed the resultant data for the purpose of finding the learning effects for three experimental groups (Fig. 8.18).

For the mode of "Multiple-choice questions," we found the type of explanation is the most effective for the leaning achievement. (1) Explanation, (2) key sentences, and (3) key phrases ($F\ (2114) = 48.1, p < 0.05$).

For the mode of "Free recall," we found the type of explanation is the most effective for the leaning achievement. (1) Explanation, (2) key-phrases, and (3) key-sentences ($F(2114) = 22.9, p < 0.05$).

For the mode of "Descriptive questions," we found the type of explanation is the most effective for the leaning achievement.

(1) Explanation, (2) key phrases, and (3) key sentences ($F\ (2114) = 53.4, p < 0.05$).

We found that the best results contents construction must include sentences for explanation in a sound narrations' frame. Sound narrations and sentences representation showed a higher "synergy effect."

The content with adding sound narrations is more effective for the frame/content accompanied with many explanatory sentences. Especially, it seems that this construction method promotes to make the learners understand semantics in

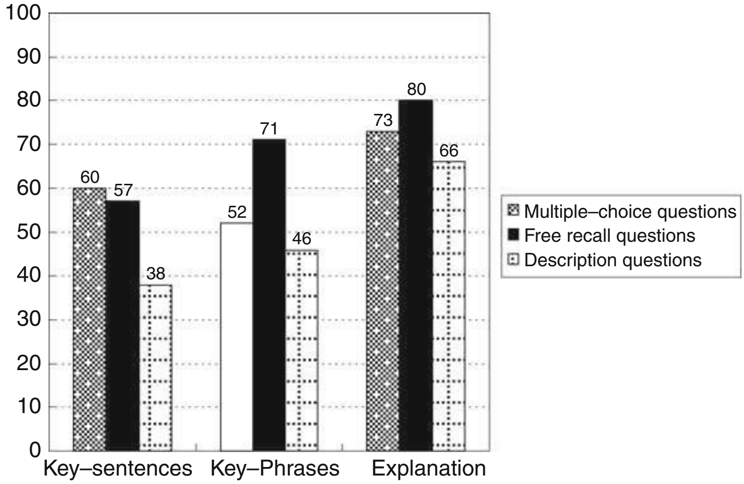



**Fig. 8.18** Test result of sound-narration contents

figures. This means that sound narrations help the "Dance of understanding" in the case of reading many explanatory sentences for the internal semantics on structures, functions, and relationships in figures. It also means that a kind of "synergy effect" exists there.

## *8.6.2 Experiment II: The More Effective Method of Adding Sound Narrations*

For the purpose of investigating the more effective method of adding sound narrations for the frames belonging to K-zone, we executed the experiments with sound narrations. We examined the effects of adding sound narrations for the frames in K-zone based on the problem mentioned in Section 8.6.1.

### 8.6.2.1 Procedure

For the purpose of explanatory, the more effective method of adding sound narrations, we provided with the four forms of frame construction as shown in Table 8.3. According to Table 8.3, we set up four conditions. The subjects were 12 university students. They were asked about *ordinability* of understanding for each of four conditions. Each subject presented four kinds of contents and 5-rating scale for the questionnaires as shown in Tables 8.4 and 8.5.

### 8.6.2.2 Test Result and Analysis

By the combined method of partial ordering, we calculated percentile ($P$) with four ranks for the order. Then we calculated the summation of the percentile values

**Table 8.3** The form of frame construction

| Sound– narrations \ Sentence | Key– phrases only | Explanation |
|---|---|---|
| Repeating | Content A | Content B |
| Complementary | Content C | Content D |

**Key phrases only* consists of several key sentences.
**Explanation* means full explanation by sentences.
**Complementary* means sound narrations which explain the functions or behaviors of the objects in the figure
**Repeating* means sound narrations with explanatory sentences in the frame.

**Table 8.4** The question items about the explanatory sentences

| The question items (5-rating scale) |
|---|
| Can you read well contents in the figure by the explanatory sentences? |
| Can you read the construction/structure of the figure by the explanatory sentences? |
| Can you read the functions/behavior from the figure by the explanatory sentences? |
| Can you read the characteristics of the figure at a glace by the explanatory sentences? |
| Can you understand the concept, principle and relationship in the figure by the explanatory sentences? |

**Table 8.5** The question items about the sentences & sound-narrations

| The question items (5-rating scale) |
|---|
| 1. Is "explanation" by sentences & sound-narrations together appropriate for understanding the content of the figure? |
| 2. Is "explanation" by sentences & sound-narrations together appropriate for understanding the construction/structure of the figure? |
| 3. Is "explanation" by sentences & sound-narrations together appropriate for understanding the functions/behavior from the figure? |
| 4. Is "explanation" by sentences & sound-narrations together appropriate for understanding the characteristics of the figure? |
| 5. Is "explanation" by sentences & sound-narrations together appropriate for understanding the concept/principle/relationship in the figure? |

for each subject. Moreover, we calculated the mean values divided by the judged number.

Table 8.6 shows the comparative orders of those average values.

$$P = 100 \cdot \frac{n - r + 0.5}{n}$$

*P*: Position of percentile
*n*: Ordered number
*r*: Order for one case

We examined each of the comparative orders of average values for four contents (Content A, B, C, and D). As a result of that we found out the following: Content C > Content B > Content A > Content D.

**Table 8.6** shows the comparative orders of those average values

| Subject | A | | B | | C | | D | | E | | F | | G | | H | | I | | J | | K | | L | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ordinability / Content | order | $P_A$ | order | $P_B$ | order | $P_C$ | order | $P_D$ | order | $P_E$ | order | $P_F$ | order | $P_G$ | order | $P_H$ | order | $P_I$ | order | $P_J$ | order | $P_K$ | order | $P_L$ | $P_A+P_B+\cdots+P_K+P_L$ | Average | Total order |
| A | 3 | 37.5 | 4 | 12.5 | 4 | 12.5 | 3 | 37.5 | 4 | 12.5 | 3 | 37.5 | 3 | 37.5 | 4 | 12.5 | 4 | 12.5 | 3 | 37.5 | 3 | 37.5 | 3 | 37.5 | 325 | 27.08 | 3 |
| B | 2 | 62.5 | 2 | 62.5 | 2 | 62.5 | 1 | 87.5 | 1 | 87.5 | 2 | 62.5 | 2 | 62.5 | 2 | 62.5 | 1 | 87.5 | 1 | 87.5 | 2 | 62.5 | 2 | 62.5 | 850 | 70.83 | 2 |
| C | 1 | 87.5 | 1 | 87.5 | 1 | 87.5 | 2 | 62.5 | 3 | 37.5 | 1 | 87.5 | 1 | 87.5 | 1 | 87.5 | 2 | 62.5 | 2 | 62.5 | 1 | 87.5 | 1 | 87.5 | 925 | 77.08 | 1 |
| D | 4 | 12.5 | 3 | 37.5 | 3 | 37.5 | 4 | 12.5 | 2 | 62.5 | 4 | 12.5 | 4 | 12.5 | 3 | 37.5 | 3 | 37.5 | 4 | 12.5 | 4 | 12.5 | 4 | 12.5 | 300 | 25.00 | 4 |

For the contents with adding sound narrations, we found that the frame description by key phrase only is more effective in the case of adding complementary sound narrations which explain the functions or behaviors of the objects in the figure, rather than repeating explanatory sentences in the frame by sound narrations. This result means that a kind of "synergy effect" among figures, explanation by key phrase only and complementary sound narrations occurred. Therefore, from the point of "cognitive load" to understand a frame content, we need to examine the optimized combination between explanatory sentences and sound narrations, whether complementary sound narrations or full-sound repeating narrations for the explanatory sentences in a frame. For the contents construction with sound narrations, we found the new fact that the compounded construction among key phrases and sound narrations with figures is more effective for understanding the meanings in the frame/content rather than repeating the explanatory sentences by sound narrations, in the case of increasing the explanatory information by sound narrations.

So, we can conclude that "synergy effects" among figures, explanatory sentences, and sound narrations are not linear phenomena, but very complicated ones for contents construction with multimedia. It depends on the harmonized complementary degree between explanatory sentences with figures by key phrases and enough sound narrations.

## 8.7 Dance of Understanding and Knowledge-Circulated Managing

The multimodel presentations such as texts, figures/tables, sound narrations, pictures, photos, movies, and animations are very attractive and useful for e-learning contents construction. However, we need to look into the optimal combination

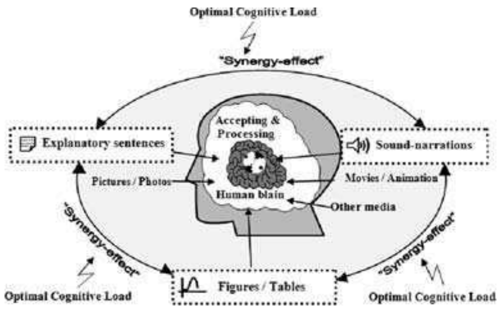



**Fig. 8.19** Dance of understanding

on blending those media for the purpose of enhancing "synergy effect" of understanding. Sometime, the multimodel presentation for e-learning contents seems to disturb human learning behaviors for the reason of not concentrating to understand more essential matters in the contents. In this context, we propose the concept of "Dance of understanding" (Fig. 8.19) from the point of the semantic relationship among those media. We define that "Dance of understanding" is internal behavior to make harmony in brain for understanding a series of learning/instructional materials, accompanied with the several represented media. We would like to regard the degree of this harmony as "synergy effect."

In consideration of the concept of "cognitive loads," learners' media preference and capacity in blain for accepting/processing those information have some kind of constraints (Eveland & Dunwoody, 2001). As a result of that, in the case of much cognitive loads, a learner's learning achievement seems to decrease. In this research, we try to find out "synergy effect" as the optimal "Dance of understanding" from the point of understanding the semantic relationship among figures/tables, explanatory sentences, and sound narrations.

Furthermore, we study the construction methodology of frames/contents as one important issue of instructional design in this framework. In the framework of our research, Know-How of the contents construction and production must be accumulated and reused in organizational knowledge-circulating management system (Nonaka, 1995).

Especially, the logical-relational knowledge for sequencing learning objects adaptively is quite important. Therefore, the architecture of e-learning information system to realize those tasks must be investigated. Then, the instructional knowledge such as aptitude (individual differences such as learning needs, learners' prerequisites, learning styles, learning behaviors, etc.), and treatment (frame construction sequencing), and interaction (ATI) must be accumulated in e-learning LMS and circulated through real and daily e-learning practices in any educational organization (see Fig. 8.20).

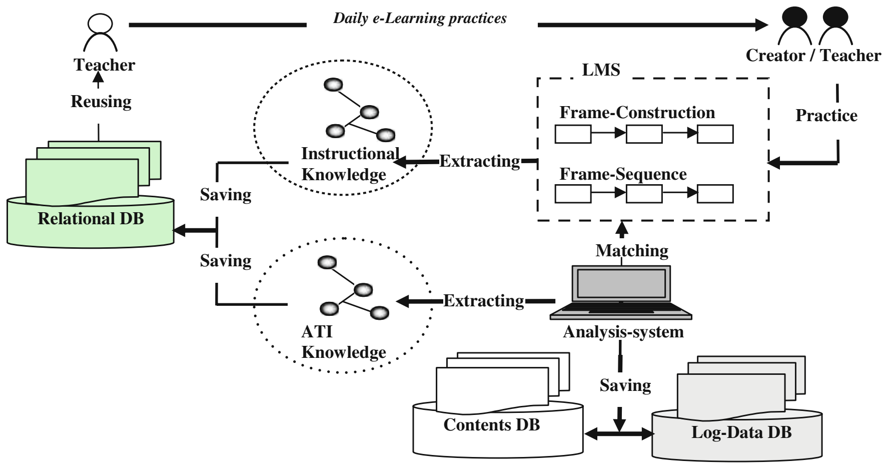



**Fig. 8.20** Knowledge circulating management system for Know-How contents construction

## 8.8 Conclusions

We describe the conclusions from the results of experiments for (1) contents analysis, (2) contents construction, and (3) synergy effect.

Especially, we examined whether our method of qualitative analysis is appropriate and useful or not for scientific/technological topics on the field in e-learning contents.

### *8.8.1 Contents Analysis*

We proposed the method of contents analysis from semantic relationship between figures and sentences in frames. On the basis of this analysis, we also proposed the qualitative method for contents construction. Moreover, the contents were evaluated for the degree of understanding by extracting semantic characteristics in the frames. We proposed the new method for Instructional Design to construct more effective contents from the points of linguistics semantics. As a result of that, we extracted three patterns: "progressive pattern," "regressive pattern," and "spiral pattern" from the characteristics on analyzed frames.

### *8.8.2 Contents Construction*

Our study on contents construction of e-learning is based on Bruner's representation model which consists of enactive, iconic, and some symbolic learning media. In general, when we produce learning contents, we use explanatory sentences in addition to figures/tables. In this case, we need to consider carefully the semantic relationship between figures/tables and sentences. This also means "bridge fusion" from concrete thinking to abstractive thinking. Therefore, we emphasize the designing aspects for constructing frames and its sequencing.

In comparison with the previous researches on this topic, our research is aimed to "synergy effect" in the meaningful relationship between figures and sentences; we take the qualitative analysis approach from the point of view of linguistic semantics.

## *8. Synergy Effect*

We focused on "synergy effect" for the following semantic relationships. First, the semantic relationship is between figures and sentences. Second, the semantic relationship is between figures and sound narrations. Third, the semantic relationship is between sentences and sound narrations. Our study is based on the theory of linguistic semantics.

For the frame construction on K-zone, the sentences which explaining the meaning of figures and tables are important. Moreover, sound narrations along the explanatory sentences seem to produce "synergy effect" for understanding the contents and to reduce cognitive loads for understanding the essential meaning behind the complex figures.

This study explores the method of more effective contents construction for the purpose of improving achievement/sustainability of human learning. Especially, we focused on the semantic relationship between figures in a frame and investigated the "synergy effect" by adding sound narrations along explanatory sentences in a frame.

We need to look into the optimal combination on blending those media for the purpose of enhancing "synergy effect" of understanding. (Diehl and Mills, 1995) We propose the concept of "Dance of understanding" from the point of the semantic relationship among those media. The "Dance of understanding" is internal behavior tomake harmony in brain for understanding a series of learning/instructional materials, accompanied with the several represented media. We assume the degree of this harmony "synergy effect."

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# Part III
# Technology–Facilitated Tools and Techniques (Isaías)

# Chapter 9
# VideoClipQuests as a New Setup for Learning

**Axel M. Blessing and Ulrich Kortenkamp**

**Abstract** VideoClipQuests (VCQs) are a teaching–learning approach focused on the learners self-activity while information is collected by searching the Internet, similar to the well-established concept of WebQuests. VCQs can be one element to sensibly integrate the possibilities and advantages of the virtual world into teaching. Some of the advantages of VCQs are that they allow the teachers great latitude, they can be created very easily, they are compatible with a multitude of learning platforms, and they can be used both in e-learning and traditional lectures. Moreover, they appear to inherently motivate the learners and thus become highly accepted. In this chapter, we present the concept of a VCQ as well as first evaluation results of their influence in learning.

## 9.1 Introduction

"When all you have is a hammer, everything looks like a nail!" This saying, describing the lack of apt tools and the resulting use of inapt ones, is superbly adequate to picture the present situation of many e-learning courses. Already 8 years ago, Rolf Schulmeister (2001) diagnosed that much educational material on the Internet reveals a lack of didactical imagination of the authors, and this can still be observed.[1]

Today's situation may be attributed – at least partially – to the fact that with the emergence of learning management systems, more and more teachers and lecturers start to create their own courses. However, those instructors never obtained training on e-teaching during their studies. On the one hand, it is obvious that the development of online material cannot mean to abandon all educational theory. On the other

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[1]This article is based on the homonymous paper presented at IADIS International Conference on CELDA 2008 (Blessing & Kortenkamp, 2008).


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hand, applying the existing concepts to e-learning literally seems to lead to tedious "scrolling deserts" where learners have to wade through endless pages of screen text. What's more, we often find stock images as "multimedia enhancements" that correspond to the rest like a parsley decoration to a Wiener Schnitzel and rather hamper than support learning (Mayer, 2001).

The question is why are even contemporary e-learning courses mostly text based? Also, as course creators don't seem to be acting in bad faith, why don't they use more appropriate concepts? Either there are no such concepts or the instructors don't know them or they are not willing to use them, probably because it is too laborious.

Thus, if one of the main problems in developing good e-learning courses is the lack of didactical creativity, or the use of "old school" didactics when not appropriate, then hassle-free concepts need to be created and disseminated. This was the starting point from which we developed VCQs.

## 9.2 Theoretical Frame Work

### *9.2.1 Requirements*

While investigating how we could leverage the power of today's networked, high-speed, and rich-media capable computers, we asked several teaching experts[2] about their requirements for such a new pattern. They all agreed on the following essentials:

- Any new method must be easy to use for both the teacher and the learner.
- It should not be restricted to a single subject or topic.
- It should support the learning management system of choice.
- There has to be a real benefit, i.e., the learning process has to be supported properly.
- It should not replace traditional methods, but add to them.
- There should be a way to share such material between colleagues.
- It should use the possibilities of the computer beyond showing text and images.

In conclusion, to be successful, such a concept must meet several demands: it must facilitate the learning process; teachers must be able to apply it to a multitude of subjects; they must be able to pursuit different learning targets; the creation of material must be as easy as possible; and the concept should motivate students and hence support meaningful learning.

[2] We asked both teachers in schools and higher education, as well as students.

## 9.2.2 Basic Concept

Using the requirements presented in Section 9.2.1, we developed a pattern that is designed specifically for introducing a new topic or concept. It should raise the learners' interest and motivation, thereby creating an environment that is suitable for further learning.

VCQs are thus meant to "set the stage". They are meant as a new building block for the design of online courses, but as we see in the next sections they are at least as suitable for blended learning or even traditional teaching with media support as they are for e-learning.

### 9.2.2.1 Creating a VCQ

Basically, a VCQ consists of a video clip embedded into a web page and one or more tasks or questions that are in one way or another related to the video. It is of vital importance – and so to speak the trick behind VCQs – that the fundamental terms of the subject dealt with do not appear in the task. In other words, the questions and assignments must be verbalized in such a way that they cannot be completely understood without watching the video – an approach that we call "mask the task". The following example illustrates this leading thought (Fig. 9.1).

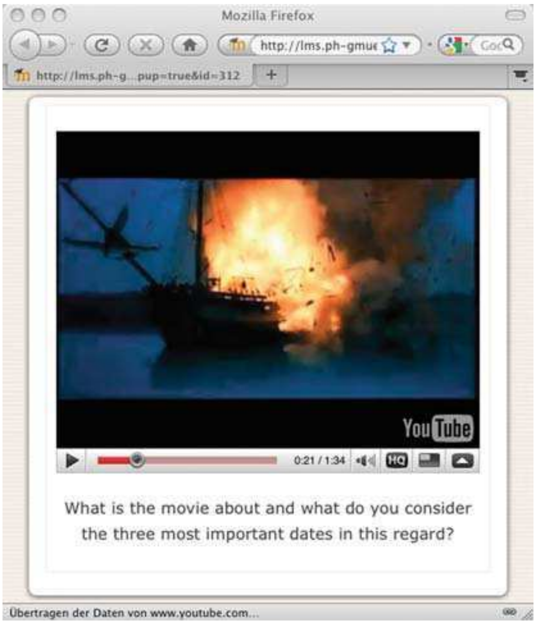



**Fig. 9.1** The concept "mask the task" within a VCQ

Only if the students are aware that the video clip shows the trailer of the movie "The Patriot", will they be able to answer the question accurately. Hence, after watching the video clip they can tell that it is about the American Revolutionary

War and the important dates are, e.g., the Boston Tea Party (December 16, 1773), the Declaration of Independence (July 4, 1776), and the signing of the Treaty of Paris (September 3, 1783).

#### 9.2.2.2 Solving a VCQ

To deal with a VCQ, the student has to accomplish two major tasks that can be designated *Rewording and Understanding* and *Gathering Information and Solving*.

The students' first major task is to rephrase the assignment so that it becomes solvable. For this reason, they have to watch the video and thus extract cues and hints from the audiovisual information provided. In the example above, it is relatively obvious (but this doesn't always have to be the case) that the video clip is about the American Revolutionary War, even if a student didn't see the related movie as a whole. In the end, the learners will be able to rephrase the question to something like "What do you consider the three most important dates in the American Revolutionary War?" Of course, they should now be able to understand the question and have an idea how to find an answer.

Subsequently, the students' second major task is to gather the information that is needed and finally answer the question. For this step, common Internet tools like Google or Wikipedia will usually be used.

On closer examination, the two major tasks can be divided into several partial tasks. Rewording and Understanding can be split into (a) read the "masked" task, (b) watch the video clip and extract the necessary cue, and (c) rephrase the task. Gathering Information and Solving can be divided into (a) find the relevant information and (b) formulate an answer. As we will see in Sections 9.2.6 and 9.4, each of the five partial tasks can be used to adjust the total difficulty and complexity of the VCQ, and thus to adapt it to the learners' prerequisites.

### *9.2.3 Motivation and Learning*

At first sight, the idea of formulating a task or question so that it *cannot* be understood may seem odd. But when we have a closer look at psychological issues, there is good reason for this modus operandi: motivation.

Motivation can be defined as a current state of arousal that determines the direction, persistence, and intensity of a person's behavior (Heckhausen, 2003). Especially in learning processes, motivation is of high importance, as it initiates and supports learning (Winkel, Petermann, & Petermann, 2006). Thus, the crucial question in almost every learning setting is how to motivate the learners.

One possibility of motivating the learners is to present them a barrier or an insolvable task, as both are means of motivation (Zimbardo, 1995). For VCQs this means that to overcome the barrier, in order to fully understand the assignment and so change the insolvable task into a solvable one, the learner is virtually "forced" to watch the video. As a person's motivation is related to essential aspects of the learning process like learning rate or resistance to extinction (Zimbardo), VCQs can be presumed to facilitate learning, a matter for which we already have statistical evidence (see Evaluation).

Moreover, video clips belong to the real life of adolescents and young adults. This fact allows us to deduce a supplementary motivational potential and additionally answers one of the five key questions of Klafki's (1962) Educational Analysis: What particular cases allow for a structure of the matter that is interesting, worth questioning, accessible, comprehensible, and clear for the students?

### *9.2.4 Emotion and Learning*

Not only motivation, but also emotion is intimately connected with learning success (Spitzer, 2002). Due to a lacking uniformity in science, the least common denominator is as follows: Emotions can either be strong or weak, and they can either be positive or negative. In general, we can remember things better when we have been emotionally involved with them. It is primarily irrelevant if the matter was good (a first kiss) or bad (a car accident) and, in principle, this applies to instruction too.

As negative emotions like fear or distress don't have a supportive impact on problem-oriented learning and are rather an undesired adverse reaction, they are not mentioned here. However, the beneficial effect of positive emotions[3] – in contrast to neutral or negative emotions – was depicted in the following experiment: Test persons were first shown pictures to evoke positive, neutral, or negative emotions and right afterward a neutral word, which they were supposed to remember. It could be shown that the words they were positively affected by were remembered best (Spitzer, 2002).

Hence, learning is more effective when combined with positive emotions, but the common instructional approaches that are based on the mere presentation of facts and data are highly unlikely to provoke them. Any person is more affected or driven by emotions, stories, and particularly other persons. As most video clips are in fact stories, include other persons, and/or are supposed to evoke emotions, this can consequently be regarded as another beneficial factor of VCQs, although this has not yet been statistically confirmed.

### *9.2.5 Ease of Creation*

Except for the rule "mask the task", VCQs allow any latitude. The possibilities are manifold and mainly limited by the video clips that are available, but as video hosting Web sites become more and more popular and even specific educational programs exist, finding a suitable video clip isn't difficult. YouTube (www.youtube.com), TeacherTube (www.teachertube.com), Curriki

[3] As a side note, it is important to realise that "positive" doesn't only comprise emotions like delight or pleasure. It is rather an emotional involvement which is not negative, like Cahill et al. (1994) could show.

(www.curriki.org), and Apple iTunes U (www.apple.com/itunesu) are some of the most prominent examples. Most Web sites provide code snippets which can be used to embed the video into a web page using copy and paste.

The complete process of creating a VCQ is as follows. As an e-learning environment, we used Moodle (http://moodle.org), a free, open source learning management system.

1. Find a suitable video clip and copy the relevant code snippet to the clip board. Since it is possible to embed video clips in Moodle, we use the accordant code for embedding (Fig. 9.2).


**Fig. 9.2** Area of a YouTube page with code snippets

2. In the Moodle course, turn on editing and add a web page as a new resource in the designated week/topic (Fig. 9.3).

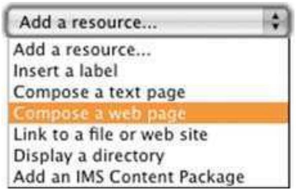



**Fig. 9.3** Adding a resource in moodle

3. In the new web page, enter a name and summary, then toggle the editor to the HTML mode by using the "< >" button and paste the code snippet into the HTML source code (Fig. 9.4).
4. Toggle back to the WYSIWYG mode and specify the task or question (Fig. 9.5), then save your web page.

VCQs are independent of specific software. If VCQs are to be conducted within an e-learning course, any learning management system can be used for embedding or linking videos, presenting texts, and assessing students via quizzes or uploads. These are all basic features that any learning platform should include.

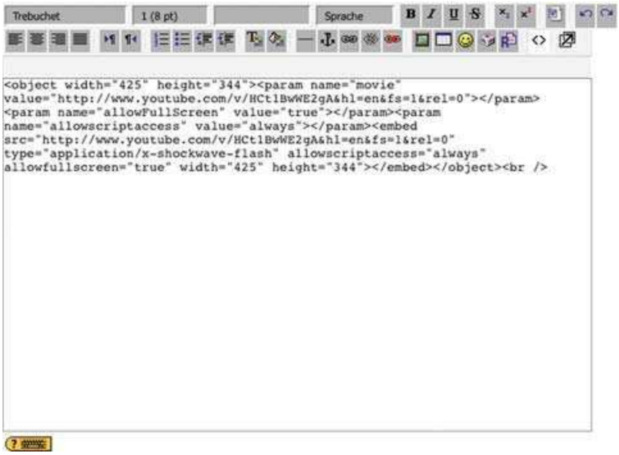



**Fig. 9.4** The HTML mode of a web page


**Fig. 9.5** The WYSIWYG mode of a web page

### *9.2.6 Learning Targets, Tasks, and Assessments*

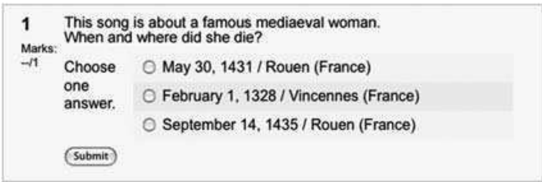
Due to the freedom of action that VCQs permit, learning targets based on learning theories of almost any kind are supported, as there is a strong relationship between learning theories on the one hand, and learning targets, assignments, and assessments on the other. Hence, depending on the topic, on the video material available, and on the task, various matters with various objectives can be presented to various audiences.

Because learning success is dependent on many factors on the learners side, like previous knowledge, intelligence, giftedness, or learning strategies (Leutner, 2006), it is important that the learning – or teaching – process is matched to the learners prerequisites. As mentioned previously, the learners handling of a VCQ consists of two major tasks which can be divided into several partial tasks. This fragmentation is quite helpful when having a closer look at the possibilities VCQs offer in terms of the distinction between low and high achievers.

For low achievers, the Rewording and Understanding and the Gathering of Information and Solving mustn't be too difficult. We will exemplify this with the "Maid of Orleans" VCQ, depicted in Figs. 9.6 and 9.7.


**Fig. 9.6** The "Maid of Orleans" VCQ

**Fig. 9.7** The "Maid of Orleans" quiz




The first partial task of Rewording and Understanding is to read the "masked" task. Therefore, it mustn't be too complex or confusing. As you can see in Fig. 9.6, the task is formulated unambiguously. Second, the learner has to watch the video clip and extract the necessary cue. Please note that it is very easy to extract the important hint from the video clip because the song title is displayed. So the third step is to rephrase the task, which will lead to "When and where did the Maid of Orleans die?"

Gathering Information and Solving consists initially in finding the relevant information. In the case of low achievers, this should be subdivided into (a) finding a web resource that contains the answer and (b) finding the answer within the web page. The teacher can help students to master (a) by giving a hint to use Wikipedia as a web resource. When entering the search term "Maid of Orleans" in Wikipedia, the student is confronted with a disambiguation page offering four options: an unfinished poem by Voltaire, a historical tragedy by Schiller, an opera by Tchaikovsky, and a single by Orchestral Manoeuvres in the Dark (OMD)[4]. Even if the learner didn't recognize that the video clip is by OMD, this doesn't matter as each of the four pages contains a hyperlink to the page "Joan of Arc" ("An epic and scandalous satire concerning the life of the not yet canonized Joan of Arc ('the Maid of Orleans') [. . .]"[5]; "The play loosely follows the life of Joan of Arc";[6] "[. . .] based on several sources: [. . .] Jules Barbier's Jeanne d'Arc (Joan of Arc) [. . .]";[7] and "Both songs are about the French heroine Joan of Arc"[8]). So once the learners are on the respective Wikipedia page, they only have to look for the place and date of Joan of Arc's death, both to be found in the section "Execution" ("Eyewitnesses described the scene of the execution by burning on 30 May 1431. Tied to a tall pillar in the Vieux-Marche in Rouen, she asked two of the clergy, Fr Martin Ladvenu and Fr Isambart de la Pierre, to hold a crucifix before her"[9]).

In a final step, the students have to formulate an answer. It is of course easier to answer a closed question, and in an e-learning environment this means a multiple-choice test (Fig. 9.7). There are many advantages and disadvantages of multiple-choice tests on computers, which don't need to be discussed here in detail. But one of the advantages is that the students receive immediate feedback as soon as they have submitted the test, which again is conducive to learning (Musch,1999).

High achievers can be faced with tougher tasks. Assignments don't have to be made of closed questions and hints don't need to be easy to extract. Quite the contrary, the more challenging the assignment, the better the learning success (Schnotz & Kürschner, 2007).

As an example, let's use the subject "School Rampages" that can be introduced with The Boomtown Rats' video "I don't like Mondays", followed by tasks like:

- By what incident was the song inspired?
- Where and when did the incident that the song is about happen?
- Find at least three more examples of similar incidents.
- Where did such incidents happen in your vicinity?
- What reasons are given to explain why people act like this?
- Give your opinion, what causes such incidents.
- Etc.

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[4] http://en.wikipedia.org/wiki/Maid_of_Orleans
[5] http://en.wikipedia.org/wiki/The_Maid_of_Orleans_(poem)
[6] http://en.wikipedia.org/wiki/The_Maid_of_Orleans_(play)
[7] http://en.wikipedia.org/wiki/The_Maid_of_Orleans_(opera)
[8] http://en.wikipedia.org/wiki/Maid_of_Orleans_(The_Waltz_Joan_of_Arc)
[9] http://en.wikipedia.org/wiki/Joan_of_Arc

It is quite obvious that all five partial tasks are more demanding, especially extracting the cue, finding the relevant information, and formulating the answers.

In order to answer the questions or fulfill the tasks, the learners' first mission is to find out what the song is about. This can be done by using the chorus "I don't like Mondays" as a search term. Finally, they will find out that the song is about the 16-year-old Brenda Ann Spencer, who fired a gun at people in a school playground across the street from her home, killed two adults and injured eight children and one police officer. With this information, the learners can rephrase the questions and tasks and solve them.

Tasks like the ones mentioned here can, in Moodle, be realized with the assessment activity, where students can upload a file. Such a task is naturally more ambitious than a quiz and therefore more appropriate for this audience. The little drawback on the side of the teachers is that they have to revise the assignments manually, while quizzes are corrected automatically.

We will give more examples and variations in Section 9.4 and further possibilities, but the presentation of our evaluation outcomes first.

## 9.3 Evaluation

We used VCQs in the e-learning part "Internet search engines" of a blended learning course called "Basics in Information Technology" at our university. The learning target thus being the sensible handling of search engines, i.e., getting high-quality search results as fast as possible.

A feedback module in the e-learning course served to evaluate the method. It contained four statements that could be rated by a five-point Likert scale from "strongly disagree", "disagree", "neither agree nor disagree", and "agree" to "strongly agree". Forty-four students participated in the survey. The statements and ratings are shown in Table 9.1. The first value gives the number of students that selected this answer and the second gives the percentage of this answer with respect to the sum of all answers.

**Table 9.1** Statements and ratings

| Statement | Strongly disagree | Disagree | Neither agree nor disagree | Agree | Strongly agree |
|---|---|---|---|---|---|
| VideoClipQuests are fun | 3<br>6.8% | 3<br>6.8% | 11<br>25.0% | 15<br>34.1% | 12<br>27.3% |
| VideoClipQuests are motivating | 2<br>4.5% | 4<br>9.1% | 5<br>11.4% | 21<br>47.7% | 12<br>27.3% |
| Using VideoClipQuests, searching the Internet can be well practiced | 0<br>0.0% | 4<br>9.1% | 13<br>29.5% | 16<br>36.4% | 11<br>25.0% |
| There should be at least one more VideoClipQuest in the progression of the course | 4<br>9.1% | 3<br>6.8% | 6<br>13.6% | 17<br>38.6% | 14<br>31.8% |

It can be clearly seen that a majority of students agreed or even strongly agreed to all of the four statements. This fact becomes even more convincing when we oppose the two combined disagree columns to the two consolidated agree columns (while omitting the neither-nor column):

- 61.4% vs. 13.6% of the students hold that VCQs are fun.
- 75.0% vs. 13.6% find them motivating.
- 61.4% vs. 9.1% agree that one can exercise Internet searches with VCQs.
- 70.4% vs. 15.9% would like to carry out another VCQ in the progression of the course.

The means and standard deviations of the items substantiate these findings (Table 9.2; "strongly agree" = 5, "strongly disagree" = 1).

**Table 9.2** Means and standard deviations

| Statement | M | SD |
|---|---|---|
| VideoClipQuests are fun. | 3.68 | 1.16 |
| VideoClipQuests are motivating. | 3.84 | 1.08 |
| Using VideoClipQuests, searching the Internet can be . . . | 3.77 | 0.94 |
| There should be at least one more VideoClipQuest . . . | 3.77 | 1.24 |

In brief, it can be said that a vast majority of the students value VideoClipQuests as being fun and motivating while they also agree that the learning aim can be achieved. So from a student's point of view, VCQs are well accepted.

## 9.4 Further Possibilities

Supplementary to the facts and examples already mentioned, we will bespeak further possibilities in this section in order to show the methodical richness of VCQs.

*Video clips*. The video clip can basically be anything from entertainment to education, including music, movies (or rather a part, like a trailer), or news. It is of course important that the film is able to provoke emotion, motivation, and/or curiosity, so that a *typical* (i.e., boring) educational video clip is rather inapplicable. The video shouldn't be too long; we made good experiences with videos that have a running time of 30 seconds to 3 or 4 min.

*Assignment and assessment*. With VCQs, learners can work on the same or on different tasks and they can do so alone or in groups. To differentiate within a heterogeneous group, students can work on core and bonus tasks. Weak learners can, for example, identify facts while strong learners can, additionally, give their opinion. Learners can be tested with a typical online test that consists of multiple-choice questions or text fields and they can write and upload a paper. Furthermore, students can work together on a wiki (see below) and the teacher can use third-party software like Hot Potatoes (http://hotpot.uvic.ca) to create special assessments like crosswords.

*VCQs and wikis*. As it isn't easy to imagine how a wiki can be used in a VCQ, here is a concrete example. As a video clip, the song "We didn't start the fire" by Billy Joel is used which can, e.g., be found on TeacherTube. The verses simply consist of a sequence of historical events from 1949 (Joel's birth year) to 1989 (release date of the single), the first one being "Harry Truman, Doris Day, Red China, Johnnie Ray/South Pacific, Walter Winchell, Joe DiMaggio/Joe McCarthy, Richard Nixon, Studebaker, television/North Korea, South Korea/Marilyn Monroe". The "unmasked" task for the learners is to select one of the names or incidents given, to figure out what is behind it, and to write a short text in the wiki. The wiki itself can consist of the lyrics (with additional dates separating one year from another), where each name or event is a hyperlink to a subpage.

*VCQs in face-to-face learning*. Besides dedicated e-learning courses and blended learning situations, VCQs are also suitable for lectures and seminars without additional e-learning material. The task can be written on the blackboard or handed out as a paper-based work sheet. The teacher starts the video clip using a PC or notebook and an LCD projector. The only premise is that the students have Internet access. In such a setting, VCQs gain a special appeal when only the length of the video clip is available to find the answer. This requires a minimum length of the video of course, and at the same time it makes it easier for the teacher to reckon the teaching time.

*Let the students quest.* It doesn't always have to be the teacher who creates VCQs, it is just as well possible that students develop them. For this purpose, the students can be divided into groups and each group works on their own VCQ. After the teamwork, all VCQs are presented and the students have to solve the VCQs where they weren't involved. Depending on the class, the teacher can scaffold this by naming possible resources and by giving individual help.

*Sharing VCQs*. Aside from the customary information concerning learning and teaching (like class level, subject, learning aims, etc.), VCQs merely consist of two further specifications in most instances: the web address of the video clip and the masked task (in some cases where multiple-choice questions are involved, the distractors used may be a third useful statement). If both teachers use the same software, it is usually possible without any difficulty to export a course – or even only a part of it – and to import it. The transmission of the data can be done via e-mail, flash drive, and so forth. In the event of different systems, some text has to be exchanged, i.e., the hyperlink to the film and the masked task (plus maybe the distractors), which can be done via e-mail. As VCQs can be created easily, there is no problem in rebuilding it.

## 9.5 Summary and Future Work

With VCQs, we present an e-learning pattern whose main advantages lie in its ease of use; in its induced freedom of action of the teacher regarding learning targets, assignments, and assessments; and in the apparent motivation of learners.

Furthermore, they can be shared without difficulty, even from one learning management system to another. The basic idea is simple yet clever and – as the evaluation shows – feasible. Due to their simplicity, VCQs can be combined perfectly with traditional methods like group work or differentiation. Hence, VCQs meet all the demands that teaching experts make.

In prospective investigations, we will include aspects of emotion in the questionnaire for the students in addition to the already existing statements about motivation. Thus, we can examine the theoretical basis of this facet with empirical data. Furthermore, a comparison of VCQs with other approaches will be made in order to gain insight into the effectiveness and sustainability of the method.

To prove – or challenge – the easy creation of VCQs, we will first of all include the topic in the next semester's class about e-learning and let the students develop VCQs. Additionally, we will introduce VCQs to teachers by further training and by letting them create VCQs as well. So we will have feedback from future and already employed teachers regarding this hypothesis.

Finally, we can imagine a Web 2.0 application that is based on VCQs created by a community of teachers. A repository that is created as a mash-up based on, say, YouTube could serve as a pool of ideas that will stimulate the dissemination of the concept and its use in the classroom or in e-learning*.

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*Meanwhile such a web application has been created. It can be found online at http://myvcq.de, currently in German language only.

# Chapter 10
# Research on Computer-Supported Collaborative Learning in Transdisciplinary Groups

**Edita Butrime, Rita Marciulyniene, and Rita Valteryte**

**Abstract** This chapter analyses the transdisciplinary action research of future IT specialists and artists. The problem is that after graduating from studies, majority of students will work in transdisciplinary and continuously changing teams, as the modern world is inconceivable without labor collectives or project work groups designed for the solutions of certain problems. They must be prepared for such collaboration. This chapter discusses a 5-year experience where transdisciplinary action research projects are applied while working with general-type university and specialized art university students in Lithuania. Computer science and art students were involved in the research. The learning process was organized in such way that students learned while working in transdisciplinary groups creating a common product intended for solving a real empirical task. Computer-supported collaborative learning tools were applied for communication/collaboration among group members. The authors try to show how transdisciplinary action research influences students' educational results and how students themselves assess such learning. The results of qualitative empirical and quantitative research are presented.

## 10.1 Research of Computer-Supported Collaborative Learning in Transdisciplinary Groups

Nowadays, among the most significant tasks of teachers' are teaching students to work in a rapidly changing information environment, motivating students to apply the most advanced technologies, and encouraging students to provide their work results in an appealing way. This is important because in this case students will be not only passive participants of the knowledge society, but its active designers as well.

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When solving a problem, a person in the knowledge society appeals to completely different ways of awareness and empiric behavior rules than in the classical knowledge system that have been taken from a modern tradition. Not only have such variations of awareness been determined by the predominance of technological actions, but also by exchanged logics of an innovation that can be called as information rationality (Augustinaitis, 2002, para. 1). Thus, it is significant to teach students to work in collaboration to reflect and comprehend the essentiality of life-long learning – we are learning always and everywhere.

In the first part of this chapter, a concept of transdisciplinary action research is provided. In the second part, the concepts of collaborative learning and computer-supported collaborative learning are delivered. In the third part of this chapter, the overview of 5-year experience concerning the application of transdisciplinary action research projects with students of Computer Science faculty and Institute of Arts is presented. In the fourth section, the authors discuss outcomes of a qualitative research. Finally, it concludes with a discussion of outcomes of a quantitative research of computer-supported collaborative learning (CSCL) transdisciplinary action research.

Research object is computer-supported collaborative learning transdisciplinary action research, the participants being students from Computer Science faculty and Institute of Arts.

The research aim is to determine if transdisciplinary action research influences students' educational results and how students themselves assess such learning.

The problem is that many graduates of computer science, programming, graphics, and design specialties become involved in creating multimedia products. These tasks are usually carried out by diverse group specialists. The question is how to train a specialist who will be able to work in the new knowledge society environment, encouraging transdisciplinary action research in continuously changing teams. The research methods used are the analysis of scientific literature and documents, qualitative empirical research, questionnaire, and descriptive statistics.

## 10.2 Transdisciplinary Action Research

The first meeting of scientists concerning transdisciplinary action research took place in 2004, in Stockholm – Euroscience Open Forum, 2004 (ESOF 2004). In this forum, much attention was paid to links between movies and exhibitions related to arts and science. During the closing session of the forum, Jean-Patrick Connerade, the president of EuroScience, expressed his happiness concerning the event's success and the achieved result – to design a steady foundation for the dialog of various scientific fields and society in Europe (Euroscience Open Forum, 2004).

> The developed economic and social role of knowledge alters the pattern of modern scientific research. In it there are disappearing boundaries of traditional disciplines; their standard of value is becoming not only its scientific novelty and the acknowledgement in the academic community, but the innovation and effectiveness of the application of current knowledge

> as well as its benefits for a society. (Ministry of Education and Science of the Republic of Lithuania, 2005, p.6)

Application of ICT in education creates new objectives, their attainment of which is innovative and topical for the training of future IT specialists. One way to achieve this new objective is by using transdisciplinary action in learning. Nicolescu (1997) defines transdisciplinarity as a certain knowledge level that creates the discontinuous structure of transdisciplinary space, and the aim of which is to perceive this world under the aspect of the generality of knowledge and unification.

> As the prefix "trans" indicates, transdisciplinarity concerns that which is at once between the disciplines, across the different disciplines, and beyond all discipline. Its goal is the understanding of the present world, of which one of the imperatives is the unity of knowledge (Nicolescu, 1997, para. 6).

According to Wikipedia encyclopedia, (Tarpdiscipliniskumas, 2009, para. 1) transdisciplinarity is the collaboration of different disciplines and their methods. Transdisciplinarity is the collaboration of different scientific fields and the application of their methods necessary just for certain work that is terminal and completes after having fulfilled a particular task.

Bitinas (2006, p. 171) defines action research as an educational process based on a new (or at least relevantly new, but topical) idea that is designed under the researcher's initiative, his collaborative efforts, and the participants. According to Dick (1997, para. 1), action research can be described as a family of research methodologies which pursue action (or change) and research (or understanding) at the same time. In most of its forms it does this by using a cyclic or spiral process which alternates between action and critical reflection; in the later cycles, continuously refining methods, data and interpretation in the light of the understanding, developed in the earlier cycles.

Bitinas (2006, p. 171) divides action researches into analytical and constructive. In this case, we applied constructive action researches that empirically implement a more common and certain education system into them. Their purpose is not only to approve well-known technologies, but also to construct new technologies.

In summary, it can be stated that action research involving IT and art students can be called transdisciplinary action research.

## 10.3 Computer-Supported Collaborative Learning

Collaborative learning is being applied since the twentieth century. According to Kumar (1996, para. 5)

> collaborative learning provides an environment to enliven and enrich the learning process. Introducing interactive partners into an educational system creates more realistic social contexts, thereby increasing the effectiveness of the system. Such an environment would help sustain the student's interests and would provide a more natural learning habitat.

Zurita and Nussbaum (2004, p. 290) claim that "collaborative learning (CL) has been frequently seen as a stimulus for cognitive development, through its capacity to stimulate social interaction and learning among the members of a group." According to Piagetian and Vygotskian approach, there are three key components for evaluating face-to-face collaborative learning activities:

- the presence of conflicts, therefore, the necessity of negotiation instances to solve them
- the importance of coordination and interactivity
- member communication (Zurita & Nussbaum, 2004, p. 290)

The application of group learning distinguishes certain technical work conditions: It is possible to join in groups, to change them while taking into consideration students' wishes and interests, and to allow students work independently.

The learning process is dependent on a variety of factors. According to constructivist approach, student's predisposition and experience as well as the nature of learning environment and acquired knowledge are of great importance. Due to the fact that predisposition and experience are individual for each student, students learn differently from each other, despite the fact that they are being taught in the same way.

Consequently, under the constructivist approach, the most significant role of a teacher is to organize the learning environment in such a way that the student would be able to deepen his/her previous knowledge and experience while learning, actively extend his knowledge, and relate new information with authentic and reasonable context. In this way, the diverse interaction between students and a teacher is strengthened. Thus, learning is systematization of data, cyclic interpretation, and the student's independent engagement with specific activities. When information and communication technologies are deployed in the conventional teaching environment, the process of teaching changes into the process of learning. Students have to be prepared for the adaptation to a new style of learning, to become independent, in charge of themselves, learning and capable of adapting to a new interaction with peers and lecturers as well as to be able to overcome the fear and stress of new information technologies (Beresneviciene, 2001, p. 179).

Vasiliauskas (2007, p. 81) highlights that during the reorientation of modern education from verbal and passive teaching to interaction-based education, the person's activity is being raised as the most significant factor in the development process of individuality. During an active learning, a student obtains abilities in critical thinking, experience in mind broadening, change of interests, and learns to mobilize his/her efforts, i.e., develops and educates himself/herself while acting universally.

Learning through collaboration is an active way of learning. The objective of many groups is to improve learning of individual group members:

> If learners, students or adults are distributed to learning groups, they will not necessarily work effectively there and will reach good learning outcomes. The main necessity for successful group learning is cooperation. This concept means much more than being together, talks, helping others, sharing the material, although all this is very important. The work

> of persons gathered in groups can be a priori called cooperation as even working in one group everyone can work for himself to reach personal goals, whereas cooperation means working together and group achievement is more important than the outcome of its separate members (Teresevičiene & Gedviliene, 2003, p. 152).

According to Johnson, Johnson, and Smith (as cited Gedviliene, 2004 p. 294) cooperating groups need five key elements:

Positive interdependence: Lecturers can achieve a positive interdependence when common aims for a group are ascertained and roles for members of the group are distributed (responsibility).

Stimulating interaction: Discussion about cooperation is possible in case students in a group help each other, notice each other's efforts clarifying the tasks, problems, and the ways of solving them.

Individual responsibility: Each member should feel responsible for good learning of the given material or well-performed task, not just trying to make use of the group's results.

Social skills: A group cannot work effectively if its members do not apply abilities of communication, leadership, decision taking, and conflict solving.

Group processes: Students are taught to analyze the group's work periodically, especially if students are involved in group work for a longer period.

The literature indicates that it is better to teach and learn when the work goes on in diverse groups (different sex, ethnic origin, and different skills) and there is a democratic style of management.

Information and communication technologies have been applied in collaborative learning for many years. During the progress in information and communication technologies, newer and newer tools emerge, which can be applied in communication and learning. According to Haythornwaite (as cited in Zurita & Nussbaum, 2004, p. 292), computer-supported collaborative learning (CSCL) is not just collaboration around computers with the computer providing means to coordinate tasks or to simulate problem-solving situations, but rather collaboration through computers where group members use the computer to structure and define their collaborative endeavors. According to Bricker (as cited in Zurita & Nussbaum, 2004, p. 291), communication is basically possible in three different ways:

- verbal (another person receives this message through auditory or visual senses)
- physical (by reading the other person's body language and/or movements)
- graphic (by using written signs and drawings)

Taking the advantage of opportunities that information and communication technologies provide with, it is possible to implement all three ways of communication in a creative way. However, during the application of information and communication technologies, communication and collaboration are set a little bit differently than in the face-to-face environment. Both these ways have got some points in favor and against. The creative combination of face-to-face CL and CSCL can give quite good results.

Switzer and Hartman (2007, p. 205) note that there are several problems that can arise in traditional face-to-face meetings. Issues not related to the relevant task can sidetrack the group. The free flow of creative thought may be discouraged by ideas being attached or the fear of retribution. There can be premature closure of the meeting to avoid conflict. The record of the meeting can be subjective, incomplete, or lost. Triguerous, Rivera, Pavesio, and Torres (2005), while talking about discussion as an active learning method in a traditional lecture, notice "that participation tends to be measured by the dialogue arisen in class while the teaching/learning action takes place. Surely that dialogue can be questioned, since it happens under a fictitious form and it is unreal because its origins are partial" (p. 112). The authors prove that it is going on due to the fact that the lecturer or the students interested in the subject can monopolize the managerial role. The rest of the audience does not participate in the discussion.

According to Rubens et al. (2003, p. 7), the competence and expertise in knowledge society can no longer be described as the skills of one individual only. So it is important to teach students to work in teams and networks, using computer-supported tools.

> Computer-supported collaborative learning (CSCL) is focused on how collaboration and technology facilitate sharing and distributing of knowledge and expertise among community members (Rubens et al. 2003, p. 7).

In summary, it can be stated that the environment, which facilitates learning through collaboration is enriched with information and communication technologies or CSCL (i.e., after proposing to the students to communicate in virtual environment). When students communicate in virtual environment, where teachers are "far away," those, who in the face-to-face environment did not dare or were not ready to collaborate, behave more courageously or they are "forced" to put their contribution to the common project.

## 10.4 Transdisciplinary Action Research Groups

Convenient interaction of humans and computers has an impact on the availability of information and service, and it has a crucial role while seeking for the aims of information society. Moroz (2004, p. 66) states that the competitive battle is often settled on the first impression of application that is provided by a convenient connection. An inconvenient connection limits functional possibilities and beneficence of effective software. During the investigation of diverse software (Web sites, educational software, information systems, and students' practical work), it was noted that they can be divided into two groups:

- functionally mature technical functional software that is unattractive with regard to the display of colors, elements, and aesthetics
- software that is simply nice and attractive to the user and that is primitive in terms of the functions it offers

The authors of the first group software are usually programmers – professionals. The second group authors are most frequently people who possess an artistic training or attraction to artistic work. The question is how to train a specialist that could work in a new environment of the knowledge society that will be able to create both functional and attractive to the user software products. After having highlighted such a problem, there was an attempt to combine students' practical work at the faculty of Computer Science and in Institute of Arts. As joint work of the mentioned specialists allows designing a product that will be not just functional, but also attractive to the user, it was decided to apply transdisciplinary action research.

The creation of such a product under the conditions of knowledge society is especially topical. The students in computer science, learn to program, and the students-artists learn to design computer graphics (create an image of person or company that expresses the software users' interconnection and mood, i.e., design artistic work, related to digital application). Augustinaitis (2002, para. 5) notes that the basic trend in knowledge society is moving of major professions toward a post-modern model of professionalism, as there is an increasing influence of such sense giving factors as transdisciplinarity, miscellany, and awareness.

The modern world is inconceivable without labor collectives or action research work groups designed for the solutions of certain problems. In our case, such action research groups are established under the basis of transdisciplinary action research, i.e., students from the faculty of Computer Science and Institute of Arts learn together in order to create a common product. The work productivity of such groups directly depends on the successful collaboration of students in different occupations, the stability of these groups, and the professionalism of their participants, i.e., the design of functional and attractive software to the user. One of the effective ways of group learning is learning while collaborating. Tereseviciene and Gedviliene (2003, p. 66) comprehensively layout the peculiarities of the following method:

- The tasks are formed in such a way that the students take care not only of the fact how to execute his/her task, but also of how to execute task requirements for other group members.
- Clear individual responsibility for the work of the whole group. Every student receives feedback about his/her progress (after having assessed individually), and the group has a feedback with each member's progress (the work of the whole group is assessed).
- The students' aims encourage to extend each member's possibilities and keep good work relationships of group members;
- Management, collaboration, trust, and conflict solution are social skills, which are directly taught.
- The teacher observes and analyzes the issues that have arisen during the work process and simply as a lesson summarizes the efficiency of the group work.
- Their friendship is usually of a heterogeneous type.
- All group members share the leader's position.

Brazdeikis (1999, p. 45) distinguishes various stages of research group work: the emergence of an idea, software, and hypothesis; work planning and delegation of work; research, search for information, and work design; and generalization of results. These work stages of the research groups were adapted in the students' transdisciplinary action research in the faculty of Computer Science and in the Institute of Arts. The students were provided with the information concerning the task (its goal and how to perform it). During the educational process, students performed tasks (searched for necessary information, systematized it, created new knowledge, and performed tasks according to it). At the end of the group work, students provided software, designed collectively, as well as reflections concerning the research benefits. Students were asked to actively participate in the design and implementation of the research as well as in analyzing its outcome. Research participants took part in discussions: student group discussions as well as in discussions between students and teachers and between performers and customers. The project participants communicated via Internet, e-mail, and telephone. According to Dick (1997, para. 5), transdisciplinary action research is organized for several consequent years successively and improves annually while applying newer and newer technologies and improving research in regard to the research participants – students' and teachers' reflections.

In brief, it can be stated that in the methodological publications of postpositive trend, the action research method is discussed as a complete educational way for the cognition of reality. Consequently, transdisciplinary action and short-term research groups for work and learning, established under its basis, could be investigated as a new educational technology that enables the training of a specialist for the knowledge society. Good results are possible only in cases where students learn in the group actively, voice their individual opinion, participate in discussions, and provide some problem solutions. The leader's qualities are reflected in such work and learning groups, he is trained to communicate and this reflects a "postmodern model of professionalism" approach (Augustinaitis 2002, para. 5).

The transdisciplinary collaboration project groups were created from different occupation students who had been studying in different higher schools. Consequently, it was of great significance to coordinate the communication/collaboration among group members, between the group and lecturers, and among all project participants. Because of different students' timetables as well as lecturers' work schedule, it was complex to organize frequent regular face-to-face meetings, so gradually communication and collaboration transferred into the virtual environment. That happened naturally and there was no need to stimulate the process artificially, as all the required objective conditions for such communication were gathered.

During five projective activity years, not only the forms of collaboration but also the applied IT means have changed. During the first year of the transdisciplinary collaboration project, communication was mostly done during the organizational meeting for all group members and lecturers, the date and time of which were arranged via e-mail. That caused a lot of organizational problems and took a lot of time. After having assessed the first-year experience, it was decided to use IT communication means. There was a decrease in the number of face-to-face meetings. They were allocated to the review and discussion of intermediate and final work outcomes. Students could choose the forms of communication in groups and lecturers voluntarily after having assessed the experience and conditions each of them had. Due to the fact that the students in computer science had already applied intranet e-mail/communication/conference system, FirstClass and as the virtual learning environment Moodle since the first/second course, they had by far more experience in comparison with the art students. So it was necessary to do additional work with these students while teaching them how to apply CSCL environments. It was necessary to aid some of the art students to design their mail boxes. They were introduced to the virtual environment where they could find the methodological materials as well as communicate interdependently. During the latter year, the popularized CS communication means such as Skype, Google groups, and Windows Live provided each collaboration project group with a possibility to select the most suitable way of communication.

It is necessary to notice that the art students had been developing their level of comfort with IT, every year, and during the fifth year none of them needed help to design their mail box. So during the fifth year of work, the research participants used three levels of communication:

- communication between student groups and lecturers in the virtual environment (using Moodle, First Class in the Computer Science faculty and Google groups in the Institute of Art),
- individual communication in transdisciplinary groups (telephone, e-mail, and Skype), and
- regular face-to-face meetings of all student groups and lecturers to discuss tasks, results, and problems.

In summary, it can be claimed that recently there are numerous versatile virtual means of communication/collaboration, which allow a successful and smooth organization of the transdisciplinary collaboration in group activities. Such virtual environments as Moodle, communication/collaboration environments, Google groups and Windows Live as well as others can be successfully applied in the projects of transdisciplinary collaboration. They are especially useful when communication is made between students and lecturers with different occupations, versatile experiences, and different universities, as the mentioned environments are easy to install and free.

It is important to determine which of the entitled (or other) means would be the most suitable and considered the best by transdisciplinary group participants and lecturers. In the virtual learning environment Moodle, theoretic material can be placed and tasks and groups can be formulated; Wiki can be used for the creation of general group documents, the communication is both in groups and with other project participants as well as there the delivered work is assessed and discussed. E-mail, communication and collaboration system Windows Live Spaces serve for sharing of information with others as well as for designing of diaries and forming discussion/chat groups in each user's personal space; SkyDrive can be applied for the placement files with personal, limited, or public access; Messenger can be applied in audio and video chats with friends and colleagues and allows the organization of chats in groups of up to 15 people and to use Microsoft Office documents together in Office Live Space.

## 10.5 Qualitative Research

The students in the faculty of Computer Science and in the Institute of Arts have been performing collaborative practical work since 2003 (Butrime, Marciulyniene, & Valteryte, 2008, para. 26). Students in the Institute of Arts were provided with the tasks related to the certain students' bachelor thesis in the faculty of Computer Science. Students collaborate for three or two semesters.

In order to find out if transdisciplinary action influences the students' educational results and how students themselves assess such learning, a research was carried out.

During face-to-face meetings, lecturers and students reflected and discussed about what was acceptable and what was not and what was to be altered in the learning process. Every year CSCL transdisciplinary action research was altered while taking into consideration these reflections. During the first year there were many face-to-face meetings, but every year there were fewer of them.

During the second semester of the 5th year three face-to-face meetings were held:

1. Lecturers explained what CSCL is and how the learning will be run.
2. The review of work performed during the first semester. The discussion of the work process during the first semester.
3. Discussion of the whole work process and work in the last meeting.

During the whole CSCL transdisciplinary action research, the students and lecturers communicated via Internet. Art students and computer science students worked independently in different ways. The students of the fifth year in CSCL transdisciplinary action research had different learning experiences. The computer science students frequently learn in virtual environments. All the people attending the virtual meeting need to be trained and experienced in the technology, otherwise they will not be able to participate. It was the first trial for the art students. Consequently, they had to learn to communicate electronically to participate in e-discussions, respond to e-mails on time, and create e-mail boxes. For the art students a virtual environment was designed, where they constantly communicated with a lecturer and other students. In the following environment, the descriptions of all praxis work were publicized as well as supplementary assistance for the completion of their work. The students were encouraged to communicate and learn in a virtual environment. This was the first time such an experiment was conducted in the Institute of Arts. There was a blend of learning environments. The students learned in both face-to-face and virtual learning environments. At the end of the first educational month, the students were asked to write reflections concerning the virtual learning environment. After having carried out a qualitative research of the students' points of view, it was possible to distinguish the following categories:

- Advantages: The virtual learning environment is acceptable; it is possible to learn in an acceptable place and when you wish; it is possible to communicate and share the information with a lecturer and other students; it is always possible to reach all tasks and information; and learning in a virtual environment aids students to get deeper into a task.
- Disadvantages/problems: Communication takes longer than face-to-face interaction; there is a lack of experience; there is no Internet connection at home; sometimes misunderstandings occur during virtual communication; and learning virtually not always successful to force some students to learn.

The students enumerated more disadvantages than advantages. Two-thirds of all students indicated the first advantage, thus there can be drawn a conclusion that most students noticed the essential advantage of the virtual learning environment.

Some more interesting points of view:

> At last it is possible to communicate virtually at our institute too...
>
> In my opinion, there are no disadvantages in the virtual environment itself. The disadvantages lie in me, as I did not always remember to join the virtual environment, but I hope to correct the following mistake at the end of the semester (at least partially)...it is sometimes difficult to adapt to novelties, but I am for the virtual learning environment...
>
> ...a disadvantage – I cannot use the Internet...

After having carried out the analysis of the reflections, the art students were suggested taking a challenge and participating in the integrated projects with computer science students, and 4 from 17 students volunteered.

At the end of the academic year, together with students it was discussed how the last overview of the whole year's CSCL transdisciplinary action research would take place in a traditional classroom. It was decided to carry out an express interview. The express-interview was filmed and 5 students from 11 participated. One student sent his reflection via an e-mail later, so in total, data from 6 students (2 art students and 4 computer science students) were processed. All students who participated in the reflection communicated via Skype. All students selected the means of communication on their own, deciding what was more convenient for them. During the qualitative research, the following categories were distinguished:

- All group members – leaders.
- They learned one from another. Two programmers said that the artists explained to them how to form a better aesthetic image, and after that they were surprised with the quality of the outcome. The artist said that he found out that not all his projects can be implemented with modern computers.
- Communicated tactfully and respectfully

- All the students who participated in the chat thought that it was not necessary to have more than three face-to-face meetings.
- They liked to communicate in a virtual environment.
- In the beginning, the communication was a little bashful as it was necessary to get acquainted and communicate with a student in another occupation. Later, the tension was reduced.
- While talking about group members' responsibility, all the programmers who participated in the discussion acknowledged that they did not feel responsibility as they thought that the artist had to take higher responsibility as his/her work result was more visible.
- The opinions concerning motivation differed. Some said there had to be a stricter lecturers' control. Others said that the degree of freedom provided was very good.

All the students who participated in the discussion think that such projects should be held in the future. None of the students, who participated in the discussion, revealed any critics.

Some more interesting points of view:

> . . .at first it was bashful, as I had to communicate with a girl, I did not dare asking the telephone number. . .
>
> . . .when we started communicating, I have already done one variant. I showed it to an artist. He told me to throw away a lot of elements of design, and I surprisingly saw that he was right. . .
>
> . . .we did not argue in group, because our specialties are different. Everyone did his/her job. If there had worked two programmers or two artists, then there would have been some arguments. . .

The positive assessment of transdisciplinary action research is reflected in the computer science student's reflection:

> The research is actually useful for both research participants, as programmers have got an opportunity to develop in the application of the created design, and a designer can easier perceive the program application of design. Besides, if there is intention to do work related to that, there is obtained experience necessary for work in groups.

In summary, it can be stated that such a way of learning is acceptable to students.

## 10.6 Quantitative Research

The analysis of the students' work, who participated in transdisciplinary action research and worked without a partner, enables the conclusion that after having united the knowledge of students from the faculty of Computer Science and the Institute of Arts, not only functional products, but also attractive to the user products have been designed. Some of the authors' works, designed during the research work, have been implemented: the Web site of Kaunas School Librarian Methodological Council, http://bibliotekos.kaunas.lt/; e-business solutions: clothes design and order system, the management system for e-booking in "Incas" Private Ltd, http://www.paper.lt.

It was interesting to find out how students evaluate their professional skills. Students, who participated in the research, were asked to assess their professional knowledge in categories "weak," "moderate," "good," and "excellent." The results were the following: "weak" – 0% students of art and 5% students of computer sciences, "moderate" – 57.8 and 67.4%, "good" – 42.2 and 41.3%, and "excellent" – 0% in both groups.

The students had to assess the benefits of transdisciplinary actions in points from 0 to 5. After having surveyed the students, who participated in the researches, there can be drawn a conclusion that almost a half of students in Computer Science faculty and Institute of Arts gave points to the benefits of collaboration action in regard to the aspect of specialty (Fig. 10.1), application of knowledge in new situations (Fig. 10.2), and communication (Fig. 10.3).

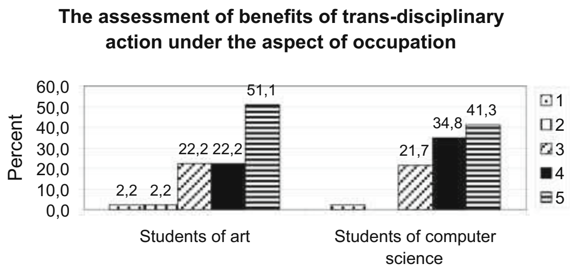


**Fig. 10.1** The assessment of the benefits in transdisciplinary actions in regard to communication aspect

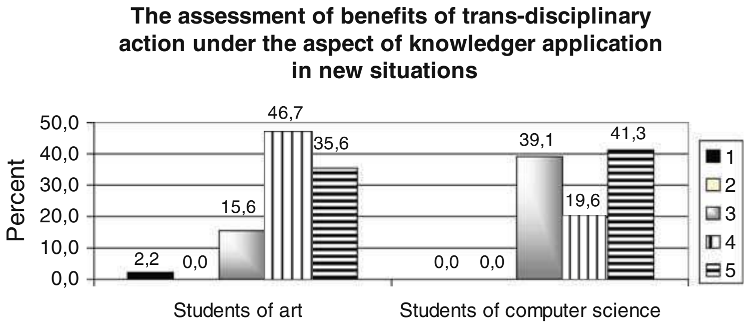


**Fig. 10.2** The assessment of students' transdisciplinary action benefit in regard to occupational aspect

Only a small number of students (24.5% in Institute of Arts and 15.2% in Computer Science faculty) had some doubts concerning the general benefits of the research. According to their point of view, they would have fulfilled work better individually. 53.3% of art students and 43.5% of computer science students claim

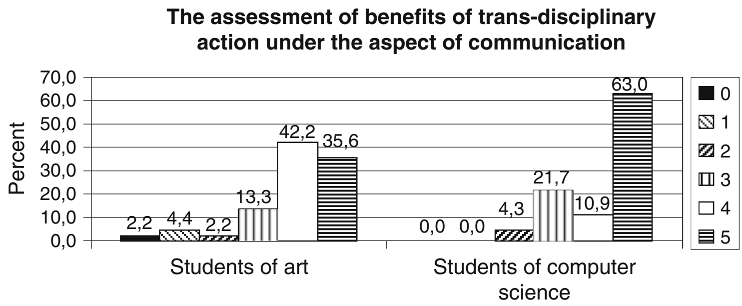


**Fig. 10.3** The assessment of how students apply their knowledge in new situations

that integrated work of both students in computer science and arts provided with a better result (Fig. 10.4).

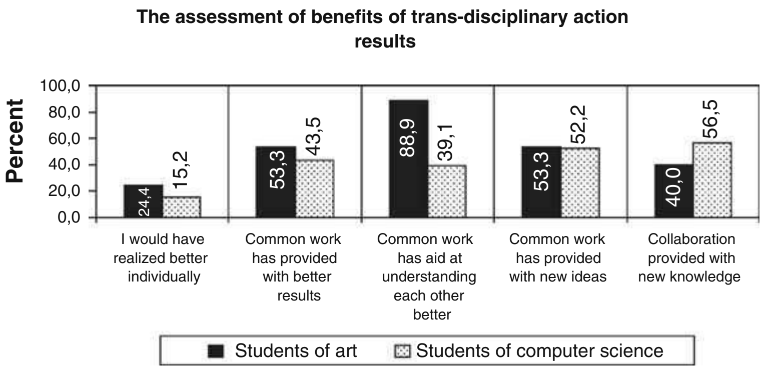


**Fig. 10.4** The assessment of students' outcome in transdisciplinary actions

Both computer science and art students think that joint research work was beneficial, as it helped in understanding each other better and provided with new ideas too, which is reflected in the research outcome (Fig. 10.4) and students' reflections.

## 10.7 Conclusion

In conclusion, it can be stated that in the CSCL, when students communicate in virtual environment, where lecturers are "far away," those students, who in the face-to-face environment did not dare or were not ready to collaborate, behave more courageously or they are "forced" to put their contribution into the common project.

After having analyzed 5-year work experience and according to the research outcome it can be claimed that:

1. Students assess the results of CSCL transdisciplinary action research positively. The majority of them pointed out that collaborative work provided with better results, new knowledge, and aided in understanding each other.
2. CSCL transdisciplinary action research influences the quality of students' work.
3. According the 5-year experience that was realized, CSCL transdisciplinary action research in a qualitatively new blended learning environment where the teaching and learning occur in both face-to-face and virtual learning environments. Students regarded less communication in a face-to-face environment.

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# Chapter 11
# Improving Teacher Performance Using an Enhanced Digital Video Reflection Technique

**Geoffrey A. Wright**

**Abstract** Reflective practice is an integral component of a teacher's classroom success (Zeichner and Liston, 1996; Valli, 1997). There is a need to further develop a more effective and efficient process that encourages reflective practice. Recent technological video advancements have provided tools to support new research. This chapter presents an innovative process that proposes to improve teacher reflective practice by using an enhanced video analysis technique. The findings suggest the video-enhanced reflection process provides solutions to the barriers that have traditionally prevented reflection from being meaningful and long lasting. The qualitative analysis suggests that video-enhanced reflection had a positive impact on teacher reflective abilities.

## 11.1 Introduction

Utah in-service level-one teachers are required to demonstrate pedagogical growth during their first 3 years to obtain level-two licensure (tenure). Site administrators are responsible for evaluating these teachers and ensuring that they are provided with the means to experience "this" growth. Current research has shown that when teachers are reflective practitioners, their teaching improves (Schon, 1987; Zeichner and Liston, 1996; Jay and Johnson, 2000; Grossman, Williston, 2003). School leaders have used various methods over the years to encourage teacher reflective practice. Recently, researchers have begun to look at how the use of video might be used to encourage and enhance teacher reflection (Cunningham, 2002; Griswold, 2004; Sherin and van Es, 2005; Stadler, 2002). Many potential benefits have been postulated about having teachers use video clips of their own teaching performance as a way to enhance reflection and improve teaching performance. Some of the benefits are (a) the ability to expand "teachers' knowledge about the ways of teaching and

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learning" (Stadler, 2002); (b) providing "an excellent starting point for professional discussion" and development (Stadler, 2002); (c) an opportunity and method to demonstrate growth (Cunningham, 2002); and (d) an opportunity to improve classroom performance and an understanding of student learning (Jay & Johnson 2000). Despite the theoretical benefits, there are several logistical and organizational challenges that pose barriers to the use of video analysis tools. This research will look in depth at the implementation of a video analysis process at an elementary school, in an effort to gain a better understanding of its impact on teacher reflection-for-action.[1]

## 11.2 Video, Reflection, and Performance

### *11.2.1 Research Background and Rationale*

There are several essential areas to consider that directly tie to and help formulate the theoretical framework and the questions associated to this research. The first area to be discussed is reflection, the second is teacher evaluation, and the third area is video observation and analysis.

There has been significant research in the area of reflective practice and the influence it has on performance. The questions pertinent to this research that came out and are addressed by the literature are: (a) What is reflective practice? (b) What does effective reflection look like? (c) What are methods of reflection? (d) Why reflect? (e) What are the past, present, and future trends of reflective practice? (f) What is its influence on teacher performance? (g) What are the methods and tools that are and have been used to promote effective reflection, and how can reflective practice be increased?

Although video has been around for over 50 years, its use in schools has been mostly limited to instructional and entertainment purposes. In addition, there is very limited research on how video can be used to promote reflection. However, an intense literature review did discover several relevant and significant questions that will be discussed and presented in this research. Those questions are (a) What is video observation (specifically as it pertains to schools)? (b) How has video been used in schools? (c) What have been the methods and tools used in schools? (d) What have been the successes, failures, and issues with using video in schools? (e) How has video been used as a tool to influence teacher reflection (what is, and is there a relationship)? (f) What are the future trends of video usage in schools? and finally, (g) What can make video observation more effective?

Teacher evaluation is an integral component of the research because it presents and helps structure the need for reflection; it frames the rationale for why a teacher

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[1] This paper is an expanded version of the paper presented at the 2008 IADIS CELDA Conference held in Freiburg, Germany.

needs to be engaged in reflection-for-action. In additional, it also defines the benefits reflective practice can have on teacher evaluation. There are several essential components associated to teacher evaluation that will be discussed in this research, they are: (a) What is teacher evaluation? (b) Why would administrators be interested in video observation? (c) Why would novice teachers be interested in video observation? (d) What is the relationship between teacher evaluation, video, and teacher reflection? (e) Why is there a need for teacher evaluation? (f) What are the Utah state and district policies concerning teacher evaluation? (g) What have been the methods and tools of teacher evaluation? (h) What are theories of practice associated with teacher evaluation? and (i) How is teacher evaluation related to teacher reflection (or can/should it be)?

### *11.2.2 Methodology*

The hypothesis of this research suggests when teachers engage in a video-enhanced reflective process their reflective practices increase. Six novice teachers (Vallen, Becky, Jacky, Michelle, Jamie, and Jonathan) and one principal (Kristy) from an elementary school were selected to participate in this study.[2] The study will compare what their normal reflective practices are (the baseline), with an intervention where they used a video-enhanced "self-reflection for action" model. The method that was used to assess and help answer the primary research question "How does video analysis impact teacher reflection-for-action?" involves comparing an intervention with a baseline measurement. The baseline was established after the teacher identified and selected a skill to work on and a teaching moment where it was implemented, then taught while implementing this skill, and finally engaged in a written self-reflection exercise. The written self-reflection baseline was then compared with the intervention – a video-enhanced reflection exercise. The resulting explicit documentation from both the baseline and intervention was then analyzed and compared using three criteria: description, analysis, and action. A thematic analysis technique was the primary data analysis method used in this study. A thematic analysis involves creating and considering cover terms, included terms, and semantic relationships between various data points. Cover terms are categories used to organize data. The cover terms used for the thematic analysis in this study were description, analysis, and action.

## 11.3 Findings

The qualitative analysis of teacher responses to the exit survey, interview findings, and comparison of the baseline and intervention methods suggest that the video-enhanced reflection process had a positive impact on teacher reflective abilities.

[2]Names were changed to preserve anonymity.

A thematic analysis was used to code and scrutinize the qualitative data. The findings are organized into five major parts, representative of the foremost questions and themes significant to the study. Each part presents a short descriptive paragraph about the focus of the section, a vignette describing significant experiences the teachers encountered during their involvement in the study, and a thematic analysis outlining the themes and a brief discussion of each section. Although vignettes were written for each teacher, only one, representative of the five, will be presented in this article.

## *11.3.1 Getting Started*

The focus of this first section is to present the teachers' initial reactions and feelings to the video-enhanced reflective process. Overall, the primary theme for this section concerns the teachers' positive support and willingness to engage in the process.

### 11.3.1.1 Vignette

Although Vallen was new to the school, he was in his second year of teaching sixth grade. He had attended a university elementary teacher education program where he said he had learned about reflective practice. During the initial training Vallen seemed to be distant; he did not engage in any of the presentation activities, nor did he have much to say during the question and answer session. He did seem to be comfortable with the idea of having to use technology; when I passed out the software installation CDs he was able to quickly load the software; however, he did not express the same enthusiasm as the other teachers. Notwithstanding, when I asked him what he thought about the process, he stated "I think this is going to be a great opportunity." He did, however, voice a few concerns; he wondered about scheduling issues (i.e., "One of the times we were planning to meet and discuss his experience he had a field trip and wouldn't be able to meet"). He also voiced a concern about "having to" watch himself on camera, "You mean I will have to watch myself on camera, I hate how I sound and look." Despite these limited issues, he did leave the impression he was moderately excited about the process, before he left, he shared that he thought this process would definitely make him think more about his teaching.

### 11.3.1.2 Thematic Analysis

Overall the teachers reported that they were initially enthusiastic about the process. They believed it would have a positive influence on their reflective abilities and stated they were willing to engage in the process. Prior to engaging the teachers in the process, they were asked about past reflection experiences. 75% of them said they had learned about reflective practices in their university preparation programs, and 100% of them believed they were already fairly reflective; notwithstanding, the majority of them (60%) acknowledged that their reflections were mostly informal (i.e., short written notes in their lesson plan). Those who stated they were reflective said they reflected on their teaching on average 12 min per day.

When the teachers were asked what they thought the primary purpose of this process was 80% reported they believed the process was designed to help them increase their reflective abilities. In contrast, when the teachers were asked about what they wanted to get out of the experience, only three of the teachers reported that they wanted to increase their reflective abilities. (The other two stated that they simply wanted to "get better at teaching.") When asked if they were enthusiastic about this process, all five of the teachers positively responded, despite a few of them having similar concerns (i.e., don't like watching themselves on camera, not having a lot of extra time to engage in lengthy reflection processes, and how to use the technology).

## *11.3.2 Teacher Written Reflections Experience*

The focus of this second section is to present the teachers' feelings and reactions to the written reflection experience. The teachers were expected to complete the written reflection following their teaching performance and prior to engaging the video reflection component. Most of the teachers reported they did the written reflection either the day of or the day following their teaching performance. The written reflection form had three components to it: a section where the teacher was expected to describe the teaching performance, a section where the teacher was to analyze and critique their performance, and a final action area where the teacher could write out their future plans, goals, and/or actions related to their analysis. In general, the teachers said that they liked the written reflection component; however, they did not think it was as beneficial to use as the video reflection component. The teachers liked how the written form guided their reflection experience by helping them break their reflection into the three parts of an effective reflection, and because the written experience informed their later video reflection and consultation experiences. The following vignette and thematic analysis further present and discuss these findings.

### 11.3.2.1 Vignette

Becky was one of the teachers who had claimed to be very reflective, despite not receiving any formal reflective practice training. Becky's written reflections were always the longest, filling up the entire written reflection sheet with descriptions, analysis, and various action-oriented goals. When asked how much time she spent on the written reflection part, she said that it usually took at least 30 min. The following is her description of her written reflection experience.

> Usually, I write a few rapid notes to myself in my lesson-planning book, and then at the end of the day, after the kids leave, sit at my desk and think about what happened. I typically try and play back what happened during class and pick out those things I thought either went well or didn't, and then write down why I think they did or didn't go well. Usually this will prompt to think of a goal I want to work on, or something I want to change or try out for

> next time. Sometimes I will reference my lesson plan book and see what I have coming up and how I might change things around, but usually it is more of just a cognitive thing.

Even though Becky said that she liked the writing process and spent a lot of time and energy doing her written reflections, she said, "I actually enjoyed the video better than the written. It was easier to do, and took me less time. But, I also believe you need both."

#### 11.3.2.2 Thematic Analysis

The written reflection experience required the teachers to write about their teaching performances immediately after they taught. Their writing needed to include a description of what took place, an analysis (critique) of their performance, and then an outline of resulting goals they thought they should work on. They completed this written component before participating in the video component of the study. Eighty percent of the time the teachers completed their written reflection the day of or immediately following their teaching performance; however, there were three instances when the teachers left the written reflection until just before engaging the video reflection. Typically, there was a delay of 1 week between the written reflection and the video reflection (due to video digitizing efforts and travel logistics).

In comparing the written reflection form (baseline) to the video reflection experience (intervention), it was difficult to evaluate and determine which method was more effective. Quantitative data suggest the teachers seemed to engage the video process more than the written, there were more video evidences tagged and commented on than written descriptive and/or analysis points. For example, in the first reflection experience there were 32 written descriptive and analysis comments, whereas there were 65 counted in the video analyses. The average comments and analysis statements on the written form was 38, whereas the average for the video analysis was 84. The survey data and teacher interview self-reports suggested that the majority of the teachers (60%) thought a mixed method using both the video and a written system, or just a video-based method, would be the most effective approach. The two major themes surrounding the use of the written reflection form were (a) teachers preferred either a mixed written and video process or just video process to the written process and (b) rarely did the teachers' suggestions regarding the video process have to do with statements about how or why they believed the process to be superior, rather, their comments had more to do with the logistics of the actual software program and how it could be modified.

### *11.3.3 Video-Based Reflection Experience*

The purpose of this third section is to present and describe how the teachers felt about and used the video reflection component. The major themes emerging from the findings suggest that the teachers preferred the video method to the written method because it gave them more insight into their teaching due to the multiple perspectives video offered and because the video analysis process was simple and efficient to use. The vignette will present one teacher's video-based reflection experience, and the thematic analysis will draw upon this narrative, other self-reports, and additional survey data to present and discuss the major themes.

#### 11.3.3.1 Vignette

Jacky said that she really liked the video process and found it to be much more enjoyable than the written reflection process. She reported that she would usually watch and analyze her video at home, spending on average 45 min watching and tagging 30 min of video. When asked how she went about tagging her video she said that she would usually tag and comment while watching; pausing the video when she had a comment to make and type it in. When I asked her what her overall feelings and impression of the video reflection experience was, she said,

> I really liked it... sure, you have to be honest with yourself, but now I feel like I know what to look for. At the beginning I was looking at the lesson as good or bad. Now I look for what I can improve in and what I am doing good at... I would love to do this again; I really think it has helped me.

#### 11.3.3.2 Thematic Analysis

This thematic analysis concentrates on and addresses one of the primary research questions: Are teachers better able to identify areas for improvement (action) because of video-enhanced reflective analysis? The primary sources for these findings come from: video intervention data, teacher self-reports aggregated from informal interviews, researcher observations, and survey results.

The general answer to the question "*Are teachers better able to identify areas for improvement (action) because of video-enhanced reflective analysis?*" is yes. Four of the five teachers gave a "yes" response to this question. One teacher reported, "It (the video-enhanced process) has allowed me to see my weaknesses and helped me see my strengths; things that I never thought about before." Both past research and the data collected in this study suggest that video does help teachers to better identify areas for improvement because the video increases a teacher's ability and likelihood to notice things about their teaching and because the volume of what they notice increases, their analyses encompass more areas of concern, and consequently increase the depth or volume of things they want to work on.

### *11.3.4 Video-Supported Consultation Experience*

The purpose of this fourth section is to present and describe the teachers' experiences and feelings about the consultation component of the video-enhanced reflective process. The consultation component required each teacher to meet with the principal after first completing the written and video tagging phases of the reflection process. It was anticipated that the teacher and principal would engage in a critical conversation about their teaching and establish goals and or action plans based on the teacher's reflections, in hope of helping the teacher improve his/her teaching. The major themes emerging from the findings suggest that (a) the teachers believed the consultation to be an integral component of their reflection experience and (b) they liked being empowered with the responsibility to evaluate their own teaching, where the principal was used as a resource rather than the authoritarian evaluator.

#### 11.3.4.1 Vignette

Michelle arrived for each of her consultations very keen and professional; she always greeted the principal with a smile and handshake. At each of her consultations, she had a pad of paper and her computer. She would normally first open up her computer, state the goal she had worked on, and then start showing Kristi her coded video evidences. Similar to how she did with the other teachers, Kristi always sat right next to Michelle. During each of the consultations, Michelle would go from tag to tag and talk about what she had noticed and learned and then ask for Kristi's perspective. She would then take notes on the ideas Kristi would share with her. Michelle reported that "The consultation part was really helpful. It was great to have an expert point out things that I hadn't thought of or seen in the video myself. I kind of knew of what I wanted to work on, and usually she reaffirmed those ideas, but then also gave me other good ideas." Michelle also pointed out that she appreciated how the process provided her the opportunity to play the role of the evaluator, taking the perspective of the principal, watching and analyzing the performance from an outside perspective.

#### 11.3.4.2 Thematic Analysis

The thematic analysis suggests (a) the teachers believed the consultation to be an integral component of their reflection experience; (b) the teachers liked being empowered with the responsibility to evaluate their own teaching, where the principal was used as a resource rather than the authoritarian evaluator; and (c) typically, the teachers would modify and or add to their written reflection goal as a result of their consultation experience.

Each teacher reported they believed the consultation to be an integral component of their reflection experience. They suggested that the consultation provided them a chance to get feedback and learn from the principal, an opportunity to share some of their thoughts and ideas about their teaching, and an opportunity to have the principal validate their efforts.

The teachers also liked being empowered with the responsibility to evaluate their own teaching, where the principal was used as a resource rather than the authoritarian evaluator. Consistent with teacher evaluation literature, where research has shown that teachers feel uneasy and often do not perform as they normally do when they are observed and evaluated (Protheroe, 2002), the teachers in this study said they were more comfortable with this process because they controlled what was being observed and evaluated. In support of this finding, one teacher shared, "ultimately the process was for us, which made it so much less stressful and fun to do."

The third theme reported that the teachers typically modified and or added to their written reflection goal (87% of the time) as a result of their consultation experience. It is believed this resulted from the principal's ability to focus the teachers' attention on additional details, and from the supplementary opportunity the consultation gave the teachers to further analyze and reflect on their performance.

## *11.3.5 Principal's Experience*

The purpose of the fifth section is to present and describe the principal's experiences and feelings regarding the use and influence the video-enhanced reflection process had on her and the teacher participants. The principal's primary role in the process was to help organize the calendaring logistics of the consultations and then meet with each teacher for a consultation, where she engaged the teacher in a critical dialog regarding their performance. It was anticipated that during the consultation the principal would work with the teacher to build upon the teacher's personal self-reflection/assessment experience, helping them to further identify areas of weakness/strength; more intensely critique and analyze performance; and finally establish an action plan or goals for future teaching efforts. The major themes emerging from this section suggest (a) the principal enjoyed the reflective process; (b) she believed the process had a positive influence on her teachers' reflective habits; and (c) her enthusiasm to engage and belief in the process probably influenced the teachers' willingness to engage in the process.

### 11.3.5.1 Vignette

Kristi approached the research study with a lot of enthusiasm. Prior to starting the research, Kristi was asked how she felt about the process and what she hoped to get out of it. She said,

> I am really excited about this process; it's such a great way to help my beginning teachers. . . I hope my teachers become more reflective; that they see the benefits of being reflective and that it has a positive influence on who they are and how they teach.

She used this same enthusiasm as she engaged each of the teachers in the consultation phase, which consequently seemed to have a positive influence on the teachers. One teacher reported,

> I really appreciate how Kristi is always so supportive and excited about helping me improve my teaching. She puts so much effort into helping us look for and understanding things about our teaching.

The principal's preliminary efforts to get the process going further validated her enthusiasm and support of the project. In support of this finding Kristi said,

> I hope you guys know that I personally feel reflection is important. That doesn't mean, however that this is something you have to do, or that I am going to be controlling this study. This is an opportunity for you guys. It's not for me; it's for you. I do however; want you guys to take ownership of the process and to see what kind of impact it might have on you.

The video-enhanced reflection process required the principal to meet with each of the teachers for a post-consultation that usually lasted approximately 30 min and was essential a focused critical discussion about teaching. During this time, she would invite the teachers to open MediaNotes and show her what they had tagged. During this "show and tell" stage, she would consistently watch and intently listen to the video clips. She would typically pull her chair up close to the teacher and huddle around the teacher's laptop. While she watched the clips she would usually have the teacher pause at each of the "tagged" clips and have discussion about them. Immediately after watching the video clips and giving instructional feedback, she would ask the teacher how they believed they did and what their goal would be for the next reflective exercise. She would have the teacher write down the goal and then give some ideas of what to be aware of while working on it. During the subsequent interview consultations, she would follow up on the previous goals and find out how the teachers believed they were doing on past goals.

#### 11.3.5.2 Thematic Analysis

The primary themes from the study regarding the principal's consultation use and experiences are (a) the principal personally felt the process made a difference in the teacher's reflective abilities and in her own performance; (b) the principal's willingness and ability to work with each teacher, coupled with her ability to recognize and communicate helpful instructional feedback, is an integral part of the consultation and process; and (c) the principal provided additional commentary to how the teachers had already defined and interpreted their teaching.

The data suggest that Kristi's efforts helped the teachers further examine and critique their performance, consequently helping them see other things they wanted to work on, and in some cases helped them adjust and or clarify their original goal.

## 11.4 Implications

The findings from this study have both theoretical and practical implications. The theoretical implications discuss how the findings of this study relate to the theories of video analysis, teacher evaluation, and reflective practice. The practical implications discuss the considerations of practically implementing the reflection model elsewhere.

## *11.4.1 Theoretical Implications*

### 11.4.1.1 Reflective Practice

The literature associated to reflective practice suggests there are several barriers that have hindered "the achievement of reflection" (Hatton & Smith, 1995, p. 36). The first barrier concerning the *perception of how reflection is not seen as an essential and mandatory component of a teacher's job* was addressed by having administrative "buy-in" and support. For example, in this study, although the teachers understood the purpose of the reflective process was for their benefit, they perceived that because the administrator was involved in the process (i.e., the teachers would have to present their reflection to the administrator in the consultation phase of the process) that their reflection was both essential and mandatory.

The second barrier concerning *how the benefits of reflection are outweighed by its cost* (i.e., time and effort) was overcome by establishing a reflection process that decreased teacher time commitment and effort. In this study, this was accomplished by providing the teachers a specific protocol that routinized their reflection efforts, thus making their reflection more efficient.

The third barrier addressed by this study concerned *the ambiguity and definition of reflection* (Jay & Johnson, 2000). This barrier was addressed by engaging the teachers in a preliminary discussion about the definition, purpose, and the "how to" of effective reflection. For example, in this study, during the preliminary training phase of the research project the teachers were taught what effective reflection looked like and involved.

The barrier concerning *training the teachers on how to reflect and what to look for during a reflection opportunity* (Jadallah, 1996) was overcome by outlining, teaching, and helping the teachers understand Dewey's three-part action-based reflection typology. During the introduction of the study, the teachers were taught about the purpose of reflection and what they should get out of the process. Then it was explained to them how breaking down their reflection into the three parts of description, analysis, and action would help them more efficiently and effectively reflect on their teaching. During the explanation phase, the teachers were provided a role-play of a teacher engaging each of the three parts of reflection and were then asked to also role-play a fictitious reflection experience. It was believed this training session helped the teachers gain a fundamental understanding of how to reflect.

The study addressed the barrier *helping the teachers to know what to look for during their reflection* by providing the teachers' explicit standards detailing measures and examples of professional teaching criteria to use in their reflections. For example, in this study, the teachers were provided standards and several key words and descriptors of effective teaching to guide their reflection experiences (i.e., set standards).

### 11.4.1.2 Video Analysis

Although video-related literature suggests video analysis has a positive influence on teacher development, this study made several specific contributions to the theoretical underpinnings of video analysis by helping resolve three of the barriers that have limited the success of video implementation in teacher training. Concerning the first issue of *providing a systematic method for analyzing video*, this study developed and implemented a video analysis process that was found to be efficient and effective within the context of this study.

This study helped resolve the issue of *video being too cluttered for teachers* by breaking the video analysis into three parts: description, analysis, and action and by having the teachers focus on only one or two specific evaluation criteria (i.e., the teachers were to select one or two of the set teacher evaluation standards to analyze while watching their performance). By providing teachers a way to "chunk" their video analysis sessions and by outlining specific criteria they were to look for, the teachers were better able to identify specific things pertinent to the standard they had selected.

Finally, this study addressed the issue concerning *limited empirical research on how video can be used to promote reflection* by developing and completing a study where video analysis was used with in-service teachers for purposes of increasing their reflective practices. Although additional research needs to be done to further clarify the influence that video analysis has on in-service teachers' reflective practice, this study established a seminal baseline that can be used for future efforts.

#### 11.4.1.3 Teacher Evaluation

The findings from this study add to the theoretical underpinnings of teacher evaluation by addressing several of the issues that have often prevented effective teacher evaluations. The first issue concerns *the bias and subjective nature of teacher evaluation* was addressed in this study by shifting the burden of evaluation from principal to teacher. This shift of responsibility empowered the teachers with the autonomy and opportunity to look for things in their teaching that were most pertinent to them. The shift of responsibility motivated the teachers to more actively self-assess their performances, which Dewey (1933) theorized would help them experience a greater opportunity for growth. Because the teachers were empowered with the responsibility and opportunity to guide their own evaluation via self-reflection, the teachers in this study were more willing to look for those things that are more difficult to pinpoint, remedy, and or accept as weaknesses.

The second issue concerns *the belief that evaluations rarely produce meaningful, lasting effects* (Arter, 1999). Although this study cannot empirically prove that the outcomes of the video-enhanced reflection process were both meaningful and lasting, it does show that video-enhanced reflection has great potential to be more meaningful and lasting. Particularly, the study showed that teachers could identify issues and decide upon the solutions. In addition, the teachers also shared that because they were able to see on video what they were doing wrong (or ineffectively), their capacity to resolve the issue was greatly enhanced.

The final issue concerned the *definition of effective teaching*. Margolin, Forsbach, & Griesemer (1998, p. 4) argued that one of the reasons teacher evaluation rarely makes any significant difference in teacher performance is because "there is no codified body of knowledge that theoretically, or empirically defines effective teaching." While this study might not completely resolve this dilemma, it does propose a work-around. In this study, because the teachers were provided the autonomy to decide what they wanted to work on and formulated their own goals or action plans addressing issues important to them, it appears that the issue of what effective teaching looks like was diminished. That is not to say an explicit definition is not important. Rather, the work-around allows the teachers the opportunity to define what effective teaching looks like for them – at their current level and understanding of teaching. Had the teachers been provided the perfect example of what their teaching needed to resemble (i.e., an empirical definition of what effective teaching should look like), it would not have been as meaningful because it would not have represented them, or where their current understanding and abilities were at.

### *11.4.2 Practical Implications*

Although the findings of the study outline and focus on several of the positive takeaways, there are definite costs to implementing a process such as this. For example, one of the major costs of implementing this process concerned camera and digitizing logistics. In this study, the primary researcher shouldered the responsibility to gather all the cameras, make sure they were all working, set them all up, collected all the tapes, and then digitized all the teaching samples. Although these tasks were not difficult, they did require a significant amount of time and effort. Practically speaking, if a school was to implement this process it would need to invest both time and money to ensure the process would efficiently and effectively work.

## 11.5 Summary

The findings from this study suggest that video-enhanced reflection facilitates teacher reflection because it provides additional perspectives, thereby increasing the quantity of things teachers notice about their teaching, which consequently helps them to more effectively identify areas for improvement.

As a teacher is able to accurately describe their teaching performance, their analysis becomes increasingly meaningful, thereby helping them establish a meaningful action plan. Four elements contributed to this success: method, means (time and tool), rationale, and peer (mentor or administrator) support. Each of these four critical elements will be discussed in the following section.

### *11.5.1 Method of Reflection*

Teacher reflection literature suggests that one of the primary barriers preventing reflection from being meaningful and lasting is the lack of a clearly established and useful method of reflection. A method is important because it outlines the overall objective and approach teachers should have while engaging in the reflective process. The method does not have to be systematic, inflexible, or rigid; however, it should include a description of expectations outlining the benefits, purpose, and the routine of the reflection experience.

### *11.5.2 Means for Reflection (Time and Tool)*

It is essential to specifically allocate and specify a moment when teachers know they are to sit and analyze their teaching. The findings suggest when teachers are provided a specific time to reflect, their willingness to engage in reflective practices increases. The teachers reported during the exit interview that the issue of time was an important element of their reflective practice.

The tool issue is also an important element of the “means” factor. The tool is important because it provides the vehicle that facilitates and gives direction to the teacher’s reflection. In the past, many preservice programs required teachers to keep reflection journals, complete various reflection-based forms, and so forth. More recently, video analysis has become a means others have started to use. Regardless of the means (though the teachers in this study preferred the video tool), having a tool does help focus and facilitate reflective practice.

### *11.5.3 Reflection Rationale*

As teachers understand why and how reflection can directly benefit them, they will have an increased motivation to engage in reflective practices. Providing teachers a rationale for why they should actively participate in the reflection experience was an important factor to the success of this study, because as soon as the teachers understood the value of the process their willingness to participate increased.

### *11.5.4 Support of Reflection*

The final component that contributed to the successful reflection experiences of the teachers involved providing teachers with encouragement and accountability measures. Reflection is not always an easy process; sometimes it can be difficult to analyze a personal performance and to then focus on methods to improve specific areas (Dewey, 1933). Peer or mentor support helps resolve this issue because they bring in different perspectives, experiences, skills, and understanding that help teachers brainstorm possible solutions and stay motivated. In addition, a mentor can also help to keep teachers accountable for their reflections. When teachers know they are expected to report and work with someone toward completing a task, they are usually more prone to complete and engage in the task. In this study, the teachers were provided several venues of support they believed helped provide motivation and accountability. The foremost reason was the principal's support. Each of the teachers maintained that their willingness and capacity to engage in the process was influenced by the principal's enthusiasm for the process, readiness, and ability to give helpful feedback, and because they knew their position ultimately hinged on how the principal interpreted their efforts.

## 11.6 Conclusion

In comparing the written reflections with the video reflection experience, the findings implied that video provides a more rich and deep description than what the teachers recollected and wrote about in their written reflection papers. The findings also reported that the teachers felt their analysis of their teaching performance was more effective when done while using the video-enhanced reflective process because "it provided them a tool, a different perspective, and more evidence to consider." Consequently, the teachers reported that they believed their actions to be more relevant and applicable to their teaching. It is believed the video-enhanced reflection process helped the teachers: (a) identify and describe the "puzzles of [their] practice" (Jay & Johnson, 2002, p. 78); (b) more effectively analyze and critique their performance, helping them, as Jay and Johnson (2002, p. 78) put it, "find significance in a matter so as to recognize salient features, extract and study causes and consequences, recontextualize them, and envision a change"; and (c) establish an action-oriented goal to further their teaching abilities, thus accomplishing what Dewey (1933) believed the overriding purpose of reflection is intelligent, thoughtful, and purposeful action.

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# Chapter 12
# Experiencing and Learning with 3D Virtual Worlds

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**Abstract** In this chapter, we discuss the potentialities of 3D virtual worlds in education. We argue that assignments in virtual worlds and a constructivist approach go hand in hand. We identify the aspects of virtual worlds (such as ActiveWorlds and SecondLife) that make them useful for education and research, as well as aspects that do not. We found that intertwining real-life instructional courses with virtual constructivist courses was very promising in terms of the learning experience. We demonstrated this 2-fold approach with the "Virtual Worlds" course at the Hogeschool Utrecht University of Professional Education.

## 12.1 Introduction

3D virtual worlds have been around since the early 1990s, originally, mainly in games and only in single-player mode. Later, multiplayer modes were added and because of increased use and growing Internet bandwidth, the massive online role-playing game mode was added to 3D games, like World of Warcraft (Vivendi, 2004). 3D is now no longer limited to games, it allows new ways of communication and even the possibility of having several lives, i.e., Second Life (LindenLab, 2003). In this chapter, we focus on the use of 3D virtual worlds in an educational setting and relate this to the course "Virtual Worlds" of the Hogeschool Utrecht University of Professional Education. Currently, innovating educational practice applying new technologies is an important topic (EDUCAUSE, 1999), though it is not straightforward that courses utilizing state-of-the-art technology have added value for students.

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In this chapter, we explain the need for new paradigms when developing courses with new technologies. We illustrate this by positioning education in immersive virtual worlds in terms of the learning paradigm being applied. We suggest criteria for the successful implementation of a constructivist learning environment using a virtual world. We explore a few cases of the use of virtual worlds in education and identify some good and bad practices of using 3D virtual worlds. We then describe the "Virtual Worlds" course as a typical example of intertwining real-life instructional education with a constructivist learning approach using a virtual world.

## 12.2 New Technology, New Paradigm

New technology often changes the context of use, the constraints, and the opportunities of application, making existing paradigms obsolete. This results in underutilization of new technology, until new paradigms arise and users become familiar with the new way of interaction.

Literature on education shows that the traditional instructional methods can be supplemented or even be replaced by constructivist learning methods when using new technology, such as the upcoming and still evolving e-learning environments and, in the last decades, immersive virtual worlds (Antonacci & Modaress, 2008; Dede, 1995; Dickey, 2005; Educause Learning Initiative, 2006).

Eliëns, Feldberg, Konijn, & Compter (2007) describe applying the traditional learning paradigm to virtual worlds as rather naive: for the virtual VU-campus (VU University Amsterdam, 2007), there was no reason to include an outdated paradigm of learning when there might be more appealing alternatives. However, other literature claims that there is added value in using virtual worlds, preserving the traditional learning paradigm in a virtual classroom setting, mainly in creating a sense of a classroom community and in the fact that students will more easily join in class discussion in virtual life than in real life (Lamont, 2007; Martinez, Martinez, & Warkentin, 2007; Ritzema & Harris, 2008).

### *12.2.1 Constructivist Learning*

First of all, we will describe the notion of constructivism. The constructivist philosophy asserts that all knowledge is constructed as a result of cognitive processes within the human mind (Orey, 2001). We apply constructivism as a theory of learning: Constructivism is a theory of learning based on the idea that knowledge is constructed by the knower based on internal mental processes (EduTech, n.d.). Constructivism recognizes different perspectives and is compatible with various educational strategies. Most constructivists assert that a learning activity is often best supported by social interaction. The constructionist strategy focuses on the interaction between the individual and the environment. According to constructivists, learning occurs through interaction and reflection; learners can create meaning by building artifacts (Orey, 2001). Notions often associated with constructivist learning are collaborative problem solving, knowledge-building communities, situated learning, experiential learning, immersive environments, participatory processes, interaction, learning by doing, activity theory, critical learners, and other terms.

We will define constructivist learning as the process of creating, sharing, and evaluating knowledge, skills, and understanding in a collaborative environment through interaction with that environment. The process results in the learner's ownership of what is learned. We emphasize the learner's responsibility for the acquisition and the management of knowledge, skills, and understanding.

### *12.2.2 Why 3D Virtual Worlds Afford Constructivist Learning*

Course management systems (CMSs) such as Blackboard, Moodle, and WebCT can be considered virtual learning environments (VLEs). These CMSs provide tools for creating virtual communities and are a central place where students meet, discuss their work, find and organize course materials, and discuss the course content with their lecturers. Though not very immersive, VLEs allow the emergence of knowledge-building communities, promote an interactive style of learning, have opportunities for collaboration, and have meaningful engagement across time and space and thus enable constructivist learning (Dickey, 2005).

Current VLEs often enable more visual immersion, yet still providing the same tools and assets to education as the traditional CMSs have. These VLEs enable students to see each other and the lecturer by means of webcams, using, for example, Acrobat Connect technology (Adobe Systems, 2008). Though still not fully immersive, these applications have a huge advantage over traditional CMSs in the fact that they allow for nonverbal communication and create a stronger sense of community.

Fully immersive massively multiplayer virtual worlds such as Active Worlds and Second Life have seen a rapid growth over the past decade (especially the last few years). These growing communities in virtual worlds with no preset narrative have spawn interest from both (large) companies, researchers, and educational institutes. We will focus on the researchers and educational institutes. In these worlds, learners themselves construct knowledge through interpreting, analyzing, discovering, acting, evaluating, and problem solving in an immersive environment, rather than through traditional instruction (Antonacci & Modaress, 2008). Especially virtual worlds with no preset narrative, such as Second Life and Active Worlds, are considered to be very usable assets in education (Livingstone & Kemp, 2006). These worlds differ from massively multiplayer online role-playing games (MMORPG) in the sense that there is no objective in the virtual world, other than social presence. Though we focus on virtual worlds without preset narrative, even virtual worlds that do have a preset objective (i.e., games) support learning (Steinkuehler, 2004) as well as research. The MMORPG World of Warcraft suffered from a corrupted blood epidemic, a situation that now is considered a disease model by some scientists (Gaming Today, 2007). Although learning is done in the virtual world, the skill and knowledge gained in virtual worlds is as real as it gets. This aspect of virtual learning is being researched to help people with Asperger's to socialize (Kirriemuir, 2008; Loftus, 2005).

According to Dede (1995), a virtual world involves two essential capabilities for constructivist education: (1) *telepresence* (via avatars) and (2) *immersion,* which is the subjective impression that a user is participating in a life-like world (Dede, 1995). But immersion is not an absolute quality: One can feel somehow immersed in a virtual community. Moreover, immersion does not only depend on the application. Participants in the first newsgroups probably felt more immersed in the Internet community than they would feel now if we were using the same applications.

We can say that the capabilities Dede (1995) describes are less prominent in traditional CMSs (or VLEs) than in 3D virtual worlds. Today's students would probably not even consider CMSs as virtual environments. We therefore assume that constructivist learning is better supported by 3D virtual worlds than it is by traditional CMSs. This is something a lecturer should realize when considering new technologies for a course.

### 12.2.3 Downsides of Constructivist Learning

It is difficult or sometimes even impossible to define learning goals in a constructivist learning setting (Educause Learning Initiative, 2006). This automatically results in difficulty of assessment; with no fixed learning objectives there is no easy way to assess whether objectives have been met. Jonassen and Rohrer-Murphy (1999) argue that designers committed to designing and implementing CLEs (Constructivist Learning Environments) need an appropriate set of methods for designing CLEs and analyzing learning outcomes that are consistent with the fundamental assumptions of those environments. They propose the use of an activity theory-based framework to assist in the mentioned tasks; activity theory is closely related to constructivist theory in the areas of collaborative problem solving, experiential learning (Mason, 2007), and situated learning (Hayes, 2006).

Immersive virtual worlds have another downside as well. Being immersive, they can be so engaging to students that it distracts them from the actual course objectives (Educause Learning Initiative, 2006). A good example was found by Martinez and colleagues (2007), where a student did not come to the course because he rather spent his time in a virtual bar.

### 12.2.4 Do 3D Virtual Worlds Always Support Constructivist Learning?

We agree with Dede (1995) that 3D virtual worlds can support constructivist learning, but in our view, the success of a constructivist virtual learning environment does not depend on telepresence and immersion. We will provide one example of an educational application in a virtual world allowing telepresence and immersion, but with no added value for the learners. We will also discuss successful learning environments using 3D virtual worlds and will discuss key features for the implementation of similar environments.

We are looking for criteria for the successful implementation of constructivist learning environments with virtual worlds. Some key features for education that are supported by virtual worlds have been described by Cross, O'Driscoll and Trondsen (2007) and related to learning strategies: (1) Flow – balancing challenge and inactivity for an engaging experience; (2) Repetition – virtual worlds allow for endless repetitions with no extra costs; (3) Experimentation – virtual worlds allow for simulation and modeling; (4) Experience – being part of a collaborative community; (5) Doing – virtual worlds are big practice fields; (6) Observing – learning by observing how others do things; and (7) Motivation – the rich context motivates through situated learning. We agree with the criteria, but unlike Cross, O'Driscoll, and Trondsen (2007), we do not think that learning exclusively takes place in the virtual world. We will paraphrase those criteria, mainly by renaming them, and will add (8): Reflection, as a key feature of constructivist learning that does not necessarily take place in the virtual world. This way, we will focus on (1) Flow, (2) Training, (3) Experimentation, (4) Collaboration, (5) Learning by Doing, (6) Observing, (7) Motivation, and (8) Reflection.

## 12.3 How to Assess Subjective Impressions

We identify (1) Flow, (2) Training, (3) Experimentation, (4) Collaboration, (5) Learning by Doing, (6) Observing, (7) Motivation, and (8) Reflection as key features for constructivist learning environments with virtual worlds.

Some of those criteria are objective. Virtual worlds always allow Training and Experimentation. The fulfilling of some of the other criteria depends on the situation. Learning by Doing, Observing, and Reflection can be supported by the educational setting. If the circumstances are known, it is possible to check whether those criteria are met or not. Flow, Collaboration and Motivation, however, are subjective criteria. They apply to the learners' experience in interaction with the environment rather than to the learning environment itself. To validate those criteria, we should measure the learners' experience.

### *12.3.1 Measuring Experience*

In our view, experience is not an isolated phenomenon, but a process in time, in which individuals interact with situations. During this process, interpretation takes place: individual meaning is constructed. Therefore, we consider experience a subjective and constructive phenomenon. Both the individual and the situation contribute to the experience, that's why we argue for a holistic approach in measuring experience. Measuring experience should include assessment of the respondent's expectations, of the actual *living through* the experience, and of the aftereffects (Vyas & van der Veer, 2006).

Vyas and van der Veer (2006) developed several strategies to assess the respondent's interpretation of the situation at different moments in time. Basically, they interview the respondents prior to the experience and afterward. The assessment of the *living through* is done by observing the respondents who perform tasks while they talk aloud.

Another tool which is used to measure subjective impressions is the Visual Analogue Scale. Visual Analogue Scales or VAS scales are used in the medical world for subjective magnitude estimation, mainly for pain rating. They consist originally of straight lines of 10.0 cm long, whose limits carry verbal descriptions of the extremes of what is being evaluated. VAS scales are of value when looking at changes within individuals; their application for measuring a group of individuals at one point is controversial (van der Heide, 2002; Langley & Sheppeard, 1985).

## 12.4 Observations in Theory and Practice

3D virtual worlds enable modeling and simulation and they facilitate communication between personalized avatars. In some cases, intelligent agents can be created for the virtual world. These aspects result in the creation of virtual lives and the formation of social networks, in many ways similar to those in reality. This resemblance of reality makes these virtual worlds an immense virtual lab for communication studies, social studies, psychology studies (Stanford University, 2008), architecture, and medical studies (Kamel Boulos, Hetherington, & Wheeler, 2007). These and many other examples of educational use of Second Life have been collected by Conklin (2007). From a broad range of examples, we have chosen two that in our opinion are exemplary for constructivist learning in virtual worlds.

Our first example is the Virtual Neurologic Education Centre (VNEC) on Second Life. VNEC was developed by Lee Hetherington at the University of Plymouth, Devon, in the United Kingdom. It contains a simulation where people (avatars to be more precise) can experience common symptoms that may occur from a neurological disability (Kamel Boulos, Hetherington, & Wheeler, 2007). This is an immersive experience, partly to make people aware of neurological disabilities, but the education center has information facilities as well. In terms of the criteria mentioned in Section 12.2, this education center scores very well on all eight points. A member group is associated with the VNEC, so a community has been formed around it. VNEC uses the available technology to near-full potential and it creates an environment that has most elements for constructivist learning.

The second example is an experimental course by Polvinen (2007) for Fashion Technology students at Buffalo State College. This course consisted of both a real-world part and a virtual-world part, where the virtual-world part complemented the real-world. The students used Second Life to creating fashion, doing a fashion show, creating fashion collections with a vendor display, and many other activities that fashion designers would do in real life. Polvinen (2007) concluded that the aspects involved in real-world production of a fashion show can all be simulated in the virtual world, including product design, development, and presentation. In this course, virtual worlds are a very cost-effective way to simulate processes from the real world, including many social, business, and psychological aspects.

Multimedia virtual worlds are especially useful in constructivist learning by enabling experiential learning, situated learning, and collaborative problem solving. From existing examples of education using virtual worlds and from literature, we draw the following conclusions.

Virtual classrooms in a traditional instructional setting do not fully utilize the possibilities of the immersive virtual world. They do however have added value over nonimmersive virtual worlds by creating a class feeling. Compared to real-world classroom settings, the virtual ones suffer from the engaging context of the classroom (virtual worlds encourage exploration). An advantage of the virtual classroom over real-world classrooms is that students join a discussion more easily through chat than they would do in real life. Whether this is an advantage is debatable: Do students acquire the competence to speak in public?

When transforming a course from real life into a virtual world, the initial learning objectives of the course will need to be reformulated and assessment should be reconsidered. Virtual worlds afford another type of learning than real-life education. The learning objectives of courses in virtual worlds should match the possibilities of a virtual approach, and assessment should take place in an appropriate way.

Modeling, simulation, and collaboration are effective tools for knowledge creation and knowledge transfer. In general, you can get rid of real-world constrains (Wages, Grünvogel, & Grützmacher, 2004).

Virtual worlds are especially an asset to real-life education when students can try out concepts that would be too difficult, too expensive, or too risky in real life, or when lecturers need to demonstrate things that are difficult, if not impossible, in real life, such as complex large-scale molecule models.

The course Virtual Worlds (which will be described below) combines the best of both worlds. Traditional instructional methods (classroom setting) in real life provide the course framework, a solid knowledge base, and create opportunity to share design knowledge. The virtual world (in this case an Active Worlds world) is used for practical assignments. We found that this complementary approach works very well, collaboration continued naturally in both worlds (virtual and real), resulting in a community of learners.

## 12.5 A Course on 3D Virtual Worlds

The course "Virtual Worlds" is part of the Digital Communication curriculum (third or fourth year of University College) of the Hogeschool Utrecht University of Professional Education in the Netherlands. The goal is to teach students to think about virtual worlds in a conceptual way. The course deals with virtual worlds from a communication perspective; the exercises are about possible usage of virtual worlds' advantages and disadvantages.

One half of the course is about theory, the other half is about practice. Contrary to previous years, in the spring 2008 course, students' practical assignments took place in a shared virtual world (enabling collaboration), situated in Active Worlds. The students were asked to build contributions to an Asterix village. Assessment and discussion took place in a plenary closing meeting. Active Worlds is a virtual world platform without preset narrative. This enabled students to individually develop and implement interaction concepts (in the current course a house and some activity in or near the house) as well as to collaboratively develop interaction concepts for the entire village.

### *12.5.1 Course Structure*

The Virtual World course takes 7 weeks. It starts with an introduction to design concepts within virtual worlds and on how to design an experience. In the first part of the course, theory focuses on perceptual opportunities. Best practices are considered. A lecture discusses whether rendering photorealistic 3D or other techniques may increase credibility of virtual worlds (Bakker, Meulenberg, & de Rode, 2003). In this part, the students practice building a VR application (a model of a house and its environment for the Asterix village) in 3D Studio Max.

In the second part of the course, theory focuses on the future of virtual worlds when artificial intelligence and photorealistic rendering will increase opportunities for agent intelligence and interaction within virtual worlds. The practical part consists of an assignment to bring their little virtual world concept to life and to describe an interesting application for the common virtual world, the Asterix village. Examples of applications include illustrating how ancient people constructed their homes and a language village for visiting avatars speaking a foreign language. In the final weeks, students reflect on the benefits of virtual worlds and present their work.

### *12.5.2 A Virtual World as an Educational Tool*

Building a village collaboratively promised advantages over individual projects. Students had to learn how to implement models in Active Worlds from each other, especially since no tutorial was available. In fact, by working as a group they all succeeded to take this hurdle relatively fast. Their houses and surroundings would never have reached the sophisticated level if they had not been able to learn and copy from each other and from other virtual worlds. In addition, creating a real virtual world as a group is expected to stimulate and motivate students as the result, for each individual, is really a new world to explore.

Re-using each others' work raised unexpected issues: One student created an animated smoke that was soon featuring the chimneys of many others. The teachers, needing to establish individual students' credits, easily established who was the original creator of unique features and successfully discussed the concept of intellectual property as a side effect. They also established a citation index to guarantee that the creators of interesting features would benefit from their work.

### *12.5.3 What Does Not Work*

Without an adequate strategy, a virtual world is just a playground. In a previous course, a Bachelor student presented his thesis work (on the possibilities of Active Worlds for schools and universities). His assignment included the creation of a building with classrooms in the virtual world and required him to present in one of those classrooms where "presence" for all students was compulsory. However, the students' avatars did not have any role other than to sit and watch the presenting avatar. In this situation, the use of a virtual world did not show any advantage. Students' avatars were indeed in the virtual room but, instead of participating in discussion, were engaged in activities like dancing the Macarena, labeled by abstract nicknames.

## 12.6 Assessment

The Virtual Worlds course was not an experiment. We heard about the course when it was about to reach its conclusion. The teachers reported interesting issues:

- The course was very successful. All the students accomplished their assignment, compared to 33% needing a second assignment in the past.
- The application of new technology was challenging. No tutorial of Active Worlds was available; conversion from 3D Studio Max was problematic and implementing interactivity reduced the performance seriously. Despite of all this, the performance of the course increased dramatically compared to previous editions.
- The Hogeschool Utrecht always performs student evaluations. The Virtual Worlds course was rated 8.4 on a scale from 1 to 10, which is the highest score ever.

Did the Virtual Worlds course meet the criteria for the implementation of a successful constructivist learning environment that we described in Section 12.2.4?

Obviously, implementing a 3D application is an activity which allows training, experimentation, and learning by doing.

Since the results were placed in a common virtual world and sharing sources was allowed, the students could observe fellow students who were performing the same task and give them feedback. Reflection was supported and encouraged during classroom meetings. Assessing flow, collaboration, and motivation is more complicated, which we address next.

### *12.6.1 The Survey*

To assess the students' experience, we might have performed interviews before the course, have followed the students during the course, and have interviewed them again after conclusion. Since our involvement with the course started late, the best possibility to perform the assessment was to develop one questionnaire with three search areas.

The students' expectations prior to the experience:

Q1. What were your expectations when you started with the "Virtual Worlds" course?
Q2. What did you think you were going to learn in this course?
    The actual living through
Q3. What is the most important thing you have learned by cooperating with the class in a virtual world?
Q4. Did you witness things you had never heard of during this course?
Q5. Did anything surprise you during this course?
    The after effects
Q6. What do you tell your friends and family about this course?
Q7. What would you advise the school on the next implementation of this course?

Additionally, we asked the students to express themselves on issues related to their attitude, their view on the usefulness of cooperation, and on the way the course was taught. We asked them to rate their answers to those questions on Visual Analogue Scales (12.3.7). For obvious reasons, we performed only one measurement. We asked the students to rate their answers to the following questions:

Their attitude during the course:

V1. Passive/active
V2. Not involved/very involved
    Their opinion about the course:
V3. Boring/surprising
V4. Unattractive/attractive
    Their opinion about the cooperation in the virtual world:
V5. Not instructive/very instructive
V6. Not useful/useful

### 12.6.2 Results

At the time we performed our survey, the course was finished. We managed to locate 14 students out of 19; they all responded to our request.

Their answers to the questionnaire showed:

- Issues concerning the students' expectations prior to the experience (Q1, Q2):

The students started with different expectations about what they would learn (3D modeling: 5; applications of Virtual Worlds: 5; and 3D modeling and Virtual Worlds: 4).

- Issues concerning the living through the experience (Q3, Q4, and Q5):

The majority of the students had been positively surprised by the course (Yes: 10, Not surprised: 3). Most of the students had witnessed things they had never heard of (Yes: 10; No: 3, and Not answered: 1). One student was negatively surprised by the amount of time 3D modeling requires but reported nevertheless positively to friends and family.

- Issues concerning the after effects (Q6, Q7):

Technology was challenging: Many suggestions for improvement concerned this subject (4 were related to Active Worlds, 5 to 3D Studio Max, though 5 suggested to not change anything). Ten students looked back at the course with explicit satisfaction ("I worked very hard but had a lot of fun," "it was fun to do and we could work together in the virtual world," "it was worth it"), despite of the technical problems they mentioned. Almost everybody who did report to friends and family had reported positively. The only respondent who had reported negatively had thought he was going to learn how to make a complete 3D environment and had been disappointed by the course mainly discussing design theory and the state of 3D technology. He would rather have spent more time in class discussing technical issues. For the second part of the survey, we used VAS scales. VAS scales are mostly used to assess changes in time of individual ratings of subjective findings: Comparing the results of a group of individuals is not straightforward. We are aware of this problem, which is why we only give an impression of the results. The questions concerned:

- The students' attitude (V1, V2):
- The course (V3, V4):
- The cooperation in the virtual world (V5, V6):

In summary:

- Figure 12.1 shows that most of the students called their own attitude Active; almost everybody considered themselves involved.

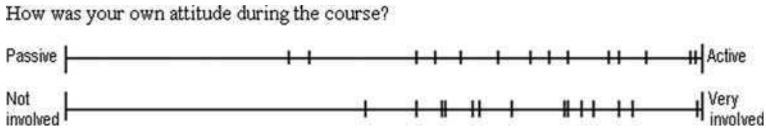


**Fig. 12.1** The students' answers to the questions concerning their own attitude.

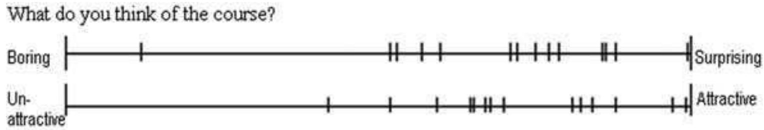


**Fig. 12.2** The students' opinion about the course.

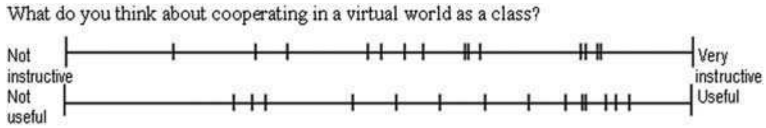


**Fig. 12.3** The students' opinion about the cooperation

- Figure 12.2: The large majority of the students reported having been surprised by the course. The students labeled the course Attractive.
- Cooperation was not always evaluated positively (Fig. 12.3). This might be related to the problems the group had encountered with intellectual property. One of the students who had criticized cooperation answered question Q3 saying that he had learned that "they steal everything. My fishes!" Nevertheless, even at this point the scores were mostly positive.

Although we did not prove that the learning environment of the Virtual Worlds course meets all the criteria we identified in Section 12.2.4, the results of our survey support a positive answer to our question.

## 12.7 Conclusions and Future Work

Current literature about best practices and our own findings in our Active Worlds course show the following:

- In 3D virtual worlds, it is possible to show (and teach about) some things in a more realistic way than in a real world since, as Wages, Grünvogel, and Schutzmacher (2004) state, one can get rid of real-world constraints.
- In a shared virtual world, students can learn from each other and cooperate in creating, which, in addition, is strongly motivating.
- Individual assessment is not straightforward as students work in groups. Copying and reusing each others' work should in many cases be considered positive

learning behavior, though special measures are needed to credit individuals for unique contributions. Discussing this in (real) group sessions works well, as do individual plenary final presentations.

- Moving traditional classroom activities into virtual worlds is not always effective, as in the case of attending lectures.

There will be new editions of the Virtual World course. We intend to investigate the students' experience to scaffold our claim that this course meets our criteria for a constructivist learning environment with a virtual world.

The 2008 Virtual Worlds course was successful and an improvement to its classical predecessors. Students were more present, more active, and, according to informal evaluation, more satisfied. Teachers estimate that students gained more conceptual insights in virtual world applications. This success surpassed teachers' expectations.

It is evident that the relation between the course subject and the applied technology was fundamental: A course about virtual worlds with an assignment in a virtual world is a powerful combination. Other success factors might be the choice for an immersive collaborative structure or the village metaphor.

Before we would dare to generalize this local success, we intend to explore other learning domains, other collaborative narratives, and related world metaphors.

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# Part IV
# Communications and Methods (Kinshuk)

# Chapter 13
# CARTE: An Observation Station to Regulate Activity in a Learning Context

## Experiments in a Practical Class

**Christophe Courtin**

**Abstract** This chapter discusses the introduction of a new concept called "regulation" into a use model, which is part of a theoretical observation model called trace-based system (TBS). This concept defines a retroaction mechanism in an observation station. We present the results of experiments, in a learning context, with a prototype observation station called Collection, activity Analysis and Regulation based on Traces Enriched (CARTE).

## 13.1 Introduction

In this chapter, we present in greater detail a prototype of the observation system Collection, activity Analysis and Regulation based on Traces Enriched (CARTE) designed in our laboratory (Courtin, 2008) and especially the feasibility of a regulation mechanism, which is based on an observation instrumentation.

An observation station is a system based on a theoretical observation model that provides observers (e.g., teachers, learners, and experts) with observation services. We present a prototype which is coupled with collaborative learning software tools that enable participants to communicate with each other, to organize the group work, and to produce content collectively. We use such a system to keep track of learning activities in order to provide observers (e.g., learners, teachers, and experts) with information which helps participants in their own practice.

The final research question is how may regulation influence the learning process to take into account the social dimension? However, it is worth noting that our

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This work is part of the research cluster ISLE (*Informatique, Signal, Logiciel Embarqué* or Informatics, Signal, Embedded Software), in the project "customization of the technology-enhanced learning systems (TELS)", supported by the region Rhône-Alpes in France.

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professional practice as teachers allows us to manage instrumented collective learning situations (ICLS), but it is advisable to be cautious about the semantic value of the results obtained by a system of observation of corresponding activities. Therefore, we will focus on computing aspects without forgetting the final objectives which are centered essentially on computing environment uses in a collective learning context. In other words, we attempt to evaluate the feasibility of our regulation mechanism, implemented in the prototype of the CARTE observation station, based on the theoretical model called trace-based system (TBS) described below. The evolution of this work will consist of evaluating how relevant this regulation is to support the social dimension in collaborative learning situations.

In this chapter, we first restate briefly the concepts of the theoretical observation model, which underlines the CARTE observation station model, and we shall attempt to find answers to the activity regulation problem with the help of retroaction. From this, we describe the corresponding working process with the architecture of the CARTE system. Finally, we present experiments which highlight the feasibility of a regulation mechanism in an observation station with the technical results of the CARTE prototype. We compare the last experiment to a previous one that was similar, but without the retroaction mechanism, in order to evaluate the benefits of regulation in collaborative learning activities.

## 13.2 Traces

This chapter provides a computing point of view about the concept of regulation in instrumented collective learning situations (ICLS), which widely covers other scientific fields, especially those in human sciences. We have introduced the term "regulation" (Martel et al., 2004) to represent all mechanisms that enable participants to organize themselves in a shared environment. The objectives of the regulation are to ensure social control (i.e., respect of social rules such as not talking to other participants) and to fit the activities to the pedagogical objectives according to a specific context (e.g., suggesting new exercises to students having difficulty). We propose a more precise definition of regulation in the following part.

We define an instrumented collective learning situation (ICLS) such as a traditional collective learning situation (i.e., in situ and in real time, such as a classroom) supported by a computing system which enables participants to communicate with each other, to coordinate their own activities, to produce content, and to regulate this situation as explained above. In our research work, we use the computing device to obtain clues about the learning context. From this, we chose to set up a specific instrumentation based on the computing events in order to obtain more elaborate traces (than the log system) of the participants' learning activities. From the point of view of a human observer (e.g., a teacher), the final traces, that is to say those with an abstraction level close to that of the human observer, are called indicators (i.e., they determine success or failure in an exercise). These indicators enable the description of actions as they are defined by the observer him/herself. The instrumentation technique we use is equivalent to the log system technique, except for the fact that it takes place at the level of the software tools themselves and close to their use model.

We would accept the idea that going from a traditional to an instrumented situation would benefit all the participants if the latter maintained the activities' human dimension. It is worth noting that computing environments' techno-centered design, which is too widely spread (Rabardel, 1995), limits use observation. The difficulty is increased by the singular nature of the use for which a model cannot be anticipated. With that in mind, we maintain that it is essential to involve interactants very early in activity analysis. This involvement occurs in the observation system design stage and thus in that of corresponding models as explained below.

We observe mediated situations with the help of organized knowledge which stems from computing environment instrumentation. The choice of instrumentation for observation is based on the idea that observation objectives are predefined by the observer him/herself (teacher, sociologist, ergonomist, etc.) (Carron, Marty, Heraud, & France, 2005). We then define the concept of "observed," which represents data relative to an activity observation. An activity trace, which is built from a use model, is composed of time-situated "observed" sequences. The use model supplies the necessary semantics to interpret the elements that compose the activity trace. The association between a trace and the corresponding use model (Settouti, Prié, Mille, & Marty, 2006) is termed MTrace. In order to interpret the MTrace, the human observer has to participate in the definition of the semantics of the use model elements.

We have placed traces at the heart of the theoretical observation model called TBS, presented in Fig. 13.1, to the definition to which we have contributed with other actors in the Technology Enhanced Learning and Teaching (TELT) field (Settouti, Prié, Mille, & Marty, 2006). We add a retroaction module to this model that we will describe in the next section. We propose a generic trace structure, presented in Fig. 13.2, in order to take into account the various trace sources (logs, snapshots, annotations, etc.). Common elements among all these sources (e.g., description) define the meta-data and specific elements of each source (e.g., a *page* in a text editor, a *table* in a structured chat room) define optional parameters. The observer defines these parameters' semantics in the use model. As specified above, we have chosen to collect traces by means of instrumentation of the computing environment's tools. We introduce two types of templates: signals and sequences (see Fig. 13.2). A signal generally represents basic information corresponding to an elementary action on software tools (e.g., saving a page). A sequence represents enriched information, which makes sense for an observer and which stems from composite actions represented by signals or even by other previously created sequences (e.g., edit_page + save_page = edition). We distinguish several levels for sequences according to how they are composed: signals and/or sequences of level *n* (Courtin & Talbot, 2007).

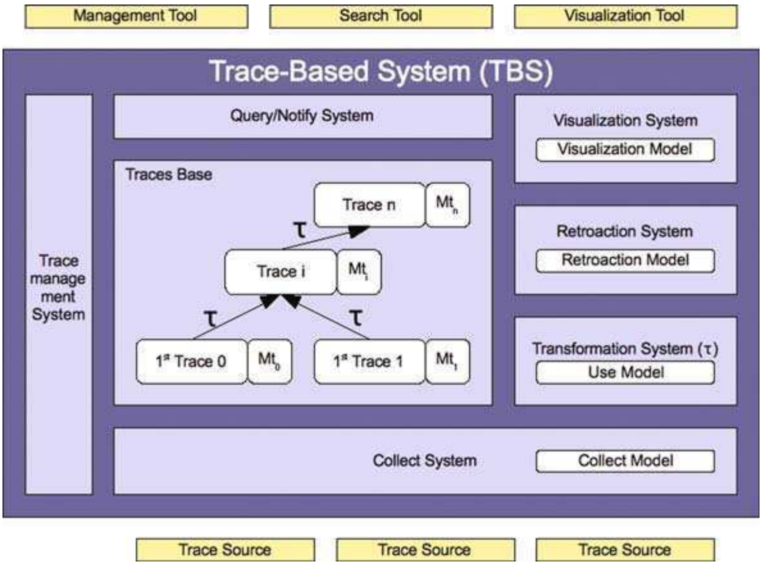


**Fig. 13.1** Trace-based system (TBS)

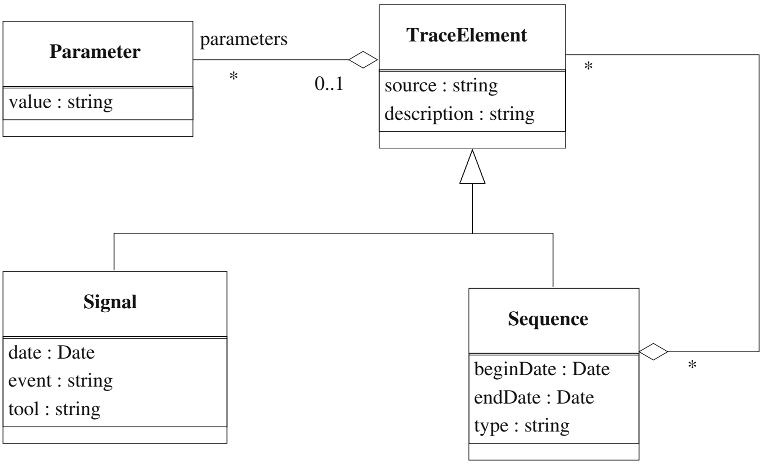


**Fig. 13.2** Trace structure

## 13.3 Retroaction and Regulation

The introduction of regulation concerns taking into account a fourth dimension in the classical clover model (collaborative work model), which is divided into three spaces: communication, coordination, and production (Ellis & Wainer, 1994). A fourth space entitled "regulation," which is orthogonal to the other three spaces, is added to this model in order to take into account the activities' social dimension (Chabert, Marty, Caron, Vignollet, & Ferraris, 2005). Regulation is a very broad concept and it is necessary to define it in this chapter before presenting our research work. We consider all the mechanisms for activity configuration in the computing environment to ensure coherence between work in progress and activity objectives (e.g., workgroup management during the activity, modification of the choice of proposed exercises according to the situation, etc.) included in regulation.

The CARTE observation station we have produced matches the theoretical observation model specification, presented in Fig. 13.1, where a use model is associated to traces. MTraces thus created may be combined by means of transformations ($\tau$) in an analysis tool to produce higher abstraction level MTraces, or language level ones, in order to help a human observer to interpret activities in a given application domain. Therefore, our application context constrains us greatly. Indeed, users are not involved in the design of the generic software tools which compose the computing environment used for their activities. This constraint hinders use analysis significantly. We get around it by involving the observer in computing environment use modeling. The resulting model, built by the observer, defines the software tools' working process without having to modify them. This approach's originality comes from the independence of the various use models and the software tools and their adaptability to match the various observation objectives. In other words, it is a matter of adapting a generic tool to a specific use by modifying the working process from traces, without modifying the tool itself. These different use models enable one to specify social rules (e.g., forbidding unauthorized intrusion in a chat-room discussion), which imply different uses that from the user's point of view are interesting for his/her activity.

The analyzer tool we have associated to the CARTE observation station, of which the working process is described in Fig. 13.3, provides "awareness" and/or

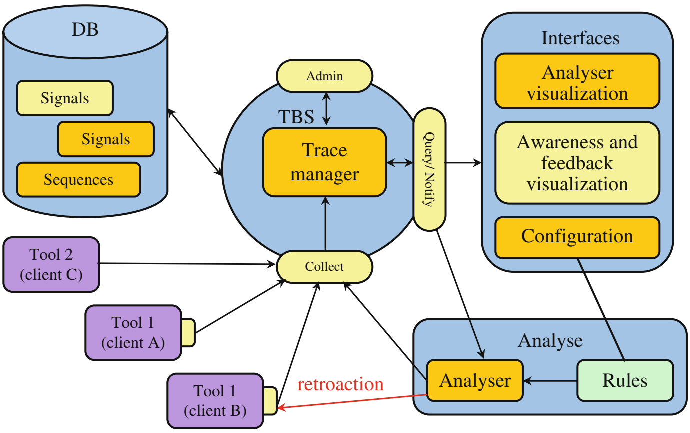


**Fig. 13.3** CARTE architecture

"retroaction" type traces. In the first case, the observer receives information relative to "observeds" described with the use model. By interpreting this information, the user/observer (teacher, student, etc.) will be able to act on the computing environment to move the activity toward predefined objectives. In the second case, the traces trigger the execution of actions on the tools in order to facilitate their use (e.g., task linking) or even to enrich their working process (e.g., automatically warning a user of the modification of a document that concerns him/her) without adding new functionalities.

In this subsection, we describe the principle of the retroaction mechanism used for the regulation of collaborative learning activity. When the observation station is started up, a base of rules (with XML format) dedicated to the regulation is loaded. The analyzer is thus ready to receive signals either collected by means of the collect Application Programming Interface (API) (e.g., the *save a page* action) or produced by the analyzer itself (e.g., the *beginning of a co-writing* action). The left-hand part of the rules that represent the specification of the use model is based on the use of operators of logic (AND, OR, NOT), of temporal relation (THEN), and of priority (brackets). Each time a signal is received, we verify whether it contributes to the condition of one or several rules. When the condition of a regulation rule is complete, the latter produces a sequence of actions which will be carried out on tools by means of the retroaction API (containing all the predefined retroaction methods).

### *13.3.1 Use Model to Support Regulation*

We have seen previously that, from our point of view, the reading of traces corresponded to the expected interpretation, which was anticipated by the observer's involvement during the definition stage of the use model of the learning software tools. In their first version, the use models were represented by a set of rules that produced templates (signals or sequences), providing awareness-type information and thus allowing the users to operate explicitly on the tools (Courtin & Talbot, 2006). We have proposed an evolution of the model by integrating retroaction execution in the rules in order to operate directly on the learning software tools.

We have considered the postulate that the concept of regulation covers all the mechanisms that ensure social control and that adapt the learning activities to the pedagogical objectives according to the context. Furthermore, as far as our experiments were concerned, the teacher had integrated the collaborative dimension (exchanges within pairs) into his/her pedagogical objectives. The objectives suppose a strong involvement of the learner in the group work mediated by the learning software tools. Below, we will attempt to highlight the effects of the increase in coupling between these tools on the participants' behavior. In other words, we wish to be able to appreciate the effects of the retroaction mechanisms and thus appreciate the increase in interactions on participants' involvement in the instrumented collaborative learning situation (ICLS).

## 13.4 Experiments

We have used an experimental approach to assess the CARTE observation station architecture and especially the regulation (R) mechanism. Furthermore, we agree with Mille, Caplat, and Philippon (2006) that user actions depend on reactions to the environment in a given activity context. The experiments we present in this chapter complete those described by Courtin and Talbot (2006), with a new type of use model featuring a retroaction mechanism. We restate briefly the context of experiments: the previous one without regulation and the last one with regulation. Both experiments were carried out during a practical class in an English course (foreign language) with students at the university. The students, in pairs, were supposed to define a set of situated English words by means of a specific collaborative text editor (multilingual dictionary). They communicated in pairs via a specific chat room to organize their work to their liking. The teacher was using the same production tool to check students' definitions and the same communication tool to answer students' questions. Furthermore, the teacher coordinated the groups by means of a group structuration tool and everyone visualizes the actions with the awareness tool. The CARTE observation station may provide participants/observers with these observation tools.

Our experiments consist in setting up a computer-based collaborative learning session (Talbot & Courtin, 2008). From a pedagogical point of view, a collaborative learning activity is one that requires mutual learner involvement and which implies educative intentions that aim to assist or to facilitate the learning process. The system is composed of the following: a production tool called Jibiki (a specific collaborative text editor to create multilingual dictionaries, created for a research project in linguistics, whose working depends on trace exploitation, Mangeot & Chalvin, 2006), a communication tool called CoffeeRoom (a chat room in which communication spaces are represented by tables), a group structuration tool, an activity monitoring tool (awareness), and the activity trace observation station CARTE.

As the activity scenario is very simple, it is not necessary to specify it with a scripting tool. The activity is carried out as follows:

Preliminary phase

- The teacher generates groups thanks to the group structuration tool.
- The teacher distributes the subjects with the words that have to be defined.

  Work phase
- The students are free to organize their work in pairs with the CoffeeRoom.
- The students define the words with the Jibiki and submit them to the teacher.
- The teacher verifies the definitions, annotates them, or validates them directly.
- Sometimes the students ask the teacher for help.

The work is finished when the class is over or when all the definitions have been completed. The main objectives of our experiments are

- to inform about other participants' actions to which an interactant is subscribed (e.g., partner actions in a pair),
- to enrich the functionalities without modifying the software tools (e.g., sending an e-mail automatically after having recognized a specific action or asking for help),
- to set controls to ensure that the social rules necessary for the learning session to take place in the right way are respected (e.g., forbidding students to change tables in the CoffeeRoom), and
- to simplify the carrying out of the operations by automating certain tasks (e.g., automating the configuration of the learners' tools from the definition of the pairs by the teacher).

It should be noted that the above-mentioned aspects deal essentially with general group activity regulation (social rules) and not directly with the pedagogical activity itself, for example, to modify the way the collaborative learning session proceeds according to educative activities that are carried out by the students (nature and tempo). However, we think that some actions thus regulated improve interactions with the computing environment and can have an influence on learning conditions. It is what we attempt to show with the experiments results.

## 13.5 Description of the Software Learning Tools

We consider the postulate that an instrumented collaborative learning situation (ICLS) has to fit the specification of a groupware model, which takes into account all aspects of the collaborative work. We thus use as a base the previously presented augmented clover model, namely the classical model with a regulation space. The experiments that we have described have been carried out by means of learning software tools, which are initially designed for independent uses, that is to say which do not support intertool collaborative activities in real time. The adaptation of these tools, which are able to interact with each other and offer functionalities that are adapted to the collaborative learning situation, has been made possible thanks to the use of the traces they produce. Taking into account the objectives of our experiments, described above, we have thus selected learning software tools which cover the various spaces of the augmented clover model.

The production tool used is the Jibiki editor (see Fig. 13.4), which allows the creation of multilingual corpuses by means of a Web client. In this tool, each participant is registered with a casual role, that is to say a role that is associated with a set of possible actions (e.g., setting a new definition, validating a definition, and administrating the corpus). Because Jibiki is a Web client, we have chosen to use HTTP requests to retroact from the observation station and thus from the retroaction module. An API (application programming interface) has thus been created to process the retroaction requests in a generic way. A request is associated with a generic method which receives the following parameters:

- ActionType which represents the action to be triggered (the actions are located by means of constants).
- ParametersList which contains all the necessary parameters so that the request is sent.

For example, deconnection corresponds to an HTTP request with the following parameters:

- Action type: Jibiki deconnection
- Jibiki address: http://yeager.univ-savoie.fr
- Port used by the Jibiki: 8999
- Corresponding Java method corresponding to the deconnection: LoginUser.po
- Session identifier: ;jsession=KBK4LJQ9zTQa13uAasQTcf63
- Parameter: ?Logout=yes

In the context of our experiments (see Fig. 13.4), we have instrumented the editor in order to detect the following predefined set of actions:

- The (de)connection of a user (e.g., the student Albert),
- The creation of an entry (e.g., the word "gender"),

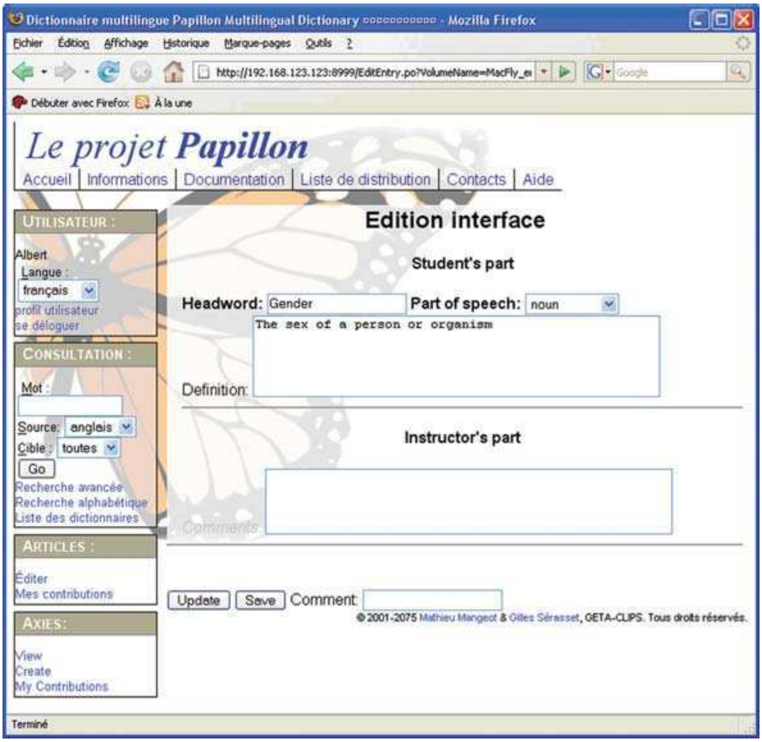


**Fig. 13.4** Jibiki

- The editing of a definition (e.g., “the sex of a person or an organism”),
- The submission of a definition (to be checked by the teacher),
- The setting on standby of a definition to be corrected,
- The reviewing of a definition (to take into account the teacher’s annotations),
- The validation of a definition (when it is correct), and
- The integration of the definition in the corpus (when it is validated).

A pair management tool has been specifically implemented to match the experiments’ needs (see Fig. 13.5) by respecting a strict specification, according to which the functionalities for the collaboration are based on the use of traces. This specification guarantees the independence of this coordination tool’s implementation with regard to other tools, while allowing functional interdependence. In other words, the interactions with other tools are carried out solely by the retroaction rules defined in the analysis module of the observation station. In practice, after the teacher has set the pairs, the traces collected by the observation station trigger rules in which

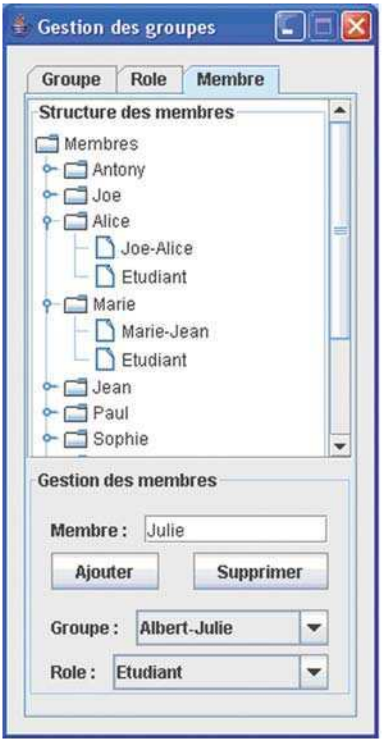


**Fig. 13.5** Pair management tool[1]

[1] Translation:
“gestion des groupes/membres” means “group/member management”
“ajouter/supprimer” means “add/delete”

retroactions enable the creation of the corresponding tables in the CoffeeRoom. It should be noted that with this intermediate mechanism replacing the CoffeeRoom by another structured communication tool would not affect the implementation of the pair management tool.

As has been explained above, the specification of the learning software tools implies no modification of their code. Thus, an awareness tool (see Fig. 13.6) has been designed to gather information relative to the context of the activity in progress (e.g., the group structure, the name of a participant in difficulty, the action that has just been carried out, etc.). This information stems from "observeds" defined by the observer him/herself, with a level of interpretation very close to that of the latter.

The CoffeeRoom is a structured chat-room tool (the conversation spaces are represented by tables, presented in Fig. 13.7) used for communication among participants according to rules defined by the teacher at the beginning of the session. For example, during the preparation of the practical class, the teacher defines the pairs by


**Fig. 13.6** Awareness tool[2]

[2]Translation: the most recent action is at the top of the list
"Conscience de l'activité (des groupes)" means "(group) awareness"
"Sans groupe" means "without a group"
"Valeur du paramètre" means "parameter value"
9:21: Albert has written the word "gender" without talking at his table
9:21: Albert has finished the word "gender"
9:9: Albert is trying to join another table

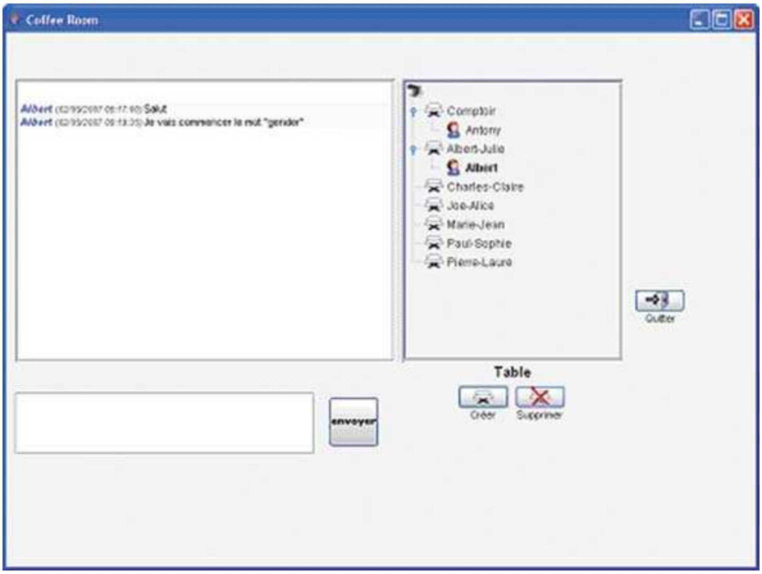


**Fig. 13.7** CoffeeRoom[3]

means of the workgroup management tool previously presented, then enacts rules of social control by means of the observation station's rule editor. From then on, any action which breaks these social rules (e.g., Albert is attempting an unauthorized move to another table in the CoffeeRoom; see Fig. 13.6) will cause retroactions, such as sending warnings in the awareness tool (e.g., Antony, the teacher, is warned about participant Albert's attempted intrusion into another pair) or acting on the tool in which the transgression has been committed (e.g., the participant is returned to the table he/she came from). Therefore, this communication tool, when it is instrumented, has its functionalities enriched by the use of the activity traces of a group within a set of tools (taking into account part of the context).

In the context of our experiments, we have instrumented the CoffeeRoom to allow its automatic configuration from the session specification, which is carried out by the teacher (i.e., pair definition, setting-up of social rules, etc.). The retroactions thus identified are creating or deleting a table (from traces stemming from the configuration of the group management tool); connecting or disconnecting a user, adding a user to a table (according to the defined pairs); and sending a message to a table (e.g., to warn the partner automatically of the validation of an action). Following the example of the Jibiki, the CoffeeRoom has an API to carry out the aforementioned retroactions. In the same way, a generic method receives parameters such as the reference of the server, which centralizes the messages and on which

[3]Translation: "envoyer" means "to send"

there are already the methods corresponding to the various (retro)actions. This technique allows one to be both independent of the communication tool (if it contains separate discussion spaces) and to take into account the specificities of the chosen tool (here, the CoffeeRoom). The retroaction API, which is linked to the server of the CoffeeRoom, enables remote access via the Remote Method Invocation (RMI) protocol. The regulation module then has a Java interface listing all the possible retroactions which will be called up remotely at that time.

We have presented above an instrumentation of the various tools, which allows the analyzer to implement both types of regulation, namely human interventions from information which stems from the "observeds" (awareness) and retroactions triggered by one or several rules predefined by the observer him/herself. In both cases, the system is based on the exploitation of activity traces that are collected, then analyzed in the observation station by means of predefined use models.

## 13.6 Results

Our research objectives consist of transforming information that stems from computing traces in order for it to be relevant for a human observer and in testing our models' strength. In the first experiment, the software tools used in the collaborative work were independent of each other. However, we were defining a use model to recognize actions performed on one or several software tools. The observation system was able to provide participants with awareness information, but it was not able to trigger actions directly on the software tools. Thus, the latter were limited to their own functionalities. We briefly reiterate below certain limitations observed during the first experiment:

- Lack of information on activity within a pair (e.g., a student is not warned about the acceptance of a definition sent by his/her partner),
- Difficulty in identifying those who need help,
- Difficulty in having the rules respected (for example, pair separation) and in taking into account pedagogical context features,
- Presence of certain repetitive tasks specific to tools (e.g., in Jibiki, the definition validation by the teacher is always followed by a corpus introduction; two actions are necessary), and
- Lack of synchronization for actions performed within different tools (e.g., group management by teacher and corresponding configuration of the CoffeeRoom).

Therefore, it is a matter of analyzing the effects resulting from this new use model feature by means of the experiments presented below.

With regard to the last experiment, a computer-based study alone does not allow us to evaluate the regulation's effects on learning quality. On the other hand, this experiment has revealed the use model's capacity to specify the regulation actions of the activity in progress during an instrumented collaborative learning session. In order to present these results, we propose to describe the retroaction mechanism and present the related effects on the learning activity. To carry out retroaction on tools, we have modified the analyzer tool (see Courtin & Talbot, 2006) to add a list of actions to perform on the right-hand part of the rules. These actions are triggered after the sequence is recognized and added to the TBS. The use model allows us to define an abstraction level between actions to be carried out and the various tools' API (application programming interface). In concrete terms, a name is associated with every action as well as parameters for which the semantics are defined at the use model level. In our case, for example, the actions on Jibiki are sent to it in an HTTP request form, whereas those dedicated to the CoffeeRoom or to the awareness tool are carried out with remote methods invocation (RMI) in Java language.

From a functional point of view, the use model integrating the retroaction mechanism implies an incoming instrumentation for the tools concerned, which completes the outgoing instrumentation that ensures the connection between the trace sources and the first trace of the collect module of the CARTE system (see Figs. 13.1 and 13.3). From the point of view of the system architecture, there is no direct link between the tools; all the actions are triggered from the MTraces, which are produced by the TBS. A major advantage of this level of abstraction that is the use model is that it preserves the independence of the tools which are thus interchangeable. For example, the action that consists of putting a participant back onto his/her table in the CoffeeRoom is associated with the event *join* with two parameters: the name of the discussion space (here, the table) and the user's identifier. With another communication tool, whose structure features communication spaces bearing different names (e.g., rooms), the rule would then be the same, which would exempt us from modifying the use model at the observer level. We also note the relevance of going through this level of abstraction, which places the trace at the heart of the system and which then guarantees the persistence of the trace of all the stages that have led to a retroaction, the latter itself generating a new trace. For example, when a participant tries to change tables (event *join* with another table name), the trace produced by this attempt triggers a rule which executes an action on the CoffeeRoom (join his/her own table) and another one on the awareness tool (notification for both the teacher and him/herself), which will generate two new traces.

Retroaction increases coupling between the various software tools, which tends to change the way the tools are perceived by the interactants. For example, the fact of joining the awareness tool with Jibiki, which was initially designed to do collective editing with a very low coupling, allows us to warn the pair partner about definition validation and to visualize the right version. We have noticed the analyzer tool's efficiency, which enables it to be used online during the learning sessions. The rules we have specified in these experiments enable the following:

- To have feedback about the other participants' activities (e.g., a student is warned in the awareness tool when his/her partner has completed a definition not to do the same),
- To change the way the tools are perceived because of the increased interactivity,

- To automate certain tasks, in particular for the teacher (e.g., in Jibiki, with only one action, the definition validation by the teacher is automatically followed by a corpus introduction, what is an ergonomic improvement without modifying the software tool), and
- To reinforce social control at the group level (by restricting, for instance, the possibility of communication between students belonging to different groups).

The fact that retroactions are useful traces for recognizing other activities reinforces the idea that the sequences from which they originate have to be stored in the TBS. Likewise with the traces produced by these retroactions. This illustrates the trace-centered nature of our observation system.

As a result, the retroaction mechanism enriches the use models by adding virtually new functionalities without modifying the software tools themselves. From this, we have also observed new students' behavior, like discussion after a word has been validated in order to understand the right definition. In other words, these new virtual functionalities may increase the collaboration within student pairs.

We can notice that through these experiments, the enrichment of interactivity, on the basis of information emanating from the context (activity in progress, difficulties encountered, etc.), gives rise to new behaviors. For these experiments, the collaboration between participants within a pair was part of the pedagogical objectives defined by the teacher. It remains to be seen whether these new behaviors meet the expectations of the latter. The CARTE system already allows us to perceive very promising answers to this question which will be the basis of new experiments in the context of the setting up of a test-bed project (customization of the technology-enhanced learning systems [TELS] of the research cluster ISLE of the Rhône-Alpes Region, 2008–2011), dedicated to researchers in computer science, social sciences, didactics, etc. The observation station will then be able to interact with this activity's trace-centered benchmarking platform.

The expectations of the observers (e.g., experts, teachers, and learners) are the production of indicators, that is to say traces with a level of abstraction close to their interpretation. During the preparation of the learning session, the teacher defined explicit rules that specify the use model for the analyzer. For example, when a user writes "help" on a table, a message is sent directly to the awareness tool for the teacher's attention. This trace is then calculated from the event "send a message on a table" containing the single text message, *help*. For the teacher, it is an indicator of the type "awareness," confirming any difficulty encountered by a learner. Another example of an indicator, namely the warning message about an attempt to intrude on another table, may be interpreted by the teacher as being a test of navigation in the CoffeeRoom, or the wish to communicate with another pair, or the search for solutions elsewhere in spite of the instructions, etc. The goal of this regulation (the fact of thwarting the attempt automatically) is to introduce social control into the session to guarantee the respect of the pedagogical objectives.

With the experiments, it appears that the CARTE system seems to support basic regulation in ICLS. However, we have noticed some limits in the current version of the prototype to express specific actions of regulation such as the following: to warn the teacher when a pair of students has completed *n* definitions in a given period of time. Indeed, iteration and time dimension are not already supported by the rules editor. In fact, we get around the iteration drawback by repeating *n* times the corresponding MTrace (signal or sequence). These technical drawbacks may be solved by adding a new analyzer and then by applying a new use model, working on previously generated MTraces (i.e., with the first analyzer). We plan to carry out this work for the next version of the prototype.

## 13.7 Conclusion and Perspectives

We have described an improvement of the trace-based system (TBS) to allow and take into account regulation in collaborative activities in a learning context. A prototype observation station called CARTE has been presented, and the results of the experiments carried out with students at the university have enabled us to test our models' strength and have highlighted the added value of such a trace-centered system with a retroaction mechanism.

We are currently working on how to operationalize our observation system in a project about multilingual dictionary asynchronous co-construction (Mangeot & Chalvin, 2006). An important first stage of this work consists in defining relevant indicators for this new type of analysis.

We are also thinking of enhancing pedagogical scenarios (Martel, Vignollet, Ferraris, David, & Lejeune, 2006; Talbot & Pernelle, 2003) with our activity trace models, particularly by exploiting the analyzer retroaction mechanism.

Generally speaking, we plan to work in a full-service groupware perspective. This implies orienting our work toward generic observation services for collection, analysis, awareness, retroaction, etc.

Given that the CARTE system strictly respects the specification of the theoretical model of TBS, this observation station has been selected for the study of an activity trace management platform in technology-enhanced learning systems, in order to create corpuses of reference that are open to the international community of researchers.[4] The goal of such corpuses is to be found at the intersection of numerous problems centred on a research object, called a trace, which derives from various sources and is able to take different forms, while respecting a specification to allow interoperability with other traces and to take into account all the specificities inherent in its use (ownership, ethics, classification, etc.). This benchmarking platform is dedicated to research in computer science, social sciences, pedagogy, didactics, etc.

[4]This work in progress is part of the research cluster ISLE, project "customization of the technology-enhanced learning systems (TELS)", supported by the "Region Rhone-Alpes" in France.

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# Chapter 14
# Acceptance of Model-Based Instruction Among Students in Spanish and Mathematics

**Ulrike Hanke and Elke Huber**

**Abstract** In order to support and facilitate learning, teachers have to take into account the cognitive processes of learning when planning teaching interventions (Seel, 2003, *Psychologie des Lernens,* München & Basel: Reinhardt). The model of model-based instruction (MOMBI) is a teaching strategy derived directly from findings and knowledge about the cognitive processes of learning (Hanke, 2008, *Understanding models for learning and instruction*, New York: Springer). It suggests a teaching intervention for each of the five subprocesses of learning. However, the processes of learning are not the only things teaching has to take into account. One condition among others (e.g., learning style, intelligence) is that learners accept the teaching strategy. If they do not accept it, they will not be willing to pay attention and therefore will not learn (Huber, 2008, *Akzeptanz und Effektivität modellbegründeten Unterrichts,* Freiburg). It is thus important to explore whether learners accept the teaching interventions suggested by MOMBI. In order to test the acceptance of the five teaching interventions of MOMBI, we carried out an exploratory study in the subjects Spanish and math with 23 17-year-old students from a secondary school in Offenburg, Germany. The results indicate that students tend to accept the five teaching interventions suggested by MOMBI in Spanish and math lessons.

## 14.1 Introduction

The main interest of teaching is to support and facilitate learning; lessons and training are successful when learners have learnt more than they would have without them. Teaching is therefore a kind of intervention that endeavors to influence the learning process in order to support and facilitate learning. For this reason, teachers

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have to take into account the cognitive processes of learning when planning teaching interventions. If a teaching intervention does not take learning processes into account, it will only support learning incidentally (Seel, 2003).

The model of model-based instruction (MOMBI) was developed to facilitate the planning of lessons and training (Hanke, 2008). This teaching strategy is based on the assumptions of the theory of mental models (Seel, 1991) concerning the cognitive processes of learning and includes a teaching intervention related to each subprocess of learning. These processes and relations will be described in the following section in more detail.

But even though the intent of teaching interventions is to influence the learning process directly, teaching interventions do not necessarily support learning if other conditions, such as the learning styles, intelligence, and personality of learners, are not taken into account. One of these conditions is the acceptance of the teaching strategy. If learners do not accept a teaching strategy, they will not pay attention, will not take part, and, as a consequence, will not learn. These reflections raise the question as to whether learners accept the teaching strategy MOMBI and thus meet the first condition of effective learning (Huber, 2008).

In order to learn more about the acceptance of MOMBI among students, we implemented lessons planned according to the suggestions of MOMBI and tested how learners accepted the five teaching interventions (Huber, 2008).

The first part of this article describes the teaching interventions of MOMBI and shows how they are related to the subprocesses of learning. The second part presents the design and results of our investigation on the acceptance of the five teaching interventions suggested in MOMBI.

## 14.2 Model of Model-Based Instruction (MOMBI)

When individuals are confronted with new information of any kind, they try to process it in order to make sense of it. This information processing can take on two different forms: assimilative or accommodative (Piaget, 1976). If the individuals have been confronted with similar information in the past, they have schemata available. They are then able to explain the new information based on these schemata. This method of processing is called assimilation (Piaget, 1976) and takes place quasi-automatically as the new information is processed on the basis of existing knowledge.

If the individuals do not have schemata available to make sense of the new information, they meet with resistance in assimilating the information. In this case, a state of mental disequilibrium is provoked. As individuals have a tendency to retain mental equilibrium, they start to accommodate the new information (Piaget, 1976). During this process, they construct a mental model that integrates the new information into existing knowledge in order to explain it (Seel, 1991). This process takes place consciously and not quasi-automatically.

Both ways of processing new information – assimilation and accommodation – can result in learning, that is, in a modification or enlargement of existing knowledge or the construction of new knowledge. As assimilation is a quasi-automatic way of processing information, in which the new information is processed on the basis of existing knowledge, it does not result in the construction of new knowledge. Therefore, it can be said that the process of accommodation and the construction of a mental model are the foundations of new learning. This mental model then has to be schematized in order to be available for future processing.

According to the theory of mental models (Seel, 1991; Johnson-Laird, 1983; Gentner & Gentner, 1983), learning can therefore be defined as the construction of a mental model and its schematization (Hanke, 2006b).

A mental model is a mental representation of knowledge (Seel, 2001, 1991, 1986; Hegarty & Just, 1993), which is constructed in order to make new information plausible/understandable/useful and to allow inferences (Ifenthaler, 2006; Pirnay-Dummer, 2006; Seel, 2003, 1991). It is based on prior knowledge and is constructed intentionally when an individual is not able to assimilate, that is, not able to understand new information immediately. Mental models may be incorrect in a scientific sense, which means that they may not be similar to the models of experts in the field (Johnson-Laird, 1989; Dörr, Seel, & Strittmatter, 1986; Norman, 1983), but this is immaterial because the value of a model for the model-constructing individual is defined by its plausibility (Ifenthaler, 2006; Seel, 2003, 1991) and its usefulness (Pirnay-Dummer, 2006).

According to these assumptions of the theory of mental models, learning can be described as consisting of five subprocesses (Hanke, 2008, 2006b): (1) the subprocess of *provocation of mental disequilibrium*, (2) *activation of prior knowledge*, (3) *search for further information*, (4) *integration of a mental model*, and (5) the subprocess of *schematization*. These subprocesses are described in the following paragraphs.

Learning is initiated by new, often conflicting information from the environment, which the learners are not able to understand (Seel, 1991). This information provokes a cognitive state of mental disequilibrium in the learners (Piaget, 1976). In order to retain mental equilibrium, learners have to construct a mental model that integrates the new information into their prior knowledge and therefore makes the new information plausible (Seel, Dörr, & Dinter, 1992; Seel, 1991). The first subprocess of learning therefore can be summarized as "provocation of mental disequilibrium."

In order to construct a mental model that is able to explain the new information from the environment that provoked mental disequilibrium, the learners have to activate their existing knowledge. They have to search for knowledge about similar information with which they have been confronted in the past. In this way, they can perhaps find an analogy that enables them to make sense of the conflicting information. As mental models are based on prior knowledge (Hilgard & Bower, 1975; Seel, 1991), the subprocess "activation of prior knowledge" is very important.

In many cases, the activation of prior knowledge in order to find a useful analogy is not enough to make sense of the new information. In these cases, learners also have to search for further information in their environment, for example, ask someone or search for further written information. This subprocess is therefore called “search for further information.”

During the next subprocess, the learner has to integrate the new information into prior knowledge in the form of a mental model that makes the new information plausible. This subprocess is called “integration of a mental model.”

According to the assumptions of model-based learning (Seel, 2003, 1991), mental models are not stored, but rather have to be reconstructed every time they are needed (Gick & Holyoak, 1983, 1980; Seel, 1991). In order to be able to retrieve or understand this kind of information later on without constructing a new mental model, the individual has to process similar information several times. This process is called schematization and is a process of abstraction and generalization. As soon as a mental model has been schematized, constructed several times, and stored in an abstracted and generalized way as a schema, we can say that the new information and its handling have been learnt.

In summary, the five subprocesses of learning (Hanke, 2008) are (1) provocation of mental disequilibrium, (2) activation of prior knowledge, (3) search for further information, (4) integration of a mental model, and (5) schematization.

In order to support learning, teaching strategies have to consider these subprocesses of learning and support them. This raises the question as to how these subprocesses can be supported by teaching interventions. MOMBI describes such teaching interventions (Hanke, 2008).

As learning is initiated by mental disequilibrium, it seems reasonable that teaching should provoke this state of disequilibrium. The first teaching intervention of MOMBI is therefore *provocation*, which supports the subprocess *provocation of a mental disequilibrium*. This teaching intervention can be realized with the help of provocative questions or hypotheses that make the learners think and that they cannot answer or explain automatically.

In order to retain mental equilibrium, people have to activate their prior knowledge. This activation of prior knowledge can be encouraged by the teacher. The second teaching intervention is therefore *activation*, which supports the subprocess *activation of prior knowledge*. In order to realize this intervention, teachers can ask their learners what they already know about the topic of the lesson. A typical teaching method for this teaching intervention is brainstorming.

In most cases, prior knowledge is not sufficient or has to be reconstructed in order to explain the new information. Therefore, learners need further information on the new topic in order to be able to construct a mental model. Teachers can present this information to the learners in texts, lectures, or teacher–learner discussions. In this way, they support the *search for further information* subprocess and ensure that the learners are not getting lost in searching for relevant information. This teaching intervention is called *presentation* and is the intervention most people think of when they think of teaching.

The next subprocess of learning to be supported is the *integration of a mental model*. During this subprocess, learners integrate the new information into their prior knowledge. The result of this process is a mental model that makes the new information plausible. In order to make sure that their learners construct scientifically correct models and not only models that are plausible for the learners themselves, teachers have to support the learners individually by giving them hints and asking and answering questions. The Cognitive Apprenticeship (Collins, Brown, & Newman, 1989) refers to this teaching intervention of MOMBI as *scaffolding*. It is also a typical teaching intervention.

In order to schematize (*schematization* subprocess) a mental model, one has to reconstruct it several times. Therefore, teachers are asked to let their learners practice ("practice" teaching intervention), that is, to give them similar tasks to solve in order to encourage them to reconstruct their models several times. The process of schematization requires a lot of time. This teaching intervention is often disregarded due to the fact that nothing new seems to be learned during the process and because of time restrictions. As a result, learners are not able to transfer their knowledge.

The realization of all five teaching interventions should lead to learning, as every subprocess of learning is supported by exactly one teaching intervention. But even a teaching strategy that supports the learning processes is not effective if it is not accepted by the learners. Therefore, we have to ask whether learners accept the teaching interventions of MOMBI.

We suggest that learners will accept the teaching interventions of MOMBI in different ways because they may not be accustomed to all of them and may not immediately recognize their effect.

The teaching intervention *provocation*, for example, might not only provoke mental disequilibrium and motivate the learners to think about the learning subject, it might also irritate them, which could lead to their rejection of this intervention and an unwillingness to follow the lesson. If most learners reject this intervention, provocation should not be realized in learning environments.

The same would be the case if the teaching intervention "activation" were to be rejected. Learners could reject this intervention because they might not see the point in activating knowledge they already have since they want to learn new things.

The teaching intervention *presentation*, on the other hand, is a typical intervention. It can therefore be assumed that learners will generally accept it because they expect teaching interventions of this kind. They expect teachers to present their knowledge to them in a structured way as experts, thus making it easy for them to follow and learn the new information. They know this kind of teaching intervention from school and from university lectures.

Another teaching intervention learners are assumed to accept is *scaffolding*. This teaching intervention is not as typical as presentation, but learners generally know it at least from primary school, where teachers often support their learners individually.

Whether learners will accept the teaching intervention *practice* is questionable. On the one hand, learners are assumed to appreciate practicing, but on the other hand they might not be willing to practice too much if they think that they already know how things work. They may be bored if they have to repeat things again and again because they already seem clear. A lot of experience is required to recognize that practicing and repeating is the only way to acquire long-lasting knowledge.

In sum, MOMBI suggests teaching interventions for each subprocess of learning and has the intention of supporting and facilitating learning. But, as has been shown, it cannot be assumed that learners will accept all the interventions. In order to determine whether they accept MOMBI as a teaching strategy and its teaching interventions, we carried out the following investigation.

## 14.3 Method

In this exploratory study (Huber, 2008), we implemented MOMBI in order to investigate its acceptance among students of a secondary school in two lessons: a Spanish lesson and a mathematics lesson. In order to assess the acceptance of MOMBI on the part of the students, we used a questionnaire with six variables that have proved to have acceptable reliabilities in several previous studies (Hohenadel et al., 2007; Mendes Passos, 2007). The students had to evaluate the five teaching interventions suggested by MOMBI on a scale from 1 to 6 (1 being complete acceptance, 6 being complete rejection).

Altogether, 23 students from a secondary school were tested (15 females and 8 males with an average age of 17.4) in Spanish and mathematics lessons. All of them participated without being paid because the lessons took place during their regular class time.

The Spanish lesson was constructed around the topic currently on the lesson plan of the course – an introduction to Cuba – and took into account the theoretical assumptions of MOMBI. The mathematics lesson, which also made reference to the theoretical assumptions of MOMBI, was on exponential functions.

In the following section, we briefly present the sketch of the Spanish and mathematics lessons. Each lesson took 70 min.

The Spanish lesson was constructed as an introduction to the country and culture of Cuba. At the beginning of the lesson, the teacher presented different pictures of Cuba on the board (teaching intervention *provocation*). In the form of brainstorming, the students were then asked what they knew about Cuba (teaching intervention "activation"). To provide sufficient material for the construction of a mental model, the teacher gave them different texts that had to be discussed in groups (teaching intervention *presentation*). To support the students in the construction of their mental models, the teacher provided questions for the texts and gave them the possibility to present their results after the group phase (teaching intervention *scaffolding*). Finally, the teacher invited the students to summarize the results of the lesson (teaching intervention *practice*).

The mathematics lesson, an introduction to the characteristics of the exponential functions, was structured similarly to the Spanish lesson: At the beginning of the lesson, the teacher presented a poster with a graph of an exponential function on the board (teaching intervention *provocation*). After explaining the topic, the teacher asked the students to brainstorm what they already knew about exponential functions (teaching intervention *activation*). In order to provide sufficient information for the construction of a mental model, the teacher gave them different problems which had to be solved and discussed in groups. For example, the students had to develop the tokens of the exponential functions by comparing different value tables and graphs (teaching intervention *presentation*). In order to support the students in the construction of their mental model and prevent them from consolidating false information, the teacher provided aids for solving the exercises (teaching intervention *scaffolding*) and invited the students to present their results after the group phase (teaching intervention *scaffolding*). Finally, to initiate the schematization of the mental model, the teacher had the students summarize the results of the lesson and solve further problems presented on a worksheet. They then discussed these problems in class afterward (teaching intervention *practice*). The similar structures of the different lessons enabled us to use analogous questionnaires and compare the results of the two investigations. The only differences were the two implementations of the teaching intervention *practice* in the mathematics lesson, which we were not able to implement in the Spanish lesson.

## 14.4 Results

To verify the acceptance of the model-based Spanish and mathematics lessons from the viewpoint of the students, we asked the subjects to complete the aforementioned questionnaire. Table 14.1 provides an overview of the results.

**Table 14.1** Results of the questionnaire

| | Cronbach's alpha | | Mean | | SD | |
|---|---|---|---|---|---|---|
| Variables | Spanish | Math | Spanish | Math | Spanish | Math |
| Acceptance of the Spanish/mathematics lesson | 0.87 | 0.79 | 1.45 | 1.59 | 0.51 | 0.56 |
| Acceptance of provocation (pictures/poster) | 0.84 | 0.93 | 2.00[a] | 2.94[a] | 0.80 | 1.19 |
| Acceptance of activation (brainstorming) | 0.90 | 0.87 | 2.67[a] | 3.29[a] | 0.96 | 1.03 |
| Acceptance of presentation (texts/problems) | 0.83 | 0.91 | 2.39 | 2.27 | 0.86 | 1.06 |
| Acceptance of scaffolding I (presentation) | 0.96 | 0.90 | 2.16 | 2.36 | 0.80 | 0.96 |
| Acceptance of scaffolding II (aids) | 0.90 | 0.96 | 2.30 | 2.12 | 0.78 | 1.20 |
| Acceptance of practice (securing of results) | 0.78 | 0.88 | 1.95 | 1.71 | 0.69 | 0.93 |
| Acceptance of practice (worksheet) | | 0.91 | | 2.20 | | 1.03 |

[a]Significant differences between Spanish and mathematics ($p < 0.05$).

The means range from 1.45 to 3.29. This allows the conclusion that, in general, all of the teaching interventions – provocation, activation, presentation, scaffolding, and practice – were accepted by the students. If we compare the means of the two lessons, we can conclude that, in general, the model-based Spanish lesson was more readily accepted than the model-based mathematics lesson. However, we only observed significant differences in favor of the Spanish lesson in the variables "acceptance of provocation" ($T = 3.08$; $p < 0.05$) and "acceptance of activation"

($T = 2.20$; $p < 0.05$). These results and the significant differences between the two lessons will be discussed in the following section.

## 14.5 Discussion

The results of this study of course must be interpreted with care: The sample size is much too small to conclude that the teaching interventions of MOMBI are accepted in general. Furthermore, there was very little time for each teaching intervention and acceptance was tested only in Spanish and mathematics lessons and only with questionnaires; other subjects have not yet been tested, and acceptance of MOMBI has as yet only been investigated by way of questionnaires. A lot more research is necessary to allow significant conclusions about the acceptance of this teaching strategy. In spite of these limitations, this initial exploratory study gives an idea of how MOMBI can be used for the instructional design of school lessons in Spanish and mathematics and reveals tendencies concerning the acceptance of the teaching interventions. Therefore, the results of the study will be discussed here.

The results provide initial tentative evidence that MOMBI is a student-friendly possibility for the instructional design of school lessons. In general, the students accepted the model-based Spanish and mathematics lessons.

The significant differences between the Spanish and mathematics lessons in the two aforementioned variables can be explained in the following way: Given that the results of the model-based Spanish lesson are generally better than those of the mathematics lesson, we can assume that the students have different attitudes toward the two subjects. Otherwise, we can attribute the significant differences to an effect of random sampling. Besides these general explications, we could also explain the differences with the aid of the theoretical assumptions of MOMBI (Hanke & Huber, 2008; Hanke, 2008; Hanke, 2006b). We can therefore say that during the mathematics lesson the students might not have been activated sufficiently by the poster but were able to assimilate the information without constructing a mental model. Therefore, the students might find the *provocation* intervention in the mathematics lesson pointless. This would also explain the significant differences in the variable "acceptance of activation": Students who were able to understand the information directly found the intervention of activation of prior knowledge unnecessary and boring. Considering the many factors that influence the results – attitudes toward the subjects, fitness, luck, and intelligence – the reasons mentioned here are only possibilities for explaining the results. In order to obtain significant results about the preference of model-based lessons in different subjects, more detailed investigations with a bigger sample size are needed.

Following the discussion of the differences between Spanish and mathematics, we want to discuss the results concerning the different teaching interventions of MOMBI under investigation: provocation, activation, presentation, scaffolding, and practice.

The "provocation" teaching intervention apparently motivated the students to think about the subject material in both subjects because the new information provoked mental disequilibrium and consequently a cognitive conflict, which in turn activated a process of accommodation (Seel, 1991, p. 44). In general, this intervention was accepted, that is, the learners did not feel irritated, as might have been assumed.

The students also accepted the *activation* teaching intervention. They did not appear to be irritated by talking about what they already knew. This result might be explained by the fact that prior knowledge is always the basis of mental model construction (Seel, 2003, 1991). Consequently, "activation" helped the students to understand the subsequent subject material. Because the students did not reject this teaching intervention, we assume that they realized its effects and therefore accepted it.

As the students did not have sufficient prior knowledge to construct a mental model about the new topic, they were in need of more information. Consequently, they were semantically sensitive to cues in their environment (Aznai & Yokoyama, 1984). Therefore, they accepted the *presentation* intervention.

The fourth teaching intervention of MOMBI – *scaffolding* – was realized in two steps. In the first step, the teacher provided aids in the form of questions concerning the content of the texts in Spanish and assistance for the problems they had to solve in mathematics. In the second step, the students had the possibility of presenting the results of their group work. Both forms of scaffolding were accepted by the students. This might be explained by the students' perception of being supported in understanding the problem. In the central questions concerning the content of the texts, a certain direction was suggested for the construction of the mental model and the students were urged to think ahead, which may have motivated them. In the mathematics lesson, the same effect was achieved through assistance on the problems. It can be assumed that the possibility to present their initial mental model, which had been constructed during the group phase, helped the students to understand and remember the information in that it motivated them to reconsider their models. Furthermore, new information was introduced in each student presentation, which supported their mental model processing and prevented them from breaking it off before they had constructed a mental model. Students seem to appreciate this realization of "scaffolding." According to the assumptions of the theory of mental models (Seel, 1991), students should have constructed a correct scientific model which allows them to understand the problem by this point in the teaching process.

However, this mental model is neither permanent nor stable (Seel, 1991). On the contrary, students have to reconstruct a similar mental model every time it is needed. As practicing and repeating the same thing again and again can be boring, it is surprising that the students accepted the *practice* intervention. Besides, with regard to the schematization of a mental model, we have to say that it was not sufficient to secure the results to instigate the process of schematization. In order to schematize a mental model, the students would have to reconstruct the model many more times. We can thus not assume that our students have schematized their mental models in this short time (Hanke, 2006a). With that in mind, we can assume that more realizations of the teaching intervention "practice" would not be accepted very readily. The acceptance of the second realization of the intervention in mathematics shows this tendency. This second realization was less accepted than the first one. In forthcoming studies, the acceptance of the teaching intervention "practice" should be investigated in more detail.

To sum up, we must concede that in spite of the possible reasons presented above for the students' positive evaluation of the teaching interventions of MOMBI, we cannot exclude the possibility that alternative explanations are correct. Other factors that might have influenced the results are, for example, various personal variables, such as the students' interest in the topic, their level of intelligence, their preferences for different methods of instruction, or simply their current mood. Therefore, it is necessary to carry out further studies on the acceptance of MOMBI.

## 14.6 Conclusion

In general, the model of model-based instruction (MOMBI) seems to be a student- and teacher-friendly possibility for the instructional design of school lessons and is evidently accepted by students. However, more studies are necessary to verify these results concerning the acceptance of MOMBI. Further research should also investigate the effectiveness of the different teaching interventions suggested by MOMBI, because the main purpose of a teaching strategy is to support effective learning.

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# Chapter 15
# Communities of Learners

## Extending the Boundaries of the Learning Experience Through Cross-Institutional Collaboration

**Pat Gannon-Leary and Elsa Fontainha**

**Abstract** This chapter discusses the main characteristics associated with virtual communities of learning (CoLs), including critical success factors (CSFs) and barriers. It incorporates a brief survey of the relevant literature and illustrates these features with the *C2LEARN* project, the goals of which include the building of CoL within two higher education institutions (one United Kingdom, one Portuguese) and a study of the concomitant benefits, barriers, and CSFs. The chapter also suggests a framework for analyzing and monitoring the CSFs related to the proposed CoL.

## 15.1 Introduction

Information and communication technologies (ICTs) in Europe are still underexploited in the creation of learning environments where students are more dynamically engaged in the construction of knowledge (Balanskat, Blamire, & Kefala, 2006). If students are going to become lifelong learners, they need to learn to operate in a global context, and communications with their peers in an overseas institution can afford them an opportunity to gain understanding not only of disciplinary issues but also of how to adapt to internationalization.

The relative slow penetration of information and communication technologies in higher education (HE) teaching practices is surprising for two reasons. One is that higher education institutions (HEIs) are investing in hardware and software which allows for innovative practices of learning and teaching. The technical infrastructure is usually assumed to be resource saving and to facilitate teaching, but this is a partial truth which ignores the workload of learning new technologies. The second reason is related to students. Students make intensive use of online socialization tools in their

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social life (Cheng &Vassileva, 2006), but the same technologies, with the exception of email, are more or less ignored in traditional classes. The potential of mobile learning, wireless campus, RSS, and video-recorded lessons, among other ICTs, is far from being totally explored.

Virtual communities of learning, networks of individuals who share a domain of interest about which they communicate online and contribute to the development of the knowledge within the domain, are becoming widespread within HEIs, thanks to technological developments which enable increased communication, interactivity among participants, and incorporation of collaborative pedagogical models (Hlapanis & Dimitracopoulou, 2007; Stacey, Smith, & Barty, 2004). They afford the potential for the combination of synchronous and asynchronous communication, access to and from geographically distant communities and international information sharing. The concept of an online community as "people who come together for a particular *purpose*, and who are guided by *policies* (including norms and rules) and supported by *software*" (Preece & Maloney-Krichmar, 2005; *italics* from the original) will be adopted here and is synonymous with virtual communities.

At this point, other clarification of the terminology adopted in this chapter may be useful. The terms community of practice (CoP) and community of learning (CoL) are used interchangeably in this context. However, a distinction could be made depending whether practice or learning is the first concern of the community.

The authors, team leaders of the project *Communities of Learning: Extending the boundaries of the learning experience through collaboration across different universities (C2LEARN project)* intend to create a virtual community of learning (CoL) in two educational settings, two European universities in different countries (United Kingdom and Portugal) and then to develop its use, in order to improve knowledge of participants in the communities of both institutions' educational domains. The project is funded by the Treaty of Windsor Anglo-Portuguese Joint Research Programme, Portuguese Council of Rectors and the British Council.

The nature of the two CoLs is informal and, for that reason, participation in them is voluntary and the content not directly related to the curricula of the HEIs. This characteristic renders this research particularly innovatory, since most of the previous studies focused on CoLs specifically included in the formal curricula, that is, used as a way of delivering and improving knowledge in the formal educational setting.

## 15.2 Barriers and Critical Success Factors

### *15.2.1 The C2LEARN Project Case*

The authors have collaborated in the past on the identification and examination of the benefits, barriers, and critical success factors relating to Communities of Practice (Gannon-Leary & Fontainha, 2008). As a result of this collaboration, they are carrying their research forward into the area of Communities of Learning in the *C2LEARN* project, the main goals of which are as follows:

- to examine the existence of communities of learning (CoLs) within a United Kingdom university and within a Portuguese university,
- to analyze the benefits, barriers, and critical success factors of the existent CoLs and to map them using social network analysis, and
- to create a wider community of learning (*C2LEARN*) that affords an opportunity for students and academic staff from both institutions to interact to improve mutual knowledge of educational issues (e.g., ICTs uses on and off campus, course content, teaching and studying methodologies).

Project activities include the promotion, creation, management, and monitoring of an informal CoL where academic expectations, experiences, and perceptions are exchanged using synchronous or asynchronous methods of communication. It is a voluntary experiment where the students' participation is moderated and supervised by a faculty member who may suggest topics for discussion, do surveys, and make available educational resources for comparative purposes. Knowledge of student and faculty characteristics which impact on participation in CoLs is of particular importance. The starting activity will be a survey about the ICTs in education and the practices and opinions of both teachers and students.

In brief, the expected outcomes of the project are of benefit not only to the two institutions involved but also to the wider higher education and research community. They include:

- mapping and characterizing the existing CoLs and the new *C2LEARN* CoL,
- *C2LEARN* Web site development (including wikis, online surveys, FAQ), and
- a workshop and British *C2LEARN* event at ISEG-Technical University of Lisbon, including a videoconference open to public.

Project activity will be open to the whole community through a Web site in English with the following information: welcome page (with goals of the community, rules of participation, and membership), an archive of collaborations, digital resources made available by both moderators (leaders of the projects), statistics of CoL participation, selection of participation exemplars, expected benefits of the projects, and the *do's* and *don'ts* of studying and teaching using ICTs (and Web 2.0 in particular) from the perspectives of students and staff.

The project will have two main phases, the first of which will include collecting data from students and teachers through interviews, surveys, and documentation, followed by analysis of the CoL's current situation. A pilot virtual CoL will be created, applying and testing concepts and processes related to CoLs on a small scale, in order to promote collaboration between both universities around curriculum development and education. Phase two will involve the creation of a larger, more robust CoL, to extend beyond the lifetime of the project (2 years). All these phases will be carried on in close collaboration and in an interactive way following the suggestions of Wang, Dannenhoffer, Davidson, and Spector (2005), who call attention to the need for that kind of collaboration.

The project is still in its initial stages. Literature reviews have been conducted by both teams on CoLs in general and those specific to their country. Regular information has been exchanged between the Portuguese and English team leaders to familiarize themselves with each others' HEIs. This has been facilitated by the fact that team members have been involved in collaborative work in the past and have also conducted research within their own institutions in areas of e-learning. The following exemplify previous research undertaken by the *C2LEARN* partners:

- In the United Kingdom, the Learning and Teaching Enhancement Section of the Academic Registry has regularly commissioned research in a number of pedagogical areas. e-Learning has featured prominently in this. As early as 2001, research was being conducted into the university's adoption of the Blackboard Learning Environment (2001). Subsequently, reports were commissioned on student use of the e-learning Portal – Northumbria's name for their virtual learning environment (VLE) – on induction pages on the VLE, on interactive lectures using personal response systems, and on the development of a virtual peer mentoring system using the VLE as the medium of communication. e-Learning audits were conducted and research was initiated into looking at the risk management of the VLE. All these projects generated publications and presentations at national and international conferences. Earlier this year, the university participated in the HEA/JISC e-learning benchmarking program. All this work gave the team a holistic picture of the current state of e-learning at the institution.
- In Portugal, a survey of 526 university teachers from the Portuguese university included in the *C2LEARN* project concluded that ICTs are used in teaching mainly to deliver material and that computer-mediated communication (excluding emailing), synchronic or asynchronic, is still a rare practice (Fontainha, 2006). A demonstration version of that survey is available at http://pascal.iseg.utl.pt/~elmano/eui/eui_demo_ENG.html. The analysis of course web pages across time also revealed that there were small changes in teaching and learning methodologies, despite the strong improvement and innovations in the technologies. This occurs in other countries as argued by Eynon (2008), who states that "the majority of staff in UK universities have not adopted the use of ICTs in a significant way for teaching" (Eynon, 2008, p. 21). Also, a work in the United States based on a national survey of instructors of undergraduate economics concluded that ICTs' potential is not completely explored (Watts & Becker, 2008).

In consequence of this work, team members had a preliminary knowledge of each others' institutions prior to embarking on *C2LEARN*, and both had produced and shared research reports and similar documentation discussing aspects of e-learning within their respective establishments. They studied in detail, applying social network analysis, a virtual CoL of HE teachers from 35 countries (mainly from the United States) in existence for 16 years and based on 10,994 messages exchanged (Gannon-Leary & Fontainha, 2009a). They are also studying virtual CoLs in the United Kingdom using information from listservs and Yahoo Groups (Gannon-Leary & Fontainha, 2009b).

### *15.2.2 Barriers to Creating Virtual Communities of Learning*

In their previous research, the teams identified benefits, barriers, and critical success factors (CSFs) in respect of CoPs, represented in Table 15.1. The authors are particularly aware of the possible barriers to CoL creation. Brown and Duguid (2002) suggest situated learning is “knowing how to be in practice” rather than “knowing about practice” (Brown & Duguid, 2002, p. 138) and thus involves a process of identity development for the newcomer through participation in the practice of the community. Becoming a member of a CoL and developing knowledge and skills is, therefore, important in identity formation of the newcomer. This factor has been subject to some criticism, since it may result in the perpetuation of communities and commonality rather than the support of growth, change, and diversity (Eraut, 2003).

In some areas, such as the sciences, cutting-edge knowledge may be difficult to disseminate to large groups since it may require expertise and may be difficult to aggregate or represent (Bos et al., 2007; Olson & Olson, 2000). Also, in many disciplines, academics enjoy a great degree of freedom and exist in a culture of independence rendering open communication more difficult. With colleagues and people known personally to you, there is a sharing of tacit knowledge and transactive knowledge (Ozdemir, 2008). Motivation to join a CoL may be weak where there is a strong community of people who are physically co-located (Smith, Barty, & Stacey, 2005).

Another barrier involves the shifting membership and fluidity of composition of a CoP (Wenger, McDermott, & Snyder, 2002). Withdrawal or dropout is indicated by Johnson (2001) as the greatest problem with virtual communities. In consequence, a high degree of participation is vital to maintain energy and allow the CoP to develop, grow, and have meaning (Ellis, Oldridge, & Vasconcelos, 2004), and leadership of a moderator or facilitator is vital (Stuckey & Smith, 2004).

A further barrier involves trust. The virtual community lacks the opportunity for face-to-face interaction and socializing, which can consolidate group membership. Trust building is vital for sharing (Gibson & Manuel, 2003; Kirkup, 2002), and trust primarily develops through face-to-face interactions. There is also an issue of trust at the institutional level and institution-related problems – legal issues such as data protection and intellectual property (Cummings & Kiesler, 2005). Many academics and students are strategic users of ICTs (Kelly, Gale, Wheeler, & Tucker, 2007; Schwen & Hara, 2003), matching their usage to perceptions of meeting their operational needs, irrespective of the degree of their ICTs skills. A CoP may be short-lived if it is task based, established for a specific learning activity. On the other hand, a practice-based or subject-based CoP may develop more organically and be less transient (Fowler & Mayes, 1999).

**Table 15.1** Virtual CoLs: critical success factors, benefits, and barriers

| Critical success factors (CSFs) | Benefits | Barriers |
|---|---|---|
| *Resources (material)*<br>Good use of Internet standard technologies<br>Material resources or sponsorship to bolster and build up the community<br>Technological provision<br>*Resources (human)*<br>ICTs skills<br>Prior knowledge of membership<br>Sensitivity in monitoring, regulating, and facilitating<br>Netiquette<br>Good communications<br>User-friendly language<br>Regular interaction<br>Good coordination to achieve regular but varied communication<br>*Resources (institutional)*<br>Institutional acceptance of ICTs as communication media<br>*Resources (time)*<br>Time to build up the CoL<br>*Subjective conditions*<br>Trust<br>Common values<br>Shared understandingSense of belonging and of purpose<br>Cultural awareness | • Knowledge sharing and learning<br>• Deepening of knowledge, innovation, and expertise<br>• Enhanced learning environment<br>• Synergies<br>• Capabilities extended to higher level<br>• Gaining insights from each other<br>• Cyclical, fluid knowledge development<br>• Feeling of connection<br>• Ongoing interactions<br>• Assimilation into sociocultural practices<br>• Neo-apprenticeship style of learning<br>• Identity development and formation | • Perpetuation vs. change and diversity<br>• Disciplinary differences<br>• Culture of independence<br>• Tacit knowledge<br>• Transactive knowledge<br>• Specialist language<br>• Collegiality, strong physical community<br>• Shifting membership<br>• Creating and maintaining information flow<br>• No F2F to break the ice<br>• Read-only participants (formerly lurkers)<br>• Hidden identities, adopted personas<br>• Lack of trust – personal and institutional<br>• Selectivity in ICTs use<br>• No body language, misinterpretations<br>• Task-based usage |

Source: adapted from Gannon-Leary Fontainha (2008)

A final issue involves the use of technology to bridge the geographical gap which can lead to misinterpretation of messages, as a lot of nonverbal cues can be missing from the communication (Cramton, 2001; Gannon-Leary, 1999). Again, good practice is necessary to militate against this.

### *15.2.3 Critical Success Factors (CSFs) for the Creation of Virtual Communities of Learning (CoLs)*

CSFs comprise an area of vital significance where effort needs to be concentrated if a system is to be effective (Wilson & Huotari, 2001). The authors' documentary analyses for their earlier projects determined a set of CSFs on which they decided to focus on developing their delivery of a CoL to staff and students in their institutions (Table 15.1).

This set of CSFs could be analyzed independently and discussed in terms of how they might be evaluated in order to ensure the CoL fulfills requirements and they may, therefore, be used as the basis for a toolkit to provide a framework for diagnostics and monitoring. The authors are driven in this discussion by the desire to optimize conditions to ensure the effective use of the CoL. Therefore, they are attempting to identify development stages for the embedding of a CoL in an HEI.

Why a toolkit? Toolkits are decision-making frameworks based on expert models (Oliver & Conole, 2000). They are designed for self-diagnosis by individuals/institutions in relation to their own practices and their own institutions. They facilitate the identification of strengths and weaknesses in order to move toward solutions and success.

Prior experience of benchmarking and developing benchmarking tools included the following: development of a toolkit for the JISC Jubilee project; involvement in the readiness assessment tool (RAT) produced for the ODPM FAME project, which was influenced by the EFQM Excellence Model (EFQM, 2003); use of the Pick & Mix methodology in the Higher Education Academy's benchmarking e-learning project; development of a toolkit for the JISC Jubilee project; and work in the field of performance measurement and metrics. The following summarises previous research involving toolkits:

- The JUBILEE toolkit (Banwell et al., 2004; Coulson & Banwell, 2004) is based on characterization of user-based success criteria in relation to electronic information services. Themes were derived from fieldwork data (an exercise in which one of the authors of this chapter was involved). Five development stages were identified and benchmarks produced. Case study sites used in fieldwork were revisited and constructive comments gathered to inform future toolkit development.
- The EFQM Excellence Model dates from 1992, when it was introduced as the framework for assessing organizations for the European Quality Award. One of its potential uses is as a tool for self-assessment and the RAT produced by the FAME team (of which one of the authors was a member) was influenced by this model. The Readiness Assessment Tool (RAT) was designed to help agencies assess where they were in terms of establishing and sustaining a successful multiagency environment (FAME, 2007). This, like the JUBILEE toolkit, was developed not only on the basis of case study work but also on a review of the literature.
- Pick & Mix, the benchmarking tool for e-learning, the brainchild of Professor Paul Bacsich in 2005, was also developed after an extensive literature search. It operates within the "critical success factors" tradition of benchmarking (Higher Education Academy, 2008).

  One of the authors had also been list owner and moderator of a JISC community of practice (Lis-performance-measures), which discussed issues around benchmarking and evaluating information services – including electronic services. All these experiences contributed to the understanding of benchmarking and toolkit development.

A combination of prior experience in the development and use of other toolkits, along with documentary analyses, is proposed here in developing a set of speculative criteria. It is anticipated that these criteria will be further developed, tested, and refined during the CoL project.

The CSFs in Table 15.1 are examined in turn and, after a brief discussion, suggestions are made of specimen stages of development that might be expected. These stages benchmarking the CSFs are ranked from 1 to 5, with 1 representing a basic stage and 5 representing an advanced stage (Table 15.2). Table 15.3 illustrates the use of that framework.

The issues considered are associated with a learning environment that contributes to learning process effectiveness. The following framework analysis is for application to specific CoLs with informal characteristics and, therefore, differs from other formal learning education frameworks, such as those proposed by Marshall and Mitchell (2004).

#### 15.2.3.1 Infrastructure and Contextual Resources

Use and Provision of ICTs

This involves knowledge of the wider technological and pedagogical context and the extent to which those engaged in the CoL are able to contribute to developments therein. Within the institution it involves accessibility not only of the system but of the content within and is linked to the CoL and associated tools. Usability in terms of human-computer interaction is another consideration which involves deciding on the boundaries of the CoL and using models (Nielsen & Landauer, 1993). Preece (2001) proposes a usability framework for CoL and identifies four uses: dialog and social support, information design, navigation, and access.

With respect to technological provision, differentiation needs to be made between formal, centrally provided technical support and the kind of ad hoc support that users often need.

Institutional Acceptance of ICTs as Communication Media

There will, inevitably, inside an institution be early adopters of ICTs as communication media but, more significant, is what might be described as the second wave of adopters when the focus is less on the quantity of use and more on the quality of use. The Technological Acceptance Models (TAM) phases were adapted from Teo, Chan, Wei, & Zhang (2003) to the CoL framework. The infrastructure and contextual aspects are included in lines 1 to 6 in Table 15.2.

#### 15.2.3.2 Human Resources

ICTs Skills Status and Learning

This involves ICTs skills of staff and students who are going to participate in the CoL. In terms of staff, consideration needs to be given to their training and

**Table 15.2** Framework for diagnosis and monitoring of a CoL*

Infrastructure and contextual resources

| | | 1▷ | 2▷ | 3▷ | 4▷ | 5⊙ |
|---|---|---|---|---|---|---|
| [1] | Technology use and provision | Inadequate user/PC ratio<br>Limited scope for remote access to CoL | User/PC ratio improving<br>User access needs considered in detail | IT infrastructure adequate to meet needs of most users<br>Strategies being developed to improve access on/off campus | Access to CoL facilitated via multiple avenues (usage on and off campus)<br>Campus wireless; Extended opening hours for IT facilities | Highly developed provision and access policies meeting CoL needs of users on/off campus and 24/7 services (libraries, labs, etc.) |
| [2] | Awareness of ICTs (and W.2 in particular) potential for education | No awareness of potential | Some awareness of the wider technological/pedagogical context | . . . by a small group of participants | Participants are actively encouraged to develop awareness of the wider technological/pedagogical context | Participants are actively encouraged to disseminate and communicate information (e.g., wider technological/pedagogical context) |
| [3] | Knowledge of the wider technological/pedagogical context is . . . | . . . derived in an ad hoc fashion | . . . sought in a reactive fashion, when deemed necessary | . . . sought proactively | . . . widely disseminated throughout | . . . coupled with indicators of possible future and desired direction |
| [4] | Institutional contribution to wider technological/pedagogical knowledge | No contribution | No direct contribution but it engagement with it | Some staff contribute (.e.g., via projects) | Most staff are afforded the opportunity to contribute | Institution is "breakthrough," operating at the cutting edge |

**Table 15.2** (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| [5] | Acceptance of ICTs | Perceived usefulness and perceived ease of use | Weak usage | Medium usage | Generalized usage | Generalized, differentiated and intense usage |
| [6] | Awareness across the institution of CoL potential | Little awareness of CoL potential<br>No strategy for embedding CoL in teaching and learning processes | Awareness of CoL developments<br>Some localized use of CoL on particular modules/courses/programs by early adopters | Strategies being developed to embed CoL by first wave of adopters | Wide awareness of CoL and embedding in courses and curricula by second wave of adopters | University-wide awareness of CoL potential and embedding in courses and curricula |
| ICTs skills status and acquisition | | | | | | |
| | | 1▷ | 2▷ | 3▷ | 4▷ | 5⊙ |
| [7] | ICTs skill status student staff | No ICTs skills (computer operations, application software, or Internet/WWW) | Some basic ICTs skills<br>Use dependently | Knowledge of several ICTs skills but inefficient use<br>Internet use without filtering and selecting properly | Knowledge of several ICTs and effective and efficient use<br>Underdeveloped search strategies | Knowledge of main ICTs and effectively and efficiently well-developed search strategies<br>Ethical and legal Internet usage |
| [8] | Student ICTs skills training | Fragmented<br>No formal statement of responsibility<br>Little user needs assessment | Available with increased joined-up thinking about it | Provided and monitored in terms of its effectiveness | In place and monitored restructured framework for needs assessment | Institution-wide ICTs literacy training, embedding strategies, curriculum involvement and continuous assessment |

**Table 15.2** (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| [9] | Staff ICTs skills training | Fragmented<br>No formal statement of responsibility<br>Little user needs assessment | Available with increased joined-up thinking about it | Provided and monitored in terms of its effectiveness | Systematic<br>Training needs are identified and followed up | Systematic<br>Training is tailored for different groups; orientated to ICTs-related and pedagogic-related topics |
| Communication | | | | | | |
| | | 1▷ | 2▷ | 3▷ | 4▷ | 5⊙ |
| [10] | Communication among participants of CoL | Nonexistent or scarce | Contact is established but at a weak and introductory level | Exchange of information about learning experiences and educational and cultural context partially shared | Developed exchange of knowledge and information among participants | Knowledge sharing (general and mutual) is improved |
| [11] | Communication from the modera-tor/facilitator . . . | . . . is obtained in a piecemeal fashion | . . . needs to be proactively sought rather than automatic | . . . is automatic | . . . is automatic but may need to be sought proactively from the CoL participants | . . . is automatic from the CoL participants and from inside out |
| [12] | Communication frequency is . . . | . . . rare or absent | . . . spasmodic and patchy, not always reaching all intended recipients | . . . occasional but lacking in clarity | . . . regular but not always timely and sometimes lacking in clarity | . . . frequent, clear, timely, substantive and open |

**Table 15.2** (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| [13] | CoL resources' regularity of use | Potential participants rely on print sources with little use or awareness of CoL | Although printed sources are used, there is greater use and awareness of CoL by some potential participants | CoL resources are being used by participants | CoL resources are being used, and critical and evaluative skills are being applied to such use | CoL use is integral to the student experience |
| Time and workload | | | | | | |
| | | 1▷ | 2▷ | 3▷ | 4▷ | 5⊙ |
| [14] | Time and workload | Limited, uncoordinated time afforded students (and staff) for CoL use | Time constraints recognized and being assessed | Reciprocity – time afforded to students by moderator | Participating students recognized by moderator | Staff supporting the project recognize students using CoL through different ways |
| Trust | | | | | | |
| | | 1▷ | 2▷ | 3▷ | 4▷ | 5⊙ |
| [15] | Level of trust among participants is . . . | . . . hidden (blame culture) | . . . viewed as resultant from failure to follow social contract or netiquette | . . . viewed as resultant from insufficient training (or lack of time to learn by doing) | . . . viewed as learning opportunities, including learning about other cultures | . . . accepted as inevitable when involving different cultures and challenging more conventional ways |

**Table 15.2** (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| [16] | Trust | No trust<br>No knowledge or information | Weak knowledge about CoL and little involvement with other members | Medium knowledge about the CoL and some involvement | Good knowledge about the CoL and involvement | High knowledge about CoL<br>Try hard to meet others' needs |
| Sense of belonging, feedback and moderation | | | | | | |
| | | 1▷ | 2▷ | 3▷ | 4▷ | 5⊙ |
| [17] | Participants' sense of belonging | CoL *(C2LEARN)* is ignored, but there are other CoLs | Some sense of belonging to the CoL<br>Participation induced by moderator | Sense of togetherness or closeness in the CoL | Strong positive feeling toward the CoL | Proud to be members of the CoL |
| [18] | Participant feedback is gathered | Reactively and not encouraged | Through limited methods | via a range of methods | via a range of methods to access views of participants and non-participants (e.g., surveys, ICTs education) | Proactively using a range of methods targeted at participants and non-participants |

*Where preceded by . . . the text should be read across the row and links to the bold text in the first column.

**Table 15.3** Illustration of CoL diagnostics

| | CoL in university U01 | | | | | CoL in university U02 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Infrastructure and contextual resources* | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Technology Use and Provision | Completed | Completed | Completed | Completed | | Completed | Completed | Completed | Completed | |
| Awareness of ICTs (e.g., Web 2.0) | Completed | Completed | Completed | On-going | | Completed | Completed | On-going | | |
| Knowledge of wider technological/ pedagogical knowledge | Completed | Completed | | | | Completed | Completed | | | |
| Institutional contribution | Completed | On-going | | | | Completed | | | | |
| Acceptance of ICTs | Completed | Completed | Completed | Completed | Completed | Completed | Completed | Completed | Completed | On-going |
| Awareness of CoL potential | On-going | | | | | On-going | | | | |
| *ICTs skills status and acquisition* | | | | | | | | | | |
| ICTs skill status (student and staff) | Completed | Completed | Completed | Completed | | Completed | Completed | Completed | Completed | Completed |
| ICTs skills training (students) | Completed | Completed | | | | Completed | Completed | Completed | Completed | |
| ICTs skills training (staff) | Completed | Completed | Completed | | | Completed | Completed | Completed | Completed | |
| *Communication* | | | | | | | | | | |
| Communication among participants of CoL | On-going | | | | | Completed | On-going | | | |
| Communication from the moderator | Completed | | | | | Completed | Completed | | | |
| Communication frequency | On-going | | | | | On-going | | | | |
| CoL resources | Completed | | | | | Completed | On-going | | | |
| Awareness across the institution of CoL as a community | Completed | | | | | Completed | | | | |
| *Time and workload* | | | | | | | | | | |
| Time and workload | Completed | | | | | Completed | Completed | | | |
| *Trust, sense of belonging , feedback and interrelations* | | | | | | | | | | |
| Trust | On-going | | | | | On-going | | | | |
| Participants' sense of belonging | On-going | | | | | On-going | | | | |
| Participants' and non-participants' feedback | On-going | | | | | On-going | | | | |
| Interrelations (moderator participants) | On-going | | | | | On-going | | | | |

Legend:
Completed | On-going

development. While stages can be identified, it would be useful to substantiate these with documentary evidence such as institutional training records. In terms of students, consideration needs to be given to their ICTs skills and wider information literacy training. The ICTs-literate tertiary student must have skills in different domains: computer operations, applications of software, and Internet/WWW skills.

## Communication

Computer-mediated communication (CMC) is complex, with conflicting aspects. Communications can be spasmodic rather than regular and, since not every message posted in a virtual CoL is pertinent to every recipient, it has elements of "spam" about it. There is also the element of "big brother," in the shape of the institutional representative, be they moderator or facilitator, overseeing all posts. How far this representative is seen as omniscient and omnipresent can impact on the communication taking place. Where this is the case, communication can be inhibited by a desire to post only that which is perfect rather than any half-formed thoughts and ideas. If the representative interacts with members of the community, receives comments and criticisms constructively and in good part, then communication can be fostered.

Although students use online media not only for academic work but also for social networking, participation in a CoL of the proposed nature of *C2LEARN* has some potential barriers resultant from the fact that this is not a spontaneous endogenous process but rather an externally induced process. Insufficient participation in particular in the initial phases is a problem identified as well as discussed the better form to motivate participation. There are different modes that enhance member participation in CoL. Good management of the CoL and the information systems' quality contribute to that participation. The incentives could be material or not (Cheng & Vassileva, 2006).

#### Interaction Frequency: Coordination to Achieve Regular and Varied Communication

Moderators or facilitators of the CoP have a vital role in preventing online dropout rates (Prendergast, 2001). This is dependent on workload and time management, which enable the moderator to respond quickly, comment in a helpful fashion, chase up anyone who is lagging behind, and generally be supportive to learners (O'Dell, 1999). Facilitators need to encourage members/learners to share their knowledge and experiences with their peers and to facilitate interaction. Stages for this CSF could be derived from the work of Feenberg (1989), which summarizes the role of the moderator into three parts: contextualizing functions (e.g., opening discussion), monitoring functions (e.g., soliciting comments), and performing meta-functions (e.g., summarizing the state of the discussion). Human resources are included in the analysis framework, lines 7 to 13 (Table 15.2).

### 15.2.3.3 Time, Resources, and Workload

Development and continuation of a CoP has implications for student and staff workloads. It is important that moderators manage the expectations of their audience by setting out clear guidelines as to the detail and frequency of response that can be anticipated (Ko & Rosen, 2001). It can be argued that the team members have a responsibility for communicating these to the CoL participants and in effect managing their expectations on behalf of the project. Line 14 in Table 15.2 represents time and workload in the different phases.

#### 15.2.3.4 CoL Participants' Behavior

These subjective characteristics are "softer" measures or what might be called more "touchy-feely" concepts. As such, they are more difficult to measure, although some attempt has been made to do so in the framework analysis.

##### Trust

The issue of trust in virtual teams has been discussed in the literature (Becerra & Gupta, 2003; Duarte & Snyder, 2006; Jarvenpaa & Leidner, 1998; Walther & Bunz, 2005) and several factors for facilitating the development of trust have been identified. Frequency of communication is resultant in an increase in perceptions of trustworthiness and therefore this characteristic relates to communication frequency previously referred to. Continuing to include read-only participants enhances trust, as do timely and substantive responses to the contributions of others. Interestingly, setting even one rule, as opposed to having no rules at all, appears to reduce uncertainty in putative participants and thereby increases trust and increases the authenticity of the discussions. As Rheingold (1998) points out, as the community develops, this original rule will be superseded by norms set by the community itself.

The higher trust level among participants means that mistakes (e.g., typos, mis-translations, and cultural dissonance) are accepted as inevitable when involving different cultures and challenging more conventional ways of doing things. The levels of trust presented in Table 15.2 were adapted from Lin (2007) and Ridings, Gefen, and Arinze (2002), who include two dimensions of trust: ability and benevolence/integrity.

##### Common Values, Sense of Purpose, and Shared Understanding

While a CoL should support people coming together collaboratively, if those people fail to understand each other's activities, knowledge, and beliefs, the CoL will not develop. Uncertainties need to be clarified so that shared understanding of the CoL and its purpose can be built upon and supported, and a shared vision of the potential for the CoL membership can be developed. This shared understanding needs to include a clear understanding of the CoL's "social contract" (Rheingold, 1998). That informal, unwritten contact is supported by a blend of strong and weak relationships among people who have a mixture of motives and ephemeral affiliations (Rheingold, 2000, p. 47).

##### Sense of Belonging

In joining a CoP, a newcomer may feel that she is entering unfamiliar territory. It may take time to make the transition and to adjust to the new learning environment, just as it would if entering a new university or college class. Newcomers will arrive with expectations of the host/moderator/facilitator and of other members of the community, as well as with expectations of what they personally will get from their membership. How a sense of belonging can be instilled in them is a difficult question.

Measuring participation in online debates or discussions might signify engagement, but the degree of this engagement may not equate to a sense of belonging: A read-only participant may also be developing a sense of belonging despite their apparent nonparticipation. Tinto (1993) has cited Van Gennep's (1960) concept of incorporation in discussing social integration into an academic community. This highlights the ability of individuals to take on new patterns of interaction with members of the group they are joining and, by becoming a participant in that group, to establish competent membership. Sense of belonging levels shown in Table 15.2 were adapted from Teo et al. (2003).

#### Sensitivity, Cultural Awareness, and Netiquette

The regulatory role of the moderator/facilitator can be split into three areas: monitoring nonparticipation, controlling information flow, and ensuring equal opportunity to participate. This is a key role for team members in the case of *C2LEARN* and a topic of particular interest in the literature (Palloff & Pratt, 2001; Salmon, 2000). First, monitoring and acting upon nonparticipation is a regulatory role that should be done with sensitivity (Pincas, 2001). Second, flow of information needs to be regulated to ensure that information overload does not occur (Prendergast, 2001). Third, moderators may need to ensure that certain individuals do not dominate the group and that all participants are given the opportunity to participate (Macdonald, 2006; Millard, 2001).

Lines 14–18 in Table 15.2 represent aspects related to CoL participants' (actual or potential) behavior.

## 15.3 Conclusions

As a result of previous collaborative work, the teams have identified and examined the benefits, barriers, and critical success factors relating to Communities of Practice (Gannon-Leary & Fontainha, 2008). Now they are revisiting these in the context of CoLs.

This chapter has discussed the main features associated with CoLs, including CFSs and barriers, incorporating a brief survey of the relevant literature and illustrating these features with the *C2LEARN* project, the goals of which include the following: examining the existence of CoLs within two HEIs (one United Kingdom, one Portuguese); studying the concomitant benefits, barriers, and CSFs; mapping network connections within the CoL; and progressing beyond this to establishing a wider community of learning, enabling staff and students from the two HEIs to interact with each other about educational and ICTs issues and in particular Web 2.0 tools.

The chapter also speculates on the usefulness of a framework or toolkit and proposes one for carrying out diagnostics and monitoring the barriers and CSFs related to the proposed CoL. The projected stages of development, which might be expected in relation to a CoL, are mooted and will be subject to refinement as the collaborative project progresses. It is intended that a selection of existing CoLs is targeted and critiqued using the framework in its present format to test it retrospectively. By presenting a contribution to the identification of CSFs to the creation of a CoL in two different European learning contexts, the proposed framework could be adapted to other contexts.

While developing our students, the authors hope to develop themselves, their teams, and their institutions. Collaboration of this type should mean that research capacity is more achievable. Rather like the establishment of a CoP team, members are establishing connections within a wider knowledge and expertise base.

The different cultural backgrounds and experiences of the two contexts might initially create difficulties on the start-up and development of the two communities, but the final outcome should serve to enrich knowledge because of these very difficulties.

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# Chapter 16
# Supporting the Implementation of Case Activities Using e-Learning Technologies

**Maria Boubouka, Ilias Verginis, and Maria Grigoriadou**

**Abstract** The use of cases in education in the framework of activities is very effective, as students' engagement in the solution of authentic, and thus interesting, problems provides them motivation for learning. In recent years, the ongoing use of e-learning technologies in education has transformed the way teaching is being conducted. Although many of the studies found in bibliography compare the effectiveness of in class versus online teaching, these studies do not focus on the comparison of specific teaching methods and approaches. This work presents an empirical study aiming to compare the implementation of the case activities in class and online using a course management system in the framework of the subject matter of Didactics of Informatics. The results of this study will help identify the most effective way of conducting case study activities exploiting the advantages of in-class learning enhanced by the possibilities offered by e-learning technologies.

## 16.1 Introduction

In the recent years, the research in the field of learning points out the need for teaching methods that provide learners the opportunity to address real-world problems, as the activities of this kind are more engaging and challenging for them and, therefore, more effective (Vosniadou, 2001; Kolodner, Hmelo, & Narayanan, 1996). Case-based learning is a constructivist teaching and learning approach, which involves students in the examination of authentic problems (cases), instead of the simplified problems that are usually being used in traditional teaching. Cases in education can be found in two different types of activities: (i) as problem-solving activities, where problematic situations are presented to the students who are asked to deal with them and produce solutions (Pyatt, 2006); (ii) as examples, where students

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are asked to study problems already solved by experts and use them as examples in order to confront similar problems themselves (Jonassen & Hernandez-Serrano, 2002; Lane, 2007).

Cases as problem-solving activities first appeared in the University of Harvard near the end of the nineteenth century, beginnings of the twentieth, in the faculties of Law and Business (Copeland, 1954; Barnes, Christensen, & Hansen, 1994). In the second half of the twentieth century, the method became popular worldwide and was introduced to other disciplines such as Medicine, Science (Herreid, 2006), Engineering (Davis & Wilcock, n.d.), and Biology (Waterman & Stanley, 2005). In Law and Business education, the analysis of a specific case was usually followed by discussion conducted in the classroom (Smith, 1987), but in other disciplines was also found in combination with lecture or group work (Herreid, 2006). Despite these differences, cases were used as problem-solving activities helping students to develop both analytical and decision-making skills by dealing with complex real-world situations.

The activities in which cases where used as examples appeared in education during the last decades of the twentieth century, in parallel with the development of Case-Based Reasoning (CBR). Studies in CBR examine how a model can be developed for creating intelligent systems and explaining human cognition (Kolodner & Guzdial, 1999; Aamodt & Plaza, 1994). CBR suggests that solutions to new problems are generated by retrieving relevant experiences from memory and adapting them to fit new situations (Aamodt & Plaza, 1994). Therefore, in this type of activity, students are no longer asked to produce themselves a solution to the given problem but to study thoroughly solutions already given by experts. The study is usually guided by a series of questions that aim to help the students focus on the main points of the problematic situation and reach inferences useful for the resolution of similar problems in the future.

To synopsize, independently of the way cases are used in the framework of educational activities, they can bridge theory and practice, actualize active learning, and foster problem-solving skills (Davis & Wilcock). These characteristics make cases ideal for professional education, as they can efficiently prepare the learners to deal with complex ill-structured problems as those encountered in the workplaces (Hernandez-Serrano & Jonassen, 2003).

In the same time, a new challenge appeared during the last decades due to the development of e-learning technologies which lead to a radical transformation of the way teaching is being conducted, mainly in higher education. In this framework, a great number of educational systems have been developed. Some of these systems were designed using the case-based learning approach (Kolodner & Guzdial, 1999). These systems contain cases, consisting of descriptions of problems together with their solutions proposed by experts, which are organized in libraries. When the learners are asked to address a new problem, they can find and study the solutions of similar cases contained in the library. Typical examples of this kind of systems are ARCHIE-2, Susie (Narayanan & Kolodner, 1995), and Kite (Wang, Moore, Wedman, & Shyu, 2003). These systems focus on the individual rather than the collaborative aspect of studying a case, as they do not propose activities including in class or group discussion. Moreover, the research work concerning the evaluation of the case-based learning systems does not focus on investigating differences in the effectiveness of learning when the system is being used in comparison with a similar in class activity based on cases (Narayanan & Kolodner, 1995; Turns, Newstetter, Allen, & Mistree, 1997; Wang et al., 2003). On the other hand, researches that worked on comparing the effectiveness of in-class versus online teaching (Kleinman, 2001; Cooper, 2001; Ury, 2005; Ury, McDonald, McDonald, & Dorn, 2006) are interested in the effectiveness of an entire course in relation with the way it is being conducted (either in class or online) and do not focus on the comparison of a specific teaching approach such as the case-based learning.

Therefore, it was decided to design an empirical study where the students would have to address the same case study activity either in class or online. The topic chosen was Didactics of Informatics. The relevant course is offered in the last year of undergraduate studies of the faculty of Informatics and it aims to prepare the students who might choose to become Informatics teachers for the work world. The general purpose of the course is to enable the students to design student-centered lessons using constructivist educational approaches and tools. Designing a lesson is an ill-structured problem, as there is not a unique correct solution and many parameters have to be taken into account in order to design a lesson successfully. The majority of the students enrolled in the course are interested in becoming secondary education Informatics teachers in the future. In this context, it is very helpful for them to have an insight into the way teaching methods are actually being used in real classrooms, in order (i) to understand the limitations that may arise from their implementation in real-world setting and (ii) to develop criticism.

The case study activity used concerned the Role-Playing teaching method. The activity was conducted both in class and online using the course management system e-class (see http://eclass.di.uoa.gr/). The particular goals of this empirical study were to examine:

a. How e-learning technologies can be used to implement a case study activity from distance accordingly to the way it is being implemented in class?
b. Whether there are differences in the effectiveness of a case activity when it is realized in class or when using e-learning technologies?

In addition to these main goals, the empirical study also aimed to investigate whether case activities are appropriate to teach a subject matter like Didactics of Informatics, independently from the way it is implemented.

The rest of the chapter is organized as follows: In the next section the empirical study is being described, then the results of the study are presented and discussed, and the final sections contain conclusions and future plans.

## 16.2 The Empirical Study

### *16.2.1 Participants*

The empirical study was carried out during the winter semester 2007–2008 in the context of the course Didactics of Informatics offered in the fourth and last year of undergraduate studies at the Department of Informatics and Telecommunications of the National and Kapodistrian University of Athens. From a total of 67 four-year students who had enrolled in the course, 28 participated in the case study activity conducted in class forming Group 1, while the other 39 conducted the case study from distance through the online course management system e-class (see http://eclass.di.uoa.gr/), forming the Group 2. The students were divided in the groups randomly.

### *16.2.2 The Case Study*

The case study concerned an authentic implementation of Role Playing used to teach the bubblesort algorithm in the context of a programming course in the secondary education. In this Role Playing, six high school students played the roles of equal in number elements of an array that would be sorted using the bubblesort algorithm. The course's teacher played the key role of the algorithm that gave the students instructions guiding them to perform the sorting. The development of the case was based on an article that described the implementation of the bubblesort Role Playing in class and on an interview of the course's teacher and author of the article (Kanidis, 2005). In the context of this interview, criticism about the design of the Role Playing was developed, which can be summarized in the following two points: (i) whether the assignment of the key role of the algorithm to the teacher is satisfactory or not and (ii) whether the representation of the bubblesort algorithm is adequate or not. Trying to improve the Role Playing in relation with these points, a revised version was created (i) by assigning the key role of the algorithm to a student and (ii) by adding to the representation more elements, such as the auxiliary variable used for swapping the values of the array elements, the array slots, and the indexes $i$ and $j$. The revised Role Playing was also implemented in the secondary education (Boubouka, Kanidis, & Grigoriadou, 2008).

### *16.2.3 Materials*

In order to conduct the case study activity, relevant educational material was developed, which was either presented to the students in class (for the students of Group 1) or uploaded to the course management system for the students of Group 2 who worked from distance (see Table 16.1).

**Table 16.1** Educational material of the case study activity

| Educational material | |
|---|---|
| In class | Online |
| – Presentation of the Role-Playing method<br>– Presentation of the case study<br>– Instructions for the enactment<br>– Presentation of the revised case study | – Presentation of the Role-Playing method<br>– Presentation of the case study<br>– Video of the enactment<br>– Presentation of the revised case study |

The scope of this material was to present

1. The Role-Playing teaching method
   In order to present the Role-Playing teaching method, an introductive presentation of the method was prepared that explained the steps for designing Role-Playing activities and contained brief outlines of a series of activities used for teaching various Informatics topics, deriving from bibliography (Jones, 1987; Dorf, 1992; Addison, 1997; McNichols & Fadali, 1999; Andrianoff & Levine, 2002).
2. The case study
   In order to support the case study, a presentation was developed that contained a detailed description of the implementation of the initial bubblesort Role Playing in the secondary education. This description was also followed by two questions based on the two points of criticism (see Section 16.2.2). This presentation was also available to the students of both groups. Additionally, for the students of Group 1 who were asked to enact the Role Playing in class themselves, a set of worksheets with instructions for the roles involved was created. This enactment was videotaped and provided to the students of Group 2 through the course management system e-class. Finally, a presentation of the implementation of the revised bubblesort Role Playing was created, which was given to the students as an indicative answer to the questions.

### *16.2.4 Procedure*

In order to investigate whether the case study activity could be implemented using e-learning technologies maintaining the correspondence with the in-class implementation, the activity was divided into four concrete and independent phases summarized in Table 16.2.

During Phase A, the students were asked to design a Role-Playing activity. More specifically, the students had to choose an Informatics topic of their choice and design a Role-Playing activity aiming to teach this topic in the secondary education. Then Phase B began with the presentation of the case study. Following that the students had to answer the case study questions individually. Next, in Phase C they

**Table 16.2** Phases and assigned tasks of the case study activity

| Phase | Description | Assigned tasks: In class students ... | Assigned tasks: Online students ... |
|---|---|---|---|
| A | Students design a Role-Playing activity | – Follow a presentation about the Role-Playing method performed by the class teacher<br>– Choose a topic of informatics and describe a Role-Playing activity | – Study individually a presentation of the Role-Playing method<br>– Choose a topic of informatics and describe a Role-Playing activity |
| B | Students study the case and answer questions individually | – Follow a presentation of the case study (bubblesort Role Playing) performed by the class teacher<br>– Enact the bubblesort Role Playing following instructions<br>– Answer individually two questions concerning the bubblesort Role Playing | – Study individually a presentation of the case study (bubblesort Role Playing)<br>– View a video of the enactment conducted by the in-class students<br>– Answer individually two questions concerning the bubblesort Role Playing |
| C | Students discuss about the given case | – Participate in a whole-class discussion about the bubblesort Role Playing | – Participate in a whole-class discussion about the bubblesort Role Playing conducted through the discussion forum facility of the course management system |
| D | Students revise their initial Role-Playing activity | – Follow a presentation of the revised case study (bubblesort Role Playing) performed by the class teacher<br>– Revise their Role-Playing Activity or describe a new one from scratch | – Study individually a presentation of the revised case study (bubblesort Role Playing)<br>– Revise their Role-Playing Activity or describe a new one from scratch |

had to discuss the same questions with the students of their group, and, finally, in Phase D they were asked to revise their initial Role-Playing activities designed during Phase A. In other words, the actual case study was conducted during Phases B and C, while the Phases A and D aimed to investigate the students' ability to design Role-Playing activities before and after the case study, respectively.

More specifically, during Phase A the presentation of the Role-Playing teaching method was provided to the students of both groups. For the students of Group 1, the presentation was carried out in class by the course's teacher, while for the students of Group 2 the presentation was uploaded to e-class and they were asked to study it on their own. After the presentation, the students of both groups were asked to choose a topic of Informatics from the curriculum of the secondary education and describe briefly a Role-Playing activity they could use to teach it. The students of Group 1 designed the Role-Playing activity in the classroom using paper and pencil, while the students of Group 2 uploaded files containing their activities to e-class.

During Phase B, the bubblesort Role Playing was presented to the students of both groups (see Fig. 16.1). The students of Group 1 attended the presentation, conducted by the course's teacher in class, and enacted the Role Playing themselves. This enactment was videotaped and uploaded to e-class. The students of Group 2 studied the description of the bubblesort Role Playing on their own, as well as the uploaded video of the enactment. After studying the provided educational material, the students of both groups were asked to answer individually the two questions accompanying the case. Again, the students of Group 1 submitted their answers using paper and pencil, while the students of Group 2 uploaded their answers to e-class.


**Fig. 16.1** A snapshot of the initial bubblesort Role Playing

In Phase C, the students of Group 1 participated in a discussion held in class, while the students of Group 2 discussed online, using the asynchronous discussion forum of e-class. The axes for both discussions were the two questions concerning the case that all students had already answered individually in Phase B. The in-class discussion for Group 1 was coordinated by the course's teacher. The online discussion was initialized from the course's teacher, who posted the two questions creating equal in number threads. The teacher did not participate further to the discussion.

In the last Phase (Phase D), both groups attended the presentation of the revised version of the bubblesort Role Playing (see Fig. 16.2). Finally, the students of both


**Fig. 16.2** A snapshot of the revised bubblesort Role Playing

groups were asked to revise the Role-Playing activities that they had designed during Phase A. It was clarified that they could design a Role-Playing activity from scratch instead of revising their initial activities.

The case study activity that took place in-class lasted 3 h, while the activity conducted online lasted 12 days in order to assert that for each phase at least 2 working days were provided, as some students might not be able to access the web platform from their homes. In order to coordinate the online activity, the announcement mechanism of e-class was used aiming to inform the students of Group 2 for the time schedule and the specific requirements of each phase.

### *16.2.5 Data Collection and Analysis*

To investigate differences in the effectiveness of the case implementation in-class and online, (i) activities designed by the students of both groups before (Phase A) and after (Phase D) the case study (Phases B and C) were evaluated; (ii) student's answers given to the questions of the case (Phase B) were analyzed, trying to identify and summarize the different opinions; and (iii) discussions conducted in Phase C in-class and online were investigated.

The evaluation of the Role-Playing activities designed by the students in Phases A and D was performed by two independent evaluators with teaching experience in the secondary education, using a 5-point scale (0–4). Disagreements between evaluators were resolved through discussion. Table 16.3 shows the four criteria that

**Table 16.3** Activities' evaluation criteria

| Criterion | Description |
|---|---|
| 1 | Is the Role-Playing method suitable for teaching the selected topic? |
| 2 | Is the activity's description thorough and explicit? |
| 3 | Are the selected roles appropriate for the representation? |
| 4 | Are the supporting objects used in the representation adequate? |

established the basis for the evaluation. The results of the evaluation were also used to investigate whether the case method is appropriate for the teaching of the Role-Playing method in the framework of a Didactics of Informatics course.

The analysis of the discussion aimed to (i) identify and categorize the different students' opinions, (ii) figure the percentage of the students that participated actively in the discussion, and (iii) identify the students' opinions that provoked other students' comments leading to further discussion.

## 16.3 Results

The average grades of the activities designed by the students of both groups before and after the case study, regarding the four evaluation criteria, are presented in Table 16.4 for Phase A and in Table 16.5 for Phase D.

In order to investigate the differences between the two groups' working methods (in the classroom and online), we compared the average grades for each criterion. As can be seen in Tables 16.4 and 16.5, the students of Group 2 scored slightly higher than those of Group 1 at the three out of the four evaluation criteria both in Phase A and in Phase D. However, it is interesting to note that the score differences between the two groups, regarding all evaluation criteria, are not statistically significant at a 95% confidence level according to the results of the T-test.

**Table 16.4** Evaluation of the initial activities designed in Phase A

| Criterion | Group | Average grade | *P* | *t*(65) |
|---|---|---|---|---|
| 1 | 1 | 1.82 | 0.844 | 0.198 |
| | 2 | 1.87 | (ns) | |
| 2 | 1 | 2.21 | 0.623 | 0.495 |
| | 2 | 2.33 | (ns) | |
| 3 | 1 | 2.25 | 0.527 | –0.637 |
| | 2 | 2.10 | (ns) | |
| 4 | 1 | 1.14 | 0.708 | 0.376 |
| | 2 | 1.28 | (ns) | |

On the other hand, remarkable and interesting differences were observed not only in the individual student's answers to the questions of the case study (Phase B), but

**Table 16.5** Evaluation of the initial activities designed in Phase D

| Criterion | Group | Average grade | *P* | *t*(65) |
|---|---|---|---|---|
| 1 | 1 | 2.28 | 0.887 | –0.143 |
| | 2 | 2.32 | (ns) | |
| 2 | 1 | 2.68 | 0.508 | 0.665 |
| | 2 | 2.85 | (ns) | |
| 3 | 1 | 2.75 | 0.260 | –1.137 |
| | 2 | 2.44 | (ns) | |
| 4 | 1 | 2.29 | 0.563 | 0.582 |
| | 2 | 2.51 | (ns) | |

also in the conversation held in Phase C, concerning these questions. Commenting on the teacher's role during Phase B, the students of Group 1 were able to argue better about the role's efficiency, as some of the comments that appeared in a considerable percentage of answers given by the students of Group 1 did not appear at all in the answers of the students of Group 2 (see Tables 16.6 and 16.7). This probably results from the fact that the enactment of the Role Playing in the classroom provided them a better overview of the activity, while the students of Group 2, due to video constrains, could not comprehend all the aspects of the teacher's role and they could not locate easily pros, contras, and deficiencies of the specific role. On the contrary, regarding the question about the improvement of the bubblesort representation, the students of both groups provided almost the same points in their individual answers during Phase B (see Table 16.8).

However, the most remarkable differences were observed in the discussions (Phase C) conducted by the two groups concerned (i) the percentage of students who actively participated in the discussion and (ii) the number of different points found in their answers to the case's questions. More specifically, only 46% of the students of Group 1 actively participated in the discussion held in the classroom, whereas 100% of the students of Group 2 participated in the asynchronous discussion held in the discussion forum of e-class, submitting at least one post. In addition, the students of Group 1 managed to transfer in the classroom's discussion only 54% of the points mentioned in their individual answers. On the other hand, the students

**Table 16.6** Students' answers that commented the teacher's role positively (Phase B)

| The assignment of the key role of the algorithm to the teacher is *satisfactory* because it ensures . . . | Group 1 (%) | Group 2 (%) |
|---|---|---|
| The correct execution of the algorithm | 57 | 59 |
| Better control of the activity's implementation | 41 | 0 |
| The maintenance of the time scheduling | 7 | 33 |
| Better management of the classroom | 7 | 15 |

**Table 16.7** Students' answers that commented the teacher's role negatively (Phase B)

| The assignment of the key role of the algorithm to the teacher is *unsatisfactory* because ... | Group 1 (%) | Group 2 (%) |
|---|---|---|
| Being part of the simulation, the teacher cannot underline key aspects of the algorithm and address relevant questions to the students | 7 | 21 |
| The teacher should only supervise the activity and correct errors if necessary | 11 | 0 |
| Assigning the key role of the algorithm to a student would help the other students to better understand the algorithm | 11 | 0 |

**Table 16.8** Students' answers regarding the bubblesort representation (Phase B)

| The bubblesort representation can be improved by ... | Group 1 (%) | Group 2 (%) |
|---|---|---|
| Adding an object to represent index *i* (outer loop) | 61 | 41 |
| Adding an object to represent index *j* (inner loop) | 32 | 38 |
| Adding an object to represent the auxiliary variable necessary for the swap | 14 | 21 |
| Simulating the access at the array's elements | 11 | 13 |

of Group 2 not only managed to transfer in the asynchronous discussion all the points mentioned in their individual answers, but also new relevant points appeared in their discussion. Based on this, it was deduced that the asynchronous discussion was more successful, regarding the participation and the content, than the discussion held in the classroom.

As far as the investigation of the appropriateness of the case study method in teaching Didactics of Informatics, regardless of the way it is implemented, is concerned, the increase of the average grades in all four criteria after the case study (Phase D) for both groups suggests the positive influence of the method. The maximum increase was observed in the fourth criterion (e.g., usage of supporting objects). In other words, the major difference observed between the initial Role-Playing activities (Phase A) and the revised ones (Phase D) is the extensive use of supporting objects (see Tables 16.4 and 16.5). This probably results from the fact that the revised version of the Role-playing activity, presented after the discussion, contained more objects (e.g., cardboards for the representation of array's slots and the variables *i*, *j*, and temp). For example, consider a Role-Playing activity designed by a student in order to teach the functionality of the logic gates AND, OR, and NOT. In the initial Role Playing, designed by the student during Phase A, two different roles were specified: the gates and the input given by the user. Each student enacting a gate would have to hear his/her input and say aloud the output. In the revised Role Playing, created during Phase D by the same student, the representation was enhanced by using rope to represent the cables connecting the gates with each other, in order to better illustrate the circuit. In addition to that cardboards with the value 0 on the one side and 1 on the other were given to all the students who participated in the representation. The students who played the role of the input values could chose to hold the cardboard as they liked, defining the input values themselves, whereas the students who played the gates had to calculate the output values of the gate they enacted, taking into account the input values, and hold the cardboard in a way that the correct output value was visible to the rest of the students of the class, who watched the enactment.

Finally, another major difference observed in the revised Role-Playing activities concerns the role of the teacher in the representation. The role of the teacher in the initial Role-playing activities was either nonexistent or very vaguely described. On the contrary, for the revised activities the students not only defined, but also thoroughly described the teacher's role.

## 16.4 Conclusions

This empirical study shows that e-learning technologies can adequately support a case study activity, given that they can offer, among other functionalities, the possibility to the teacher: (i) to upload learning material, (ii) view and download the reports uploaded by the students, (iii) make announcements, and (iv) manage an asynchronous forum and participate in the discussions. The students' view of the system, on the other hand, should support them in: (i) viewing and downloading learning material, (ii) uploading their reports, (iii) viewing the announcements, and (iv) participating in the discussions.

Regarding the effectiveness of the two different ways of carrying out the case study (in-class–online), no statistically different evidence has been derived from the comparison of the average grades of the Role-Playing activities designed by the students of the two groups after the case study. This result is consistent with the results of other similar studies that compared in-class and online teaching (Kleinman, 2001; Cooper, 2001; Ury, 2005; Ury et al., 2006). However, remarkable differences appeared in the qualitative analysis of (i) the students' answers in the case study questions and (ii) the discussion conducted in-class and online, where the online students performed better by bringing up and analyzing more points considering the case study.

Finally, the improvement of the Role-Playing activities, designed by the students of both groups after the case study's intervention, suggests that effective learning can take place when the case study teaching method is applied in courses concerning Didactics of Informatics.

## 16.5 Future Plans

Future plans include the design and implementation of the same case study, with both in-class and online Phases, in the context of blended learning. Specifically, based on the results of the empirical study, it is planned to (i) provide the activity's material through the course management system and assign as homework the design of the initial Role-Playing activities, (ii) enact the Role Playing under study in-class, as the in class students developed a deeper sense of involvement, (iii) initiate the discussion in-class and give the students the opportunity continue exchanging ideas through the asynchronous forum, and (iv) assign as homework the design of the revised Role-Playing activities.

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# Chapter 17
# Practices in Old Age ICT Education

## Three Contexts Considered: Clubs, Courses and Home Teaching

**Minnamari Naumanen and Markku Tukiainen**

**Abstract** Lifelong learning as an individual activity that spans over one's life is not a reality yet, despite the general guides of educational policy. Especially the elderly, those over 65 years, are in danger of lagging behind. The solid trust in one's own activity and learning skills is required, besides, many aged today lack the learning culture (Tikkanen, 2003, *Gerontologia*, Helsinki: Duodecim). In step with an increasing elderly population, more attention needs to be paid on proper old age education technology, pedagogy, motivation, and needs. This chapter presents the experience gained from guiding elderly into the use of computers and Internet from three contexts. In addition, the chapter presents principles from literature on old age education based on cognitive aging (compensating and supporting the deficiencies and strengths) not forgetting the impact of empowerment by current ICTs in the life of elderly people. First, directing computer clubs for the elderly is demonstrated based on a WWW-questionnaire, as well as observations made during years 2007–2008 in Pieksämäki, Finland, and from Seniors' Club. Second, we show experiences from courses and home teaching for elderly. Finally, we discuss these forms of learning in two models: Chaffin–Harlow model of cognitive learning (Chaffin & Harlow, 2005, *Educational Gerontology*) and TUP-model for the contextual factors (Bednarik, Gerdt, Miraftabi, & Tukiainen, 2004, *Proceedings of the ICALT 2004: 4th IEEE international conference on advanced learning technologies*, Joensuu, Finland: IEEE), that is to say from the learner's vantage point and that of the real-world context where learning takes place. The results show that the learning program for the elderly is strongly facilitated by peer support which is experienced during informal club-based activities, as well as having a jointly planned content which is tailored to their needs, motivation, and ability.

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## 17.1 Introduction

Currently, Europe has the highest proportion of elderly people in the world, standing at 16.7% (82.7 million) of the population (496 million) of EU-27. Moreover, this percentage is expected to increase in the two to four decades to come. It is estimated that by 2050, approximately 30% (141.6 million people) of the European population will be above 65 years of age, and especially the oldest of old (80 years +) is estimated to increase rapidly (Eurostat, 2008). This demographic revolution will have its impact on national health care, social security, and the general working conditions, and innovations for continued survival become essential. Among others, innovations will be on the technological level: e-services (governmental portals, self-care sites, e-banking, e-shopping, etc.), assistive technologies at home and care units, and more flexible provision for lifelong learning, for cognitive prostheses and for rehabilitation by means of computerized networks.

How well and to what extent can and will the elderly population adopt these services? The elderly user numbers are steadily growing but are still relatively low compared to overall ures. For example in year 2005, about 75% of people over 65 years of age had no computer skills at all (Demunter, 2006). Furthermore, on average about 25% of older people aged 55–74 used Internet regularly in EU-27. The spread in usage figures among the member countries, however, is quite extensive. For example in Finland, the number is about 43–44% (Statistics Finland, 2008; Smihily, 2007). The baby boomers of 1940s are soon to be our elderly. Today, about 82% of the people aged 50–59 have used Internet during the past 3 months, while the number of those aged 60–74 only achieve 43% (Statistics Finland, 2008). The population of Europe will be more ICT literate in the future, as more and more citizens have been engaged in the use of computers and Internet during their working life. But at present, there are still elderly people for whom the digital world is new, which appears daunting to them and the benefits of which are not well known (see e.g. Morris, Goodman, & Brading, 2007).

Computer courses have been shown to have an effect on the computer attitudes and knowledge of the elderly (Morris, 1992); autonomy and communication skills can be improved (Chaffin & Harlow, 2005) and there is a strong tendency of elderly using ICT to sustain and support noncomputer-based hobbies and leisure activities and to fit the technology to their daily life (Selwyn, 2004). The advantages of continued participation in learning include, e.g., prevention of cognitive decline, interconnectedness of elderly with family and friends, assistance on health-related issues, enabling the elderly to remain safe and functionally independent, increased intergenerational interaction, and enhanced self-esteem (Jones & Bayen, 1998; Purdie & Boulton-Lewis, 2003; Rogers, Mayhorn, & Fisk, 2004).

However, it is not self-evident that elderly people will adopt ICTs and use them. As Selwyn (2004) claims, ICT is not universally attractive to nor universally needed by older users. In his study, the main reason for nonadoption of ICT was simply not having an interest in using a computer and/or perceived lack of its usefulness; also, the attribute of having once learnt to use computer does not automatically translate to later computer use in old age (see also Ng, 2008). One important option to improve this situation is to involve elderly in changing ICT and ICT education to become more attractive and useful to them, not to expect the elderly to adjust the complexities and dullness of prevailing ICT (see also Czaja & Lee, 2007; Tikkanen, 2003). If the elderly persons participate in design process, it helps in achieving the requirements formulated by Rogers & Fisk (2006) (1) to meet the needs of the elders, (2) to match their capacities, and (3) to be acceptable for them.

The attitude of elderly people toward computers and Internet is generally positive – unlike general false perception (Czaja & Lee, 2007; Eaton & Salari, 2005; Li & Perkins, 2007; Morris, 1992; Rogers & Fisk, 2006; Xie, 2007). The actualization of the learning needs and possible benefits is, perhaps, as Lawton (1998) put: “to mobilize technology to enhance both fun and function of older people.” This involves taking the age-related cognitive decline and psychomotor functionality, and (ICT) literacy into account, as well as motivational and self-fulfillment factors. What motivates the elderly to learn the usage of ICT? We shall take a closer look at such issues.

In search of comprehensive lifelong learning, also people outside the statistics, those aged 65+, should be included in the policy and above all the current practices of societies. From an individual point of view, *lifelong learning* can be defined as an action that individual engages throughout his/her life in many different situations and contexts (Tikkanen, 2003). From the perspective of official educational policy, there are guidelines stating how the learning should be facilitated and targeted so that all individuals would have equal possibility and facility to learn. In the rapid technologically changing Western society, there is an actual on-going need for any individual to learn new or “sink,” as stated by Tikkanen (2003). Elderly people of today, who are on lower levels of education may not have the capabilities (skills) to engage in learning activities prominently (Willis, 2006). Goals of self-fulfillment, participatory influencing (on society), and taking responsibility for one’s own future are important, at least in Finnish visions.

This chapter focuses on the educational side of the elderly people. In this chapter, the term “elderly” (often referred as “older adults” in the UK and US literature) is used to describe the heterogeneous user group of people aged 60+, who still want to be active participants at societal level and who are interested in self-fulfillment in diverse domains of the retired life which they are living (Laslett, 1991). First, we examine some motivational issues behind computer and Internet learning. As aging is accompanied by degrees of cognitive, sensory, and motor impairments, these are reviewed. Based on both motivational facts and impairments, teaching and learning of elderly people are covered in Section 17.2. To show some successful examples of continuing education among elderly, Section 17.3 describes different contexts and ways of guiding elderly people into the use of computers and Internet; the section will show (1) experiences gained from the Digital Cottage and Seniors’ Club (computer clubs for the elderly): background, activities, participatory design of the content; (2) computer courses; and (3) home teaching experiment. Section 17.4 summarizes the issues and discusses them in case of two models: Chaffin and Harlow (2005) model for cognitive learning and Technology, Usability & Pedagogy (TUP) model (Bednarik, Gerdt, Miraftabi, & Tukiainen, 2004).

## 17.2 Old Age ICT Education

The natural process of aging affects the cognitive and sensory capabilities of the elderly people in progressive declining manner. What these impairments are and how they should be taken into account in teaching and learning for the elderly are considered in this section, alongside accessibility. In addition, the motivational issues in ICT learning of the elderly are briefly reviewed.

### *17.2.1 Requisites for Old Age Learning*

#### 17.2.1.1 Accessibility and Age-Related Cognitive Impairments

Sharp, Rogers, and Preece (2007) define accessibility – or the wide area it touches – to "the degree to which an interactive product is usable by people with disabilities." Although old age as such is not a disability, there are still many age-related impairments that accompany natural aging, and thus aged people are often included in this group. Usability, for one, comprises of factors like learnability, efficiency, memorability, and pleasantness of the system (Nielsen, 1993). How socially acceptable and what utility the system provides plays an important role in its acceptance. Zajicek (2007) adds on physical accessibility issues of inclusion and acceptability. For example, if Web 2.0 applications were to be accessible to elderly people, they should also want to use them and see the real benefits of the usage. The software, thus, needs to be desirable. Inclusivity comes partly from the design issues if the elderly are the targeted user group and partly from their own interests if the elderly can relate to the content and service provided. Also, Dickinson & Dewsbury (2006) insist on it that the wishes and desires of the elderly be taken in account – to "fit into people's lives." To actualize this fitting, we need to know our target group: their capacity, weaknesses, and expectations. In this chapter, besides cognitive issues, we shall focus especially on motivational and pleasantness factors for learning as applied to elderly people.

There exist natural impairments that accompany normal aging. Jones & Bayen (1998) divide these declines into four categories: (1) cognitive slowing (reasoning, memory, and spatial abilities), (2) limited processing resources (attention, working memory [WM]), (3) lack of inhibition (discrimination of information), and (4) sensory deficits (especially loss of vision and hearing). If these factors are taken into account in the design and conduct of teaching for the elderly, the elderly can achieve nearly equal level of performance compared to younger adults. Impairments, thus, do not render the elderly incapable of learning, although the learning may be slower; require more recap, time, and support; and be different in content compared to younger adults. It is more important to concentrate on what elderly people can do instead of staring at deficits, as Keates et al. (2007) emphasize.

Quite often the issues concerning accessibility of ICT systems have concentrated on perceptual and motor aspects of aging and forgot the cognitive ones (Keates et al., 2007). At cognitive domain, normal aging affects especially the learning and memory abilities of the elderly. Empirical findings have shown that changes in semantic, episodic, procedural, and perceptual representation systems happen as a process of normal aging. Especially, a loss of working memory occurs (duration and just acquired information); this short-term memory is a much-needed requirement for computer use and learning. Besides, WM load is positively correlated with increasing task complexity and in case of new/unknown domain (Czaja & Lee, 2007). Losses take place also in long-term memory (free recall and retrieval), and in episodic memory (store for events in past and future). The latter weakens slightly but can be accommodated by reminders and external cues. Recognition, however, is not much affected by aging, and gains in crystallized, semantic knowledge have been reported (life experience, accumulated knowledge) (Craik & Bosman, 1994; Czaja & Lee, 2007; Mayhorn, Rogers, & Fisk, 2004).

#### 17.2.1.2 Motivation for Learning ICT

Adoption and use of technology among the elderly is influenced by many factors. There needs to be a real, perceived benefit for the use relative to the needs and interests of elderly people; a centrality of sociability (maintain social networks and communicate with family and friends) is also often mentioned in the literature (Eaton & Salari, 2005; Karavidas, Lim, & Katsikas, 2005; Morris et al., 2007; Rogers et al., 2004).

In Australia, Purdie and Boulton-Lewis (2003) made a survey about the learning needs of elderly people. They interviewed a sample of elderly people, and based on the results, constructed a learning efficacy questionnaire. The results show that most important learning needs were related to transportation, health, and safety issues and were least to do with technology, per se. Biggest barriers found were related to physical conditions (reduced mobility, degenerating sight and hearing) and cognition (memory deficit, learning difficulties, and concentration). Elderly people in this study did not identify social learning needs as particularly important, neither support from friends and family, unlike in the study by Eaton and Salari (2005).

The needs, contexts, and background of the elderly vary and are heterogeneous. In United Kingdom, Morris et al. (2007) found that the benefits of the computers and Internet are not well recognized by many of the elderly. Additionally, 60% of those who were not Internet users stated that nothing would encourage them to use it in the future, either. Barriers encountered include, e.g., feelings of being too old and lack of interest or access to Internet. In old age education, the creation of a positive first encounter is also important to cultivate attitudes (Dickinson, Eisma, Gregor, Syme, & Milne, 2005; Li & Perkins, 2007; Morris, 1992).

What motivates elderly can be deduced from activities the elderly people mostly engage in. These include Internet: information search about hobbies and local issues, e-mail, entertainment, and Internet transactions (Morris et al., 2007; Willis, 2006; Eaton & Salari, 2005; Karavidas et al., 2005). According to latest statistics, about 80% of older Internet users aged 50–75 years old in Finland use Internet for e-mailing, information search, and net banking (Statistics Finland, 2008). Keeping up with computerized technology and development of the society was found to be among the main motivators to learn ICT skills among elderly (Naumanen & Tukiainen, 2008a; Selwyn, 2004). Other motivations for learning include learning (to get knowledge) (Courtenay1989), peer support and sociability of learning experience (Ito, O'Day, Adler, Linde, & Mynatt, 2001; Karavidas et al., 2005; Naumanen & Tukiainen, 2008a; Xie, 2007), and communication with friends and relatives (Morris et al., 2007). For example, good results were achieved for evolving motivation among elderly learners in Hong Kong by using a participatory mode of learning and consistent support from different stakeholders (Ng, 2008). Thus, the motivation is both self-generated (intrinsic, the desire to know and develop) and facilitated by learning conditions, first of all by other people (extrinsic, learners, facilitators, family, and friends).

### *17.2.2 Teaching for the Elderly*

Experimental psychology is a good source of information applicable to old age education. To uncover the needs and interests of elderly people, research is required. Age-related changes in cognitive abilities are the result of cognitive slowing, limited processing resources, and failure to inhibit task-irrelevant information; also, sensory deficits seem to accompany cognitive decline, as discussed in the previous section (Jones & Bayen, 1998). These factors are summarized in Table 17.1, with implications on teaching. Mayhorn et al. (2004) also suggest similar cognitive aging factors to be taken into account in system design for the elderly; these can as well be applied to old age education. Guidelines for teaching are also given by Xie (2007) and Naumanen and Tukiainen (2007b).

The key issue is to accommodate requirements of the elderly learners: to support their working memory by offering cues, reminders, and navigational aids in systems and materials; to benefit from the accumulated experience and previous knowledge of elderly learners (use of analogies and real-life references); and to allow enough time and environmental support. In addition, structuring of tasks, customizing interfaces and toolbars, and paying attention to the working environment and equipment (peace, large enough monitors, font size, and use of buttons) are advisable.

## 17.3 Continuing Education for the Elderly

The need for continuing ICT education for elderly is apparent, in order to diminish the generation gap and to make our elderly legitimate participants in Information Society. A field of educational gerontology, i.e., the study of instructional practices for and about the aged and aging, aims to examine the factors that affect learning and offer learning opportunities for the elderly. In case of old age education, we should think (1) the nature of the education (terminal vs. life-span perspective), (2) purpose (different kinds of needs), (3) content (what, who prepares and teaches), and (4) target (active third agers vs. frail elderly) (Courtenay, 1989).

**Table 17.1** Age-related changes in cognitive ability and the implications for teaching (summarized from Jones and Bayen, 1998)

| Change factor | Examples | Recommendations for teachers |
|---|---|---|
| Cognitive slowing | Slowing of reasoning, spatial abilities, long-term memory for verbal material and activities, and reduction in processing speed | Allow sufficient time, room for questions, adjustment of control panel settings, and minimize the amount of reading |
| Limited processing resources | Impairments in attentional capacity and working memory | Environment support: favor GUIs and toolbars, make online help known, break up the instruction into small units and make goals explicit, provide enough instructors and handouts for reference, use of pictures in material, and favor recognition rather than recall |
| Lack of inhibition | Irrelevant information is more likely to occupy the WM of the elderly | One task at time, eliminate noise and other environmental distractions, and make learning objectives clear, as well as the status of learning/current state |
| Sensory deficits | Strong connection with cognitive tasks (their slowing), especially diminishing visual acuity and presbyopia (ability to focus on short distances); Difficulties in discerning colors in green–blue–violet range; and Sensitivity to glare increases | Customize toolbars (larger buttons and font size), use large monitors and position them correctly, and use high contrast between background and text |

Accessibility of ICT technologies for elder users can be addressed from two perspectives: that of software and physical interfaces (their usability) and that of age-appropriate training instructions and materials (their improvement). For the latter, which this chapter concentrates on, there are many different approaches and environments, and as Czaja and Lee (2007) note, there does not exist much data about how to best train elderly for technology-based tasks. For that reason, it is important to test different contexts where learning/usage of ICTs takes place. This chapter reviews three methods/contexts that utilize participatory design approach in case of old age ICT education (Grønbæk, Grudin, Bødker, & Bannon, 1993). The aim is to find effective ways for interaction between the elderly and ICTs, as well between the elderly and the instructors in this process. The contexts to be reviewed here are (1) computer clubs, (2) courses, and (3) home teaching.

## *17.3.1 Digital Cottage – A Computer Club for the Elderly People*

Digital Cottage (DC) was founded at the end of 2006 on the initiative of a local bank, an enterpriser and a few active elderly people of the city of Pieksämäki, Finland.

The challenge was addressed to the elderly to learn the basic skills of computer and Internet use to aid them in their everyday lives. In the beginning of March 2007, a project "ICT to support the abilities of the aging people"[1] started and took over the further planning and guiding the DC as part of its activities. Experience gained from Seniors' Club was used as a model for Digital Cottage (Eronen, Keränen, Sutinen, & Tukiainen, 2006; Naumanen & Tukiainen, 2007a).

The weekly 2-h computer club meetings were attended, on average, by 10–15 elderly people aged 58–75 years old. Nearly all of them had some previous experience of using computer and Internet. Guidance was provided at the computer class of the local university of applied science, usually by the first author or a student of the institution. There were also one to three student tutors to facilitate the learning and to give hands-on support when needed. Students were paid a small fee for their services, via student co-op Tukeva.

At the beginning of each term (fall, spring), we collaborated in planning the program for the term so that everybody could express his/her wishes and learning needs. The feedback was collected in observations made during the club meetings. A diary about the meetings was also kept at the Web site of the Digital Cottage. At the end of each term, additional feedback was obtained by filling in WWW-questionnaires.

The subject matters learnt during the year were composed of different themes under which individual topics were provided. First, the topic was introduced and briefly discussed in the group, then skills to perform the particular task were practiced together, each one using his/her own PC (with Windows XP in Finnish, Office 2003 package, and some other basic software). Topics covered during the year varied from basic use of keyboard, mouse, and folder system to services of Internet (humor, travelling + ticket ordering, and net banking), using e-mail, cleaning up the computer, image manipulation, and music and movies. Image manipulation taught as a unit, took up three sessions.

Problems encountered during the activities can be divided into two categories: (1) hardware and software related and (2) person centered. In case of hardware and software, the institution had very limited user privileges to accommodate the system for the needs of the elderly (font size, speed of the mouse, screen resolution, and background) and there were many topics that we could not practice in reality (installation of software, getting access to music databases, and using easy-to-access features). The problems related to persons mainly included a lack of motivation on part of some student tutors during the fall term of 2007. It was also quite hard to comply with the wishes of every participant.

In post-www-questionnaire, the questions asked included, e.g., how things were dealt during the club meetings (pace, materials, teachers, and alike) and what was covered too much/too little (content of the teaching); for what purpose and to what extent they used computers and Internet (computer use); what they have learnt and

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[1]Joint project of the University of Applied Science, Diak East, and University of Joensuu, 1.1.2007–30.6.2008

how useful they saw the things learnt during the year (things learnt); and some reflections on their learning (self-analysis of learning) and something about their expectations and future (expectations vs. reality and future). Selected results of feedback – about content, things learnt and self-analysis of learning and motivation – show that most participants were content with activities engaged and pace of guidance in DC (7/9). Participants acquired more confidence in use of computers and Internet (4/9) and learnt, for example, e-mailing (5/9), net business (banking, usage of timetables, and net TV) (4/9) and felt that they could affect the framework of what was taught/learnt (6/9). They preferred learning by doing things by themselves and by experimenting with additional support of the group and tutors (8/9). All regarded group as an important factor in learning new skills. The main motivation was to keep in touch with the modern times and desire to know/learn more (5/9). More detailed results can be found in Naumanen & Tukiainen (2008a).

### *17.3.2 Seniors' Club: Joy of Collaborativity*

Ancestor of DC, namely Seniors' Club (SC), was established in the year 2005 at the department of Computer Science at University of Joensuu. The main idea was to establish contact with real elderly users and work with them in ways that utilize both the elderly and research (Eronen et al., 2006; Naumanen & Tukiainen, 2007a). At the beginning, the research interest laid in software usability, but it quite soon shifted toward old age ICT guiding and finding ways that support it. It was discovered that there was still a grave need for very basic ICT skills and knowledge by the elderly.

The basic working schema for SC is as follows. There are about 10 active members in Seniors' Club. We get together once a week, 2 h at a time, at our Educational Technology laboratory to learn and practice ICT skills of many kinds. Besides getting to know computers and Internet, we have had sessions about mobile phones, digital TV, and gaming, for example. The content for each term is jointly planned. For that we have used focus-group discussions, which seem to work well with a group where members know each other well and when the domain (ICT) is more familiar. Some researchers, however, hesitate in using focus group with elderly (Lines & Hone, 2004). At the beginning, we had fixed more lecture-based introduction to digital world (which was not that successful but not necessarily "wrong way" to approach novices). We have also tried workshop activities with seniors and found out that these structured and goal-oriented entities could well serve elderly learners, too (Naumanen & Tukiainen, 2007a; Islas Sedano & Sutinen, 2007).

To support the club activities, we have student tutor to help the first author in the guidance, as well as WordPress blog, which acts as an information channel and repository for the material sometimes produced either by tutors or in some extent also by particular seniors themselves (short guides, link hints). Computers are seen as tools that are used in activities. Many times elderly teach each other in small groups while engaging in activities (like digital photography, finding information on Internet, word processing, etc.). Thus, there is also a strong peer support as one learning scaffold.

There are some more appealing features in clubs compared to course-based instruction. The teaching can be better tailored, is more free in form, and peer support in the clubs is important. Clubs also favor asking of questions, sharing information, knowledge, and opinions among its members, as there is no distinct teacher. Participants can affect the content of the club: things taught and even on the way in which they would like to be guided. Different skills, levels of experiences, and needs can be better accommodated and actually it is this diversity of experience, and the seniors themselves in peer guiding groups, which provides the scaffolding for the teaching. While a course lasts one term or 2 weeks, a club can operate for years and create a real community. As familiarity and small groups facilitate learning (Hawthorn, 2006), they may learn better.

Where elementary courses in more formal classroom settings can give an initial boost for computer skills, clubs and continuing learning of elderly people are needed to maintain and enhance the skills learnt (Xie, 2007; Naumanen & Tukiainen, 2008a).

## *17.3.3 Computer Courses and Home Teaching for the Elderly*

### 17.3.3.1 Computer Courses

In year 2007, we held two 20-h computer courses for elderly people aged 52–74 years of age (Naumanen & Tukiainen, 2007b). Courses for teaching elderly people the basics in computing were designed so that cognitive issues and special needs of the elderly were taken into an account and localized into Finnish context. We emphasized very personal and tailored approach into teaching. The motivation was not a problem, as the seniors came to a course as volunteers and had a good knowledge of what they wanted to discover during the course (each participant was interviewed by phone before the course started; the content of the course was then tailored based on their interests). Push into a course was encouraged by the children or grand children of the participants, and many highlights were much to do with this social aspect of computing (sending e-cards and e-mail) and finding interesting senior-targeted information. Teaching was tailored and improved on a run, and making questions was strongly encouraged. First, author acted as a coach for the learners, assisted by tutors of Seniors' Club and local high school students.

At the end of the courses, a WWW-questionnaire was conducted to get feedback and some results from things learnt. Observations and diary notes taken during the courses were also utilized. Overall, the elderly people appreciated the courses: They were very satisfied with it (65%) and found it mostly useful and interesting. Even though the pace was tried to keep as slow as possible, some regarded it to be too fast. Peer tutoring can be a motivating factor and favored by the elderly; some of the participants had/has in mind to spread their ICT knowledge forward. Other ways of guiding and facilitating elderly to support their cognitive processes, common interest/uptake of ICTs, and (thus far) known features include, e.g., taking a personal stance (each student is an individual), using of more than one teacher (to see that everybody keeps up the pace, if not, then it is the pace that is slowed down), and using sense of humor and showing that teacher is a human too (and prone to make errors, not remember, etc.)

In general, teaching elderly people to use computers and Internet is a demanding task. Their learning habits and expectations, among other things, may differ from those of the younger ones. This was clearly reflected in their self-assessment (of the skills, which were not that high even in case of simple tasks or definitions) and overall satisfaction of the course (which was high). Even the little things learnt may thus give much for the elderly, instead of a need to command all things covered. In addition, in the same way that we try to include elderly people into the very process of design (systems and software) we need to take them into course design as well. Then we might better harvest their prior knowledge and expectations and respond to their needs.

#### 17.3.3.2 Home Teaching

The 4-week home teaching experiment took place during the March 2008 at four local homes in town of Pieksämäki, in Finland. The average age of the participants was that of 66 years (59–72) and everybody had some experience on using the computers and the Internet, though mostly the knowledge and skills were outdated. Each participant was visited once a week, 2 h at a time. The teaching was tailored according to the needs, skills, and interests of the participants (collected via preinterviews or questionnaire) and recorded in form of teaching diaries. The issues covered mainly concentrated on services of Internet (senior sites, magazines, recipes, traveling, map sites, library, and net banking), e-mail, and Skype. The seniors who partook the experiment were appreciative at the end and hoped for more similar opportunities to learn in the future, as well. Even in case of such a small sample the diversity was great, both in terms of skills and motivation, and once again reminds us about the heterogeneity of elderly, i.e., their individuality (Naumanen & Tukiainen, 2008a).

In case of home teaching, it may suit well for those who are among the oldest old (over 80 years) and those who have some limitations to participate in computer courses or clubs. There the teaching is entirely individualized and hands-on. This approach, thus, may also work with those who live permanently at old age homes or long-term care facilities.

## 17.4 Discussion

This chapter contributes to the methodological knowledge of old age ICT education. The results found in the experiments support the enhanced activities of daily life (EADLs) of elderly people (Rogers & Fisk, 2006) by technological means – in the field of learning, communication, and leisure activities – which require great deal of cognitive capabilities from the elderly user. Experiences from Digital Cottage and Seniors' Club – computer clubs for the elderly – were presented, alongside design and implementation of computer clubs and home teaching.

Chaffin and Harlow (2005) have created a model for computer skills learning for elderly people. Its central idea is that "the fundamental interest of the learner can be discerned" and with skillful guidance the motivation will follow. Perception of control is important and once the basic skills have been learnt, autonomy and communication of elderly can be improved and computer technology can provide them new ways of addressing life's problems. In the model, the older learner is an active actor. Learning is a change in user's cognition levels, which is greatly affected by his/her environment (art, culture, and technology). In addition, older learners have a basic need for connecting to others, as well as sharing and expressing themselves. Focal points in learning/teaching are experience of actors and life centricity of activities. Older user involvement plays a significant role in all phases: planning, implementation, and assessment.

By teaching, elderly people adopt new ways of communicating and doing things. With proper instructional design, learners will improve their learning skills by solving problems, challenging themselves, and experiencing personal change. The levels of this dynamic learning process are demonstrated in Fig. 17.1.

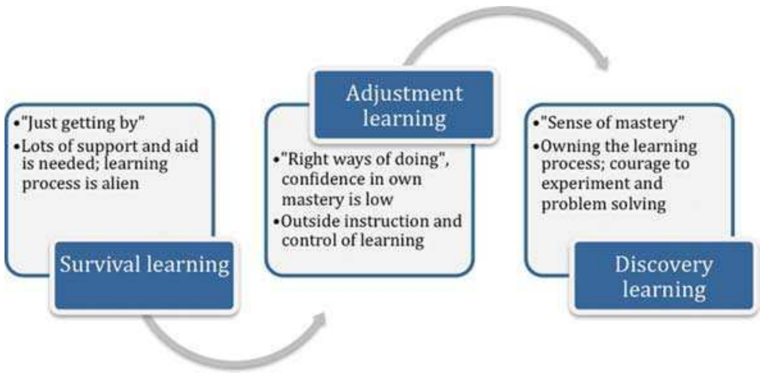


**Fig. 17.1** Levels of Chaffin-Harlow model for cognitive learning for elderly

Club-form activities build on the principles on continuing education and enable elders to maintain and improve their computer skills over a longer period of time (Naumanen & Tukiainen, 2008a; Xie, 2007). From the observations and teaching diary notes, it could be concluded that learning in DC currently is at the level of *adjustment learning*. *Outside instructions* and *control of learning* were still greatly needed, *import of skills* to be applied at home is just about to start, and *the courage to experiment* was mostly missing. Questions were often made about the security issues and topics rose by media (newspapers, TV) about computers and Internet. At the end, however, a slight change in attitudes and knowledge were noticeable and the worst fears were overcome. How does one attain a level of *discovery learning*, where *sense of mastery* and courage to experiment will arise? Some suggestions – to be applied in all contexts – include: more everyday related computer problems could be tackled (also at home). In addition, by involving the elderly more deeply in the content creation (beyond content planning) and enforcing more structured approaches (e.g., workshop activities) may help in this process. There is also, still, need to show the potential of the application of technology in the everyday life of elderly (to support and augment the activities they are already practicing), not forgetting even more personalized touch to teaching.

In case of Seniors' Club, the shift toward *discovery learning* has been marked: There are some eager experimenters and knowledge providers in the club. They, further, with their examples draw others into encouraging learning and provide valuable peer support. Anyhow, we should be careful in generalizing, as the learning – at the end – is not a property of whole group but an individual. The group performance compared to DC is better, i.e., activities are more collaborative and the degree of peer support is higher, most probably due to the cohesive group, where different skills complete – not compete – each other.

In evaluation of e-learning environments and software, a TUP model has been used (Bednarik et al., 2004). Whereas Chaffin and Harlow model constitute a model for advancing levels of learning (with user with his/her motivation, experience, values, etc., in core), and thus a part model of the TUP, the TUP model helps us to relate educational issues into the context of real world (where all activities take place). To attain usability (learning, user satisfaction, effectiveness, and motivation), the technology needs to match both the user requirements and capabilities and the pedagogy (teaching method, materials) needs to be deliberate. Model can be further augmented to fit with user-centered design of learning for elderly people (see Fig. 17.2).

In the center, there is an older learner with his/her characteristics and needs. If technology and pedagogy are in order, i.e., accommodate the needs and characteristics of the user, usability will follow (and thus also motivation and acceptability; see Chaffin & Harlow, 2005; Rogers & Fisk, 2006). It is notable, however, that use of technology and learning occurs in different contexts. Then, also the user's requirements, own activity in the learning process and interactions vary, and methods should adjust to each individual and requirement separately. Frail bedridden elderly persons do have different needs from active third agers covered in this chapter. Pedagogy and technology also account for complex interactions between learners, instructors, peers, and the particular technology in use. In case of elderly users, sociability: support from family and friends and from peers – that are experiencing the same difficulties and are representatives of same social generation – was also found important in this study. In club form activities, especially among the learners, the evolving sense of a community has a great impact on learning – if not at skills level, at least at the level of user satisfaction, which may be more crucial.

Evolving motivation can be seen as a natural consequence of appropriate content and context of learning. Situated learning (Lave & Wenger, 1991; Ng, 2008) prevailing in clubs and courses creates a learner community where apprentice ideals for learning are realized: with peer support, evolving skills and motivation lead

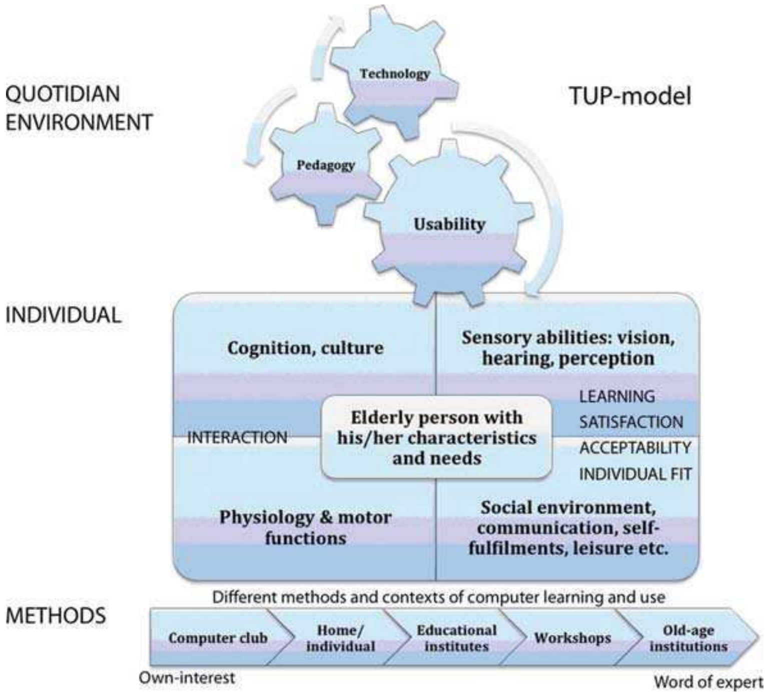


**Fig. 17.2** Different contexts of user-centered design of learning for elderly people

toward the owning of one's learning, when the learner becomes an explorer and can surpass him/herself – despite the age and limitations – and welcome the Digital Age.

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# Part V
# Integrative Methods and Online Learning (Sampson)

# Chapter 18
# Cultural Features of e-Learning

## A Euro-Asian Case Study

**Fredric William Swierczek and Clemens Bechter**

**Abstract** Cultural values have a major influence on learning. For learning to be effective, it must be adapted to the cultural context in which it takes place. e-Learning neither eliminates cultural differences nor is it culture free. The qualitative and quantitative findings of this study show two very distinct learning patterns. East Asian participants represent a high-context emphasis. South Asians and Europeans indicate a demonstrably low-context style of learning. The qualitative findings provide evidence that cultural features do have an impact on e-learning behaviors. European participants tend to be individualistic, achievement oriented, and emphasize learning by induction. South Asians reveal high power distance and also an achievement orientation. East Asians also demonstrate high power distance as indicated by a teacher-centric focus. They emphasize affiliation and avoid high uncertainty in learning situations. East Asians tend to prefer theory as the starting point for analysis. The quantitative analysis shows significant differences between the regional groups. East Asians are significantly more involved and active in e-learning than their peers in Europe and South Asia. This suggests that the high-context learning culture has a positive influence on e-learning involvement.

## 18.1 Introduction

An analysis of participants in two e-learning courses in Marketing Management and Business Simulation representing three geographic regions was conducted to determine if there were any significant differences in e-learning behaviors. This comparative study involves students of three online universities: Euro*MBA (The Netherlands), Universitas 21 Global (Singapore), and the Asian Institute of

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Technology (Vietnam). All three programs follow a student-centered and collaborative learning approach. However, the institutions serve different geographical regions and cultures.

The actual behaviors of e-learning, for example, time spent or number of sessions involved were tabulated and analyzed quantitatively. Specific responses from discussion boards of particular participants were selected randomly and analyzed qualitatively.

The dilemma in e-learning is whether to provide a universal approach to a course as if all learners were similar or to adapt an e-learning program to the specific cultural values of the participants. To explore this dilemma, this chapter begins with a review of literature related to Internet use, learning technologies, cultural features, and e-learning behaviors. The methodology is described related to the quantitative and qualitative analysis of the e-learning behaviors. The range of participants allowed a statistical comparison of e-learning behaviors of participants from South Asia, East Asia, and Europe. The interaction which took place between the participants also provides an opportunity for a qualitative analysis of postings in discussion boards and team responses. Finally, the analysis was illustrative of two learning contexts based on the findings of the e-learning behaviors and qualitative themes.

### *18.1.1 Literature Review*

Culture is defined as the patterns of thinking, feeling, and acting that people display as mental programs (Hofstede, 1997). Culture affects how a person learns (Smith, Dunckley, French, Minocha, & Chang, 2004, p. 81). The constructivist approach to learning recognizes that learners use their own mental programs to construct knowledge. They combine new information within a mental network. Cultural values have a major influence on learning. For learning to be effective, it must be adapted to the cultural context (Dunn & Marinetti, 2002). An in-depth survey of the literature shows very few empirical studies of cross-cultural e-learning. There is considerably more research related to web design and Internet use. These findings of research are compatible with e-learning because of the design emphasis. Past studies have found that users from different cultures understand similar websites and systems in totally different ways often leading to misunderstanding (Würtz, 2004). This is likely to happen in e-learning. Cultural features will be examined in-depth as they influence e-learning behaviors.

Table 18.1 illustrates the findings of a number of studies relating cultural dimensions and aggregate patterns of Internet use. In general, developed countries (North) have significant differences in Internet behaviors compared to developing (South) countries. Although this is changing, there are still cultural reasons why a digital gap still exists. This issue will be discussed in detail.

The most influential cultural dimension related to the application of the Internet is high uncertainty avoidance (Hermeking, 2005). The level of usage and adoption are negatively influenced by high uncertainty avoidance. This dimension also negatively

**Table 18.1** Cultural features and Internet behavior

| Cultural features | Impact |
|---|---|
| High uncertainty avoidance | Negative correlation with usage<br>Less adoption of ICT<br>Less proficiency in English<br>Less acceptance of foreign language |
| High power distance | Less adoption of the Internet |
| Low uncertainty avoidance | Higher innovative use of the Internet |
| Higher individualism | Higher adoption<br>Higher usage |

Source: Hermeking (2005), Holden, (2004) and Zhou (2008)

affects communicative capability such as English proficiency and the acceptance of foreign languages. Higher power distance also limits the adoption of the Internet. Since most cultures in Asia are characterized by high uncertainty avoidance and power distance, the use of the Internet in general and e-learning in particular is expected to be problematic (Zhou, 2008). This situation also applies to e-learning across cultures (Russ & Dick, 2007).

e-Learning can be defined as instructional content or learning experience delivered or enabled by electronic technologies. Specifically, e-learning is content delivery and learner–tutor interaction via the Internet (Wagner, Hassanein, & Head, 2008). The cultural features that affect Internet use and website design are likely to relate similarly to e-learning behaviors. The limited amount of empirical research on e-learning indicates that it does (Edmundson, 2005).

The cultural features reviewed in Table 18.1 were developed from Hofstede (1997) which have been used in several studies related to cross-cultural issues in IT-specific behaviors. Uncertainty avoidance refers to the need for specific guidelines and direction. Power distance refers to the level of authority and responsibility to determine the use of IT applications. High power distance means a strong emphasis on authority. Individualism relates to the focus on the role of a specific person and their motivation. Cultural features have an influence on Internet behaviors such as usage, adoption, and foreign language acceptance and proficiency.

In addition to culture, several other external factors have been identified related to the cultural influence on the design of e-learning. External factors relate to the environmental and situational variables which influence e-learning approaches and behavior. These include language, technology, the role of the instructor, and the level of interaction required. Language is a critical issue in global e-learning. Language is a cultural tool. It includes not only the obvious meaning but also local variations of understanding. Most computer-related materials are designed for English speakers. Leki (1992) focused on cultural dimensions in the context of ELF (English as foreign language) students of the analysis related to the processes that they go through study and the social and cultural contexts in which those processes are situated. The challenge for e-learning is to turn English language materials into culturally sensitive, intellectually stimulating and to transfer skills that are appropriate to non-native speakers (Al-Huwail, Al-Sharhan, & Al-Hunaiyyan, 2007). Technology is encoded with the characteristics of the culture that developed it. An example of this the individualistic values characteristic of software developed in the United States (Al-Huwail et al., 2007; Edmundson, 2006). The role of instructor-centered learning is consistent with collectivist cultures such as East Asia. The student-centered approach is compatible with individualistic perspectives such as the United States.

In interaction, East Asians prefer formality and indirect responses. Westerners are informal, direct, and more delegative in interpersonal communication. Open-ended participative approaches don't work well in cultures with high uncertainty avoidance. Individualistic active learning techniques are not effective in more collective cultures. Independent achievement-oriented techniques do not fit instructor-based learning or affiliation-based cultures (Dunn & Marinetti, 2002). Collectivist cultures are characterized by interdependence, group identity, self-restraint, and hierarchical control. Individualism values individuality, freedom, and equality (Al-Huwail et al., 2007; Adeoye & Wentling, 2007). Ascription or status-oriented cultures expect more instructor or authority-based learning approaches. Feedback for individual achievement is required to be direct, neutral, and fact based. For community-oriented cultures, the feedback is likely to be indirect and emotional (Edmundson, 2005). High power distance cultures need more involvement from the instructor. Participants in collective cultures need approaches with group work, collaboration, and social orientation. Individualistic cultures require greater freedom, creativity, and expressive opportunities (Nevgi, Nishimura, & Tella, 2008). Introduction and directions will have to be very specific and detailed for high uncertainty avoiding cultures. Low uncertainty cultures prefer less guidance and explanation. Affective and diffuse cultures prefer more collaborative approaches than specific-oriented and achievement participants. In collaborative projects, the cultural variations in task sharing and context often influence the effectiveness of the project. East Asian participants emphasize the relationship with others. European participants are task oriented. The lack of shared meaning makes communication difficult (Al-Huwail et al., 2007; Mushtaha & De Troyer, 2007).

e-Learning design is very much influenced by the cultural features which form the context in which the learning process takes place. Table 18.2 considers the specific features or dimensions from the cross-cultural theoretical perspectives with the e-learning behaviors characteristic of specific cultural dimensions. For example, an individualistic emphasis on e-learning would focus on the results of the e-learning. It would encourage argumentation based on facts and specific details. A more collective perspective would focus on discussion among e-learning participants which would be balanced and represents an overall consensus. This would be generalizable across the regional e-learner group. Table 18.2 summarizes the expected cultural features related to e-learning.

Several studies have analyzed the specific relationship of cultural dimensions and indicators relevant to e-learning (Steyn & Cronjé, 2006; Zaharris, Vassilopoulou, & Poulymenakou, 2001). The findings are very mixed ranging from no significant relationship to significant correlations for only a few cultural features. These are

**Table 18.2** Dimensions of culture and e-learning

| Dimension | Characteristics |
|---|---|
| Individualistic | Results oriented, argumentative, factual, specific |
| Collectivistic | Consensus oriented, discussions, balanced, generalizable |
| High power distance | Top down, directive, structure, one way, authority |
| Low power distance | Lateral, bottom up, exploratory, process, multiple directions, mutual |
| Masculine | Achievement oriented, competitive |
| Feminine | Affiliation oriented, satisfactory |
| Long-term orientation | Future patterns, adaptive |
| Short-term orientation | Past, traditions |
| High uncertainty avoidance | Guided, structured, closed ended |
| Low uncertainty avoidance | Independent, spontaneous, open |
| High symbolism | Indirect, symbolic, visual, emotional |
| Low symbolism | Direct, rational, formal, logical |
| Universal | Theory, generality |
| Particular | Exploratory, specifics |
| Neutral | Objective, fact based |
| Feelings | Subjective, values based |
| Specific | Analytical, distinct |
| Diffuse | Synthetic, opaque |

Source: Trompenaars and Hampden-Turner (1997), Hofstede (1997, 2008)

presented in Table 18.3. The cultural features here are considered in pairs related to the emphasis the feature indicates. In e-learning, usability is the measure of the quality of the user experience when interacting with a course **website or e-learning activity (Adeoye & Wentling, 2007). Cross-cultural usability is about making websites an effective means of communication between a global website and a local user (Smith et al., 2004). Western methodologies or techniques for user-centered design

**Table 18.3** Cultural features and e-learning behaviors

| Cultural features | e-Learning behaviors |
|---|---|
| Higher uncertainty avoidance | Longer time to learn |
| Low uncertainty avoidance | Higher learnability |
| Higher power distance | No relationship to usability |
| Low power distance | Significantly higher learnability |
| Higher individualism | Higher usability |
| Higher collectivism | Higher learnability |
| Masculinity | Higher usability |
| Femininity | Higher learnability |

Sources: Steyn and Cronje (2006), Zaharris et al. (2001) and Adeoye and Wentling (2007) and participation cannot be assumed to be usable in other cultures or in multicultural teams without adaption (Smith et al., 2004, p. 89).

Learnability is defined as the ease in terms of time and effort to acquire the content in an e-learning activity. The higher the learnability relates to greater usability. Learnability focuses on the ease of learning; it is a specific feature of usability. The findings related to cultural dimensions and e-learning show very different patterns. Individualistic and masculine cultural features are related to usability, but high power distance is not. Collective and low power features are related to learnability.Higher uncertainty avoidance is associated with a longer learning process.

The results of cultural variability of IT and e-learning-related studies show both convergence and divergence. Convergence takes place in structure and content. Divergence relates to customizing features and services to fit specific cultural values (Zahir et al., 2002). Many websites tended to be both standardized and dominated by a low-context communication style regardless of the culturally preferred style of the use (Richardson & Smith, 2007). The convergent perspective is characterized by a low-context style characterized by a rational, text-heavy, and structured content which is highly standardized (Hermeking, 2005). The findings indicate there is a convergence in some cultural values because of the Internet in which the cultural gaps are reduced, but some gaps continue students using the Internet and e-learning typically share new values that are more similar (Mushtaha & De Troyer, 2007).

This review suggests there are two different learning cultures based on the assessment of the cultural features. These are high context and low context. High-context learning cultures tend to be collective, with high power distance. They are feminine, and high certainty avoiding, more symbolic particular, feeling-based and diffuse low-context learning cultures reflect individualism, lower power distance, and are masculine. They are long term, with low uncertainty avoidance. This learning context is universal, neutral, and specific. Convergence in e-learning refers to designs that emphasize the low-context learning cultures. This study will examine the likelihood of specific learning cultures based on a quantitative and qualitative assessment of e-learning behaviors of a diverse group of e-learners representing three culturally distinct geographical regions, East Asia, South Asia, and Europe.

### *18.1.2 Methodology*

This research is primarily quantitative in nature and is supplemented with a qualitative analysis. The chapter focuses on e-learning delivery in marketing management and business simulation. A total of 22 classes at Universitas 21 Global, 6 classes at Euro*MBA, and 12 classes at Asian Institute of Technology (Vietnam) with more than 1500 MBA students have been analyzed. The participants were enrolled in the specific institutions, including a wide variety of nationalities. Because of the location of the institution, there is a regional emphasis. Universitas 21 has mostly participants from South and East Asia. In the Euro∗MBA, participants come from the European Union. For AIT, the participants are more likely from East Asia. With the variety of nationalities, it was difficult to have a sufficient sample in each nationality. For analysis, it was decided to use regionally based comparison groups. South Asians were mainly from India. East Asians mainly were Chinese with some Japanese and Vietnamese. Europeans were very diverse with no dominant nationality. For all the marketing management courses, the textbook *Marketing Management*. For the business simulation, the software Markstrat Online with related material was the platform. Although with different weightings, all courses have assessment criteria in common: final exam, discussion board contribution, and individual and group assignments of case studies. Besides the formal assessment, the courses have formative assessments such as multiple-choice questions and quizzes. The learning management system was the same for each iteration of the specific marketing course. For business simulation, the learning management system was in a more group-based interactive format.

The data collected include both quantitative and qualitative information, such as a survey on student learning satisfaction, discussion board postings, online discussions, suggestions, and group projects. In addition, all of the log-in data recorded on the web platform during the learning process were collected for the analysis. In consideration of the participants' privacy, all of the collected data were coded to protect the persons involved. The courses took place over a year. The setting was a specific degree program which differed in terms of requirements of each institution. Course delivery was done online and was very consistent for the two courses.

### 18.1.3 Purpose of Chapter and Research Questions

The purpose of the chapter is to analyze the cross-cultural features related to e-learning.

The research questions are:

1. What e-learning behaviors are influenced by cultural features?
2. Are there differences between regional cultures: European, South Asians, and East Asians in e-learning behaviors?

The objectives of this research are:

1. To assess e-learning behaviors across cultures
2. To compare the e-learning behaviors of participants from three regional perspectives
3. To determine the influence of cross-cultural values on e-learning behaviors
4. To identify specific learning cultures related to e-learning

## 18.2 Cultural Features of e-Learning

### *18.2.1 Quantitative Insights*

Figure 18.1 presents a complete picture of the learning behaviors of all the participants in the sample (1500 in two separate courses). Online sessions typically involve interaction between the participants or with the instructor. The LMS is the source for the e-learning behaviors analyzed in this study. Students spend two-thirds of their time on the discussion board, followed by viewing course content with 18%, see Fig. 18.1. The course methodology is different between Marketing Management and Business Simulation. Marketing Management is a content-based course with interaction focused on case studies, exercises, applications, and projects. Discussion boards typically emphasize course-related topics. For this course, the learning strategy is competency oriented.

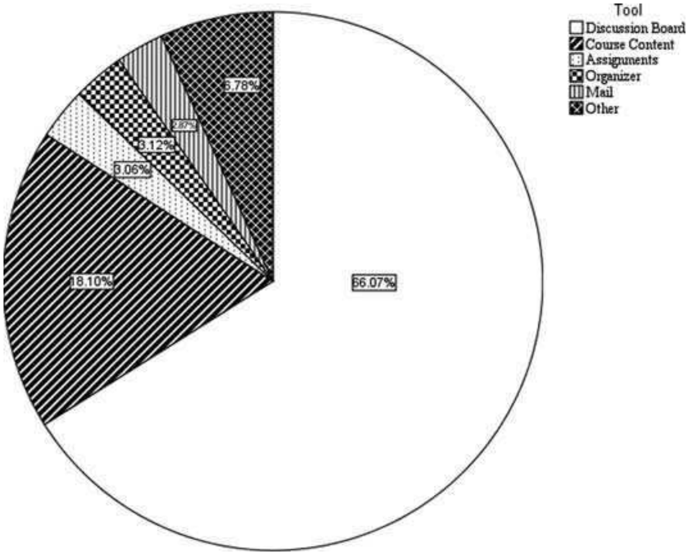


**Fig. 18.1** Time spent online (N: 20,376 online sessions)

Business Simulation is based on group discussions about specific alternatives related to products, advertising, and distribution with automatic feedback related to the impact of the group decision on performance. Discussion board involvement emphasizes the success or failure of their decisions and preparation for the next round. For Business Simulation, the learning strategy is based on practice, feedback, and reflection.

The analysis will focus on the specific e-learning behaviors by a comparison of participants from the three regions. Figure 18.1 gives an overview of the e-learning behaviors for all participants. Given the amount of time, students invest in reading and posting discussion board contributions; it is important to look at

**Table 18.4** Discussion board postings

| | DB posted | |
|---|---|---|
| Region | Mean | Std. Deviation |
| South Asia | 16.25 | 29.74 |
| East Asia | 79.4 | 55.29 |
| Europe | 38.79 | 62.33 |

the cultural differences. Table 18.4 shows the number of discussion board postings during a 12-week course by the student's region. South Asians (SA) post on average 16.25 contributions per participant on the discussion board, East Asians (EA) posted 79.4. A t-test confirms that East Asians post between 57 and 70 more contributions per course than South Asians. East Asian participants post 27–54 times more than Europeans. This is also significant. South Asian post between 17 and 27 more postings than European participants.

Comparing the two main asynchronous communication tools, email (mail read, mail sent) and discussion board (DB posted, DB read), there is no significant correlation between the two tools for East Asian students (Table 18.5). The only significant correlation is between active email sending and reading email. However, looking at South Asian participants in Table 18.6, there are more significant correlations between the discussion board and email volume.

The result indicates that South Asian students significantly use email (sending and reading) and discussion boards in parallel, whereas East Asian students favor only the discussion board. The learning management system (LMS) does not allow

**Table 18.5** Use of communication tools: East Asia

| | East Asia | | | |
|---|---|---|---|---|
| | Mail read | Mail sent | DB read | DB sent |
| Mail sent | 0.561[a] | – | | |
| DB read | 0.153 | 0.121 | – | |
| DB Posted | –0.062 | 0.126 | 0.579[a] | – |

[a]Significant at 0.01

**Table 18.6** Use of communication tools: South Asia

| | South Asia | | | |
|---|---|---|---|---|
| | Mail read | Mail sent | DB read | DB sent |
| Mail sent | 0.738[a] | – | | |
| DB read | 0.269[a] | 0.347[a] | – | |
| DB posted | 0.483[a] | 0.362[a] | 0.436[a] | – |

[a]Significant at 0.01

sending or receiving emails from third parties, i.e., all emails are course related, either being directed to other students or tutors.

Based on the learning management system data, on average the discussion board gets viewed between 1169 (South Asians) and 3136 (East Asians) times during the span of a course, see Table 18.7. This average viewing time per posting per Asian student is 1 min and 18 s. Each discussion board posting is viewed 35 times in total. Given the fact that a typical online course has between 30 and 40 students, each posting gets viewed once per student. However, the high standard deviation indicates that some students view a posting more than once and others not at all. The average viewing time per posting per Asian student is 1 min and 18 s. In contrast, the standard deviation and viewing time of a course with Europeans is around 50% lower, i.e., viewing patterns are more homogeneous and shorter. This might be related to a higher level of English proficiency and a less reflective behavior, indicative of a more direct cultural emphasis.

**Table 18.7** Regional differences in e-learning behaviors: East Asia, South Asia, and Europe

| | East Asia | | South Asia | | Europe | |
|---|---|---|---|---|---|---|
| | Mean | Std. dev. | Mean | Std. dev. | Mean | Std. dev. |
| Session (#) | 95.42 | 95.26 | 69.63 | 59.22 | 39.33 | 72.11 |
| Total time (hours) | 23:20 | 13:11 | 13.01 | 12:35 | 08:20 | 14:20 |
| Mail read (#) | 35.41 | 40.11 | 18.75 | 27.90 | 15.16 | 29.37 |
| Mail sent (#) | 4.18 | 5.67 | 2.16 | 5.73 | 2.04 | 5.28 |
| DB posted (#) | 90.65 | 61.49 | 19.41 | 37.01 | 63.17 | 88.43 |
| DB read (#) | 3136.35 | 6554.20 | 1168.89 | 4890.61 | 2506.74 | 15053.94 |
| Chat (#) | 2.23 | 8.66 | 1.33 | 3.63 | 0.42 | 2.517 |
| Organizer (#) | 141.90 | 138.16 | 182.19 | 132.47 | 69.41 | 120.36 |

As shown in Table 18.7, a session is the period of time between log in and log off. The total time is the hours they spend in learning activities such as reading content, posting, and interaction. East Asians make more use of e-learning tools by logging on to the system more frequently and staying longer online than South Asians and Europeans. A session relates to a specific e-learning activity. The difference in total time spent online during a course between an East Asian and a South Asian student is nearly 10 h. East Asians spend 23 h and South Asians spend only 13 h. The high standard deviation indicates that usage varies within the same regional group. Since all online courses are accompanied by textbooks, the overall time a student spends studying is of course far higher than only their online presence. A t-test shows that all differences are significant. Somewhat surprising is the low number of chats. This might be due to different time zones and work obligations which make real-time communication difficult. There is a difference of 6 h in Europe and $1\frac{1}{2}$–3 h in different parts of Asia. The influence of distance may influence this behavior.

There are fewer differences between Europeans and South Asians than compared to East Asians. Differences in time spent, number of mails sent and read, and working with the online organizer tool are not significant. A t-test shows only the differences in the number of chat sessions, between 0.5 and 1.3, and in discussion board read, between 246 and 2429 (95% confidence interval). The actual time students spend communicating might be higher because the system log file keeps record of chats that have been conducted via the built-in chat tool. However, many students may use their private Instant Messaging (IM) tool such as MSN, Skype, or Yahoo! An important reason for the differences might be that discussion board contributions to the course assessment form part of the overall grade, but chats, unless saved and posted on the discussion board, will not be documented and are not counted as contribution to the course. The cultural explanation might be that grades represent an achievement-oriented value. European and South Asian learners indicate that they are more focused on the specific result (grade) than the East Asian participants because they avoid "nongraded" chats. This is not likely to be related to e-learning experience because all the participants have relatively little past experience in this learning approach.

## *18.2.2 Qualitative Insights*

The findings in this section come from postings on the discussion board.

The board consists of three main parts:

1. Discussions – Peer support and Café (not graded)
2. Discussions – topic related – graded
3. Team discussions – graded indirectly by students via peer assessment

### 18.2.2.1 Café

The Café feature is to stimulate interpersonal sharing and a group identity. It provides insights into the reflection of the participants of what they are learning. In their informal aspects of communication for the Café thread, East Asian participants post intimate/private photos such as lying on a bed with friends of the same sex and sharing pictures after visiting a foreign country as a group. This is an aspect revealing the collective aspects and the affiliation orientation. East Asians continue post when they are on a business trip and cannot participate in the course. This is reflective of high power distance. They also wish each other a happy new year which is consistent with relationship or affiliation. Europeans post mainly jokes, typically being sarcastic or using dark humor. This reflects an individualistic perspective. South Asians rarely post on this type of informal discussion board, which reflects high power distance displayed through an unwillingness to share personal aspects.

### 18.2.2.2 Course-Related Topics

In the formal aspect, East Asians postings are numbered (1., 2., 3. . .., first, second, third . . .) or have at least subpoints. They follow a rigid structure. However, most postings are very short, often two sentences only. This indicates high uncertainty avoidance. South Asians post the longest responses with high variance. Some are very long and others just confirm (“fully agree”). They also like to acknowledge an opinion (“excellent idea,” “great posting”). This is a low-context aspect of communication. Europeans and South Asians typically use induction. They abstract from own work experience to theory while East Asians prefer deduction, with theory applied to a work situation work. In a typical post, they begin with a marketing concept and discuss it in the context of their activities. These characteristics relate to the particular and universal features (see Table 18.2). Asians post a direct answer to a discussion thread with few comments on a colleague’s postings. This is an aspect of high uncertainty avoidance. Europeans reply often to colleagues’ postings which results in deep threading which reflects a competitive cultural value. East Asians often end a post along the lines “Looking forward to having your recommendations” or “what do you think?” This also shows high uncertainly avoidance and a collective view. Europeans and South Asians often want to introduce their own discussion questions (other than the tutor provided). This reflects individualism, low power distance, and a preference for risk and innovation.

To illustrate cases, East Asians cite well-known local or US companies (rarely their own company). Europeans usually use their own company, no matter how small the company, usually with very critical assessment. In every second posting, Europeans show their company in a critical light to learn from it. This also reflects harmony standards that are universal for Asians. They are not critical or conflicting. In contrast, Europeans are more competitive and critical. South Asians tend to be very positive. During 15 online marketing courses for a major Indian software company with more than 500 participants and more than 100 postings related to the company’s branding, only one student felt that the company had some brand-related challenges. Such a positive focus demonstrates a noncritical value orientation and a perception of power distance because belonging to an excellent company increases their status.

Europeans share URLs related to group assignments with everyone, which demonstrates a universal perspective. Asians share only in a team room, which indicates a particular focus. Europeans address very early in the first discussion thread, issues such as CSR or ethics that don’t relate specifically to the discussion question, which illustrates a more diffuse emphasis rather than replying to the focus of the question.

#### 18.2.2.3 Peer Assessment

At the end of the course, students are asked the following question: Please nominate postings (from other students) that you felt were particularly helpful or insightful, indicating the reasons for your choice.

East Asians are motivated to answer and provide detail. Mostly of these participants answer this question. Only 15% of Europeans respond. This difference is an indicator of collective versus individualistic values. East Asians give mostly the same score to each member, which is also an expression of collective values. Europeans sometimes ask to remove an unproductive member from the team. This reflects the achievement value. They communicate this to the team member on the team discussion board, i.e., vent their feelings openly. Asians typically ask the tutor for help and will not post any critical comment on a member in the team room. This is a demonstration of high power distance. Instead, after the submission of group assignment they will give very poor peer scores. These scores count but are not traceable to a specific team member.

#### 18.2.2.4 Communication with Tutor

Another example of low power distance is that Europeans frequently chat with the tutor online. Most of the time it is just a simple question. Asians do not dare to do this. If it happens because the tutor initiates the chat, then it often becomes a very long session with many questions "teacher, what do you think about this and that?" The difference here relates to student centered (low power distance) versus instructor led (high power distance). European students open the chat with a social question like "how is the weather in your city?" This reflects an indirect approach. Whereas Asians will start straight with "Teacher, I don't understand model XYZ – can you explain." South Asian discussion postings show sometimes superficial differentiation so the thread becomes very deep with little specific content. This is consistent with high uncertainty avoidance.

#### 18.2.2.5 Peer Support

*Do you have any tips to share with your classmates on navigating the courseware? Or a query on assignment preparation, perhaps? This is the place to post comments and share your experiences.*

Peer advice gets almost no postings from Asian students. Much of this is because of high uncertainty avoidance and power distance. If students have problems, they email the teacher. The Euro*MBA students post around seven questions/comments under this thread per course. This is very reflective of low uncertainty avoidance and power distance as well as individualism.

#### 18.2.2.6 Current Issues

*Global leaders need to be aware of current affairs. This discussion thread is an open forum for you to discuss what has been going on in the world of marketing management this week. Identify an issue in the news and post your views about it. You can begin this discussion as you soon as you start the course; discussion will run throughout the course.*

This discussion thread generates on average close to 100 postings during a Euro*MBA course, covering all continents and companies. Asian students respond only if the tutor posts a news article first. After 10 postings most discussions end. This reflects the direct and low power distance of the Europeans and the high power distance and uncertainty avoidance of the Asian participants as well as their limited global mindset.

#### 18.2.2.7 Continuous Learning Process

For duration, South Asians and Europeans post before the course has opened and after the course has finished. They are actively involved and want to continue the learning. East Asians stop after the duration of the course. These values are related to active and passive learning. For East Asians, learning is limited to the course only it is fixed based on the content and time of the specific topics. High uncertainty avoiding cultures such as East Asia are more comfortable with specific guidelines and requirements. Learning takes place only within those boundaries. It doesn't continue outside the formal structure of the course.

#### 18.2.2.8 Case Studies and Textbook

Students are given a choice of case studies as part of their group assessment. Each group has to choose one out of three cases which are published in the textbook course. The first case study deals with a European Brewery (Heineken) with supporting of market research data. Case questions also center around marketing research issues. The second case is about a watch (Swatch) and third is on a coffee shop (Starbucks). Most East Asian groups choose Heineken. South Asians and Europeans settle for Swatch or Starbucks with the exception of Dutch students who naturally go for their domestic beer brand. East Asians look for facts and data, whereas South Asians and Europeans prefer more an emotional approach with more freedom to add their own interpretations, rather than using a rigid market emphasis based on data interpretation. These patterns are consistent across different groups of participants, with the same regional profile using the same case studies.

Related to the textbook in which many of the learning activities are available, Europeans regularly complain that the textbook is too American (too many US examples, too shallow). Asians appreciate the easy style of the book and its clear structure. East Asians make more use of online resources provided by the publisher, whereas Europeans don't and East Asians prefer as much information and detail as available. The more detail the better in which they focus all the facts but make no conclusion or assessment. European participants quickly identify an issue and support it with limited evidence, but more assertively. This comparison illustrates the high-context emphasis of Asian participants and the low-context approach of the Europeans. As in all the qualitative analysis, these patterns are developed from the responses of hundreds of participants from the three regions. The analysis is already in-depth from primary sources.

## 18.3 Conclusion

Table 18.8 provides a summary of the learning culture influences on e-learning as determined by the behaviors and the illustrations from the postings related to the course. The quantitative and qualitative findings show two very distinct patterns. East Asian participants represent a high-context learning culture. South Asians and Europeans in this sample demonstrate a consistently low-context culture of learning.

**Table 18.8** Learning cultures

| High context (East Asian) | Low context (South Asian and European) |
|---|---|
| Introvert | Extrovert |
| Modest | Superior |
| Reactive | Active |
| Reflective | Thinks out loud |
| Natural | Exaggerated |
| Reads First | Posts First |
| Data focused | Monolog dominant |
| High frequency | High involvement |
| Group oriented | Individual achievement oriented |
| Team harmony | Critical of peers |
| Deduction | Induction |
| Share knowledge with team | Share knowledge openly |
| Consensus | Conflicts |
| Tutor as leader | Tutor as facilitator |

Participants in the high-context learning culture tend to be less responsive and more reactive in e-learning behaviors. Learners read first, focus on data or facts, and tend to more modest and reflective in responses. They emphasize the group, shared knowledge and consensus. Participants prefer to follow a model or theory through deduction. The tutor is perceived as a leader or arbitrator in the course.

Learners with a low-context learning culture are more outgoing, very active, and respond without much reflection. Participants tend to exaggerate for effect and have a strong belief in the superiority of their ideas. Learners take quick initiative in posting without much interest in other learner responses. They want to be evaluated and are critical of other participants. Learners prefer situations or cases to draw lessons from. They typically share their perspectives with all course members, but encourage confrontation or conflict. The tutor is considered a facilitator who stimulates the participation of the learners.

The cow context culture participant takes initiative, for example, by posting before a course has started or ended or posting their own discussion threads. High-context cultures are more in a *wait and see* reactive mode. In quantity as well as quality, the high-context culture discussion postings have higher volume and more depth. In contrast, low-context culture responses are more provocative and innovative with less detail.

## 18.4 Implications

Based on this analysis, a course leader in an e-learning high-context environment should be aware that students will expect more guidance and initiative than in a low-context culture. The concept of collaborative learning approach fits perfectly in a low-context culture but needs adaptation in a high-context one. These findings have implications for e-learning course design. No one e-learning approach will be suitable for all cultural contexts. This is the expectation of the convergence perspective in which learners are expected to have similar values and behaviors. For these participants this is not the case. Culture does matter and adaptation of e-learning course will need to match the specific cultural features of the participants and the context of their learning culture to be more effective for different learners. This will involve an approach to flexible learning to facilitate an appropriate educational experience.

Learning management systems must be flexible enough to cater for groups from different cultures reflected on the level and type of content, the degree of interaction, the emphasis on direction, and how e-learning is assessed. In a high-context culture, the course leader or faculty will have to spend more time in giving guidance because participants will expect the active direction of the expert. They will want access to extensive information and assignments that will require mastery of that information. Assignments should be group based and require consensus assessments.

For low-context cultures, the course leader can be more creative and interactive to stimulate the learners, for example, by using provocative discussion threads. Content can be in the form of themes or highlights, which summarize and synthesize details with the active involvement of the participants. The learning process is collaborative rather than directive. Assignments should be specific in objectives but open in output or application. They should have clearly understood criteria for achievement to be compatible with a specific learning context. This will facilitate appropriate learning of different types of participants. This doesn't mean that e-learning should only accommodate a specific learning context. Course leaders should also stimulate different types learning to improve understanding across learning cultures. For high-context cultures, learning approaches should enhance spontaneity, creativity, and individual responsiveness. With low-context culture participants, learning approaches should encourage cooperation, collaboration, and communication across members of the same course.

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# Chapter 19
# Case Study on Student Blogs in a Blended Learning Course

**Michael Derntl and Thomas Mazzurana**

**Abstract** While blogs are an established communication channel on the World Wide Web, their use in technology-enhanced education has only recently been gaining popularity. In educational settings, blogs can be used to facilitate the creation of a community of learners, to support students in exploratory learning, reflection of learning activities, and by instructors to follow learning progress and collaborative activities. In this chapter, we present the application of blogs in an undergraduate computer science course on software architectures and web technologies. We provide quantitative and qualitative analyses of blogging behavior and learning outcome data, and provide reflections along with some recommendations on using this Web 2.0 tool in higher education settings.

## 19.1 Introduction

The use of blogs in technology-enhanced learning environments has gained significant momentum lately (Kim, 2008; Yang, 2009). Having emerged as a form of personal web publishing in the late 1990s, instructors have only recently started using this Web 2.0 tool to provide learners with a medium of communication, cooperation, reflection, and journaling (Downes, 2004). As such, it offers valuable opportunities for supporting exploratory learning and facilitating high-quality learning experiences (Fessakis, Tatsis, & Dimitracopoulou, 2008). Basically, a blog is a collection of hypertext postings written by a single author (i.e., the blogger), occasionally by a group of authors. These postings are presented to readers on the blogger's website in reverse chronological order and they typically offer facilities for archiving, hyperlinking, posting comments, and syndication of content (e.g., via web feeds). There are numerous free blog hosting services available on the web; these are generally highly user friendly, hiding all the underlying technology, and

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supporting the blogger in his/her most essential tasks, that is, posting to his/her own blog as well as reading and posting comments to other blogs. Many services additionally offer rich customization options for the own blog, including facilities for maintaining a personal blogroll (i.e., frequently read blogs) or link list, provision of personal information in the user profile, and for integrating third-party services such as weather information and quotes. As Hammond (2006) puts it, “the cost is low and little technical skill is required” (p. 1). Even though the entry barriers to participation in the blogosphere are quite low, the use of blogs in educational contexts is still in its infancy; we currently seem to be in a phase of innovation and experimentation. As West, Wright, Gabbitas, and Graham (2006, p. 60) argue, “we need to continue to move the dialogue past the novelty of (this tool) and toward a solid collection of ideas for using (it) successfully.” This chapter aims to make a further step in this direction by presenting the application of blogs in a computer science course on software architectures and web technologies at the University of Vienna. The chapter aims to share successes and issues encountered during this application by analyzing and discussing information and data on blogging activity, course setting, and student achievement. To provide practical value to readers, we also offer reflections and recommendations drawn from the case study.

The chapter is structured as follows. The following section presents background information on the use of blogs in education. Section 19.3 outlines the course context and setting and how student blogging was embedded into the course activities. Section 19.4 presents and discusses results from quantitative analysis of blogging data. The results of a qualitative analysis of blog content and a student survey are presented in Section 19.5. In Section 19.6, we provide some instructor reflections and draw recommendations from problems and lessons learned. The final section concludes the chapter.

## 19.2 Blogs in Education

Being already established as a web-based communications tool (Williams & Jacobs, 2004; Blood, 2004), blogs have been discovered as a useful means of supporting student activity in educational settings as well (Downes, 2004). Blogs offer various features for facilitating online collaboration, including linking and commenting options. As such, they may be used to enhance the learning experience by enabling the publishing of feedback and reviews by students as well as interaction between learners and teaching staff (Birney, Barry, & O’Heigeartaigh, 2006). Writing of blog postings is capable of triggering (or being triggered by) a reflective thinking process, which is one of the key success factors in self-directed and exploratory learning. In this respect, blogs offer means of keeping a “reflective logbook,” encouraging self-monitoring and evaluation of learning and practice activities (Carroll, Calvo, & Markauskaite, 2006). However, blogs may be used by some students only because they have been instructed to use them. In such cases, engagement with personal meanings, insights, and progress may be low or absent during the writing of blog postings.

Blogging as an educational activity is a novel experience to most students. However, there is evidence that the first-time educational use of blogs is capable of encouraging students to join another blog or at least plan to join another blog (Glogoff, 2003).

Blogs can also be used to track student progress by having students document their activities and “submit” their contributions by means of blog postings (Chang & Chen, 2007). This could be employed as a comfortable way of avoiding the sometimes cumbersome submission and file management facilities implemented by popular course management systems. Social learning and interaction can additionally be unleashed by provision of a joint course blog that offers a place for personal reflection and feedback by others (Hammond, 2006) or an instructor’s blog that students can use to comment and link to their own blogs. It was also reported (Luca & McLoughlin, 2005) that blogs can be used to log reflections and opinions on activities undertaken by virtual teams. For instance, students can be asked to use their blogs to comment on their teamwork activities, e.g., attendance and contribution to team meetings, mutual support of team mates, and other factors and issues affecting teamwork.

From a learner–community perspective, blogs can offer means of finding and analyzing social networks within the learners’ virtual community (Chin & Chignell, 2006). However, this is only possible if networking features such as posting comments and cross-links to blog postings is supported and actually used in a learning activity.

Reviewing previous work on blogs in education revealed that few, if any, studies transparently present the actual blogging guidelines, instructions, or requirements communicated to students. We deem this as an important issue, since the outcomes of using a new educational tool need to be traced back to instructions and facilitative interventions made during the deployment of educational blogs in a course. Therefore, in the next section we present and reflect on the course context and the blogging instructions provided to students of the particular case study presented in this chapter.

## 19.3 Course Context and Setting

The context of the case study presented in this chapter is a third-semester undergraduate module on “software architectures and web technologies” that was held during winter term 2007. The module is part of the bachelor curriculum of computer science at the University of Vienna; it consists of a lecture course (30 class hours total) and a concurrent lab course (30 lab hours total). The student workload for the whole module is about 10 h per week. The lab course was held in a blended learning mode, with face-to-face lab meetings serving as a plenum for assigning tasks, doing hands-on exercises, discussing contributions, solving task- and project-related problems, checking assignments, and presenting team project results. To have topics and background knowledge available for the lab course, the lecture was held in a blocked mode starting in the first week of the semester over 10 weeks with 3 h each. The lab course started 2 weeks into the semester, with 2-h face-to-face meetings held (almost) every week thereafter. The lab course was held in five parallel groups, of which three were held by the first author and thus are under investigation here. The other two lab groups were held in a somewhat different mode by other instructors and are not considered in this chapter. Descriptive data for the three lab groups considered for analysis are given in Table 19.1.

**Table 19.1** Lab groups overview

| | Lab time | # of students | # male/female | Age distribution |
|---|---|---|---|---|
| Group A | Wednesdays, 11 am–12:30 pm | 19 | 15/4 | $M = 23.2$, SD = 2.7 |
| Group B | Wednesdays, 12:30–2 pm | 20 | 17/3 | $M = 22.7$, SD = 2.7 |
| Group C | Wednesdays, 3:30–5 pm | 24 | 18/6 | $M = 25.4$, SD = 5.9 |
| Total | | 63 | 50/13 | $M = 23.9$, SD = 4.3 |

Students had to carry out a number of personal assignments and team project tasks during the online phases of the lab course. They were also active during in-class exercises, presentations, and discussions. The idea was to have them document their efforts as contributed online and face-to-face in their personal blog. So blogging was intended as a special kind of personal journal: it would offer the students space for posting insights, reflections, and remarks on the tasks (e.g., why they were unable to solve a problem); reflection on their project teamwork; and anything else they may consider worthwhile to mention. The instruction for using the blogging tool was given on the course homepage as follows:

> Use your blog to document personal activities in your team, during the assignments, and your contributions during the lab meetings. The blog will be used as input for assessing your contributions in the course and will be co-considered for grading. You need not document each single mini-activity, but note the following rule: any important activity that is not documented in the blog is assumed to have not happened. Try to keep your blog postings brief and insightful, and chose meaningful subjects for your postings.

For most students, blogging was a novel experience. Moreover, no one had previously used a blog in a course of their study. The primary intent in this course was to use blogs in the spirit of *reflective logbooks* (Carroll et al., 2006) to gain insights and comments regarding several aspects:

- With which activities are the students occupied during their search for solutions? Which problems do they encounter?

- Which teams are in trouble? I[1] expected that they would use their personal blog for posting private comments on their team mate's laziness, for instance.
- Which tasks are too difficult given the time frame, and how long are they occupied with the personal assignments and project tasks? This was particularly interesting, since the course under study in this chapter was held for the very first time.
- Any other thoughts, feedback, and opinions on the course that they consider worthwhile.

The blog was integrated into the Faculty's "homegrown" virtual learning environment *CEWebS* (Mangler & Derntl, 2004) and offered two distinct privacy settings for each blog posting: visible to anyone in the course (public mode) or visible to the instructor and author only (private mode). This offering somewhat worked against the community dimension of blogging, as peers were not be able to see the private blog postings of fellow students. Another important note is that our blogging service did not allow posting comments to other blogs.

## 19.4 Quantitative Analysis of Blogging Behavior

Overall, 53 of the 63 students wrote at least one blog posting. The average number of postings for each student is 8.79 ($M = 8$, SD $= 5.26$). The average length of each blog posting was 447 characters (SD $= 214$), which is about the length of the following paragraph. One-way ANOVA shows that there are no significant differences between the three lab groups regarding the number of blog postings ($df = 2$, $F = 0.051$, $p = 0.95$) and the length of the blog postings per student ($F = 0.472$, $p = 0.63$). Also, there were no significant gender differences in blogging behavior regarding number and length of postings. However, there is a significant positive correlation between age and number of blog postings (Pearson's $r = 0.231$, $p < 0.05$), which might indicate that senior students are more open toward sharing their comments and reflections on their course-related activities. Core descriptive data on blog usage is given in Table 19.2.

**Table 19.2** Blog descriptive statistics

| | # of bloggers | Total # of postings | Avg. # of postings per blogger | Max. # of postings per blogger | Avg. posting length (characters) |
|---|---|---|---|---|---|
| Group A | 17 | 147 | 8.65 | 22 | 393 |
| Group B | 18 | 164 | 9.11 | 22 | 406 |
| Group C | 18 | 155 | 8.61 | 19 | 542 |
| Total | 53 | 466 | 8.79 | 22 | 447 |

[1] The first-person remarks in this chapter express the views of the first author, who was also the instructor of the three lab courses under analysis in this chapter.

As noted in the previous section, it was possible to assign the desired privacy mode to each single blog posting. The default setting was “private,” which we would now consider as a mistake: students switched the setting to “public” for only 45 of the 466 blog postings they submitted, that is, about 10%. This fact, in conjunction with the fact that the blog tool did not offer the option of posting comments to other blogs, has lead to a complete absence of the community aspect among bloggers.

### *19.4.1 Temporal Distribution of Blogging Activity*

The temporal distribution of blog postings is charted in Fig. 19.1. The vertical axis chronologically displays each day of the semester (from top to bottom) and the horizontal axis mirrors the number of blog postings on the respective day. The thick

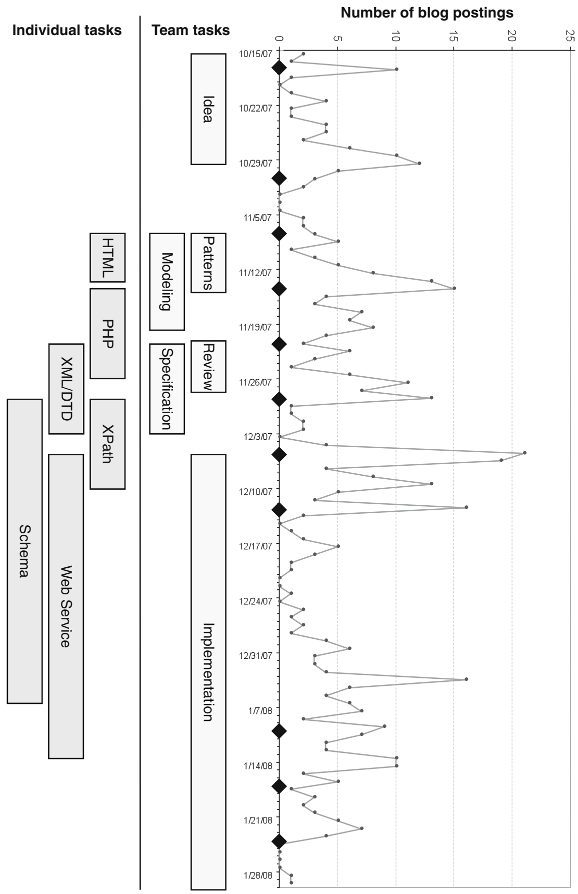


**Fig. 19.1** Temporal distribution of blogging activity (rotated)

diamonds located on the time axis represent days where lab meetings were held. The space to the left-hand side of the plot is used to show the temporal distribution and arrangement of team project tasks (to the right of the separator line) and individual tasks (to the left of the separator line), respectively. For instance, it shows that the elaboration of the project idea (block "Idea") was given as a team task at the beginning of the lab course to be completed until 2 days before the second lab meeting.

The first peak of 10 postings during the first week was caused by some test postings during the lab kickoff meetings. Note that all other peak days are located densely around the end of a given task or just before a lab course meeting. This observation reveals some key characteristics of student blogging behavior:

- Blogging activity was generally not equally distributed over the semester.
- Blogging activity peaks appeared toward the end of tasks (i.e., approaching submission deadline) and/or shortly before a face-to-face meeting of the lab group.

An explanation of this phenomenon could be that students – presumably like all other human beings – tend to tackle problems using some backward calculation from the deadline. This leads to many task-related activities being carried out only when facing the growing pressure of the approaching deadline. In fact, almost all task-related deliverables were submitted on the final day of their deadline. This pattern of behavior also imposes some drawbacks on the handling of student blogs by the instructor, as he/she will mostly have only a short time span to read the blogs and consider their relevant contents, suggestions, and issues to be addressed in the subsequent lab meeting. One remedy to this problem could be a slight deadline adjustment for tasks: When deadlines for tasks are allocated at a couple of days prior to a subsequent meeting, the instructor will have more time to read and deal with blog contributions – given the students submit on time.

### *19.4.2 Correlations Between Blogging Activity and Student Score*

Each student's overall lab course score was computed as the sum of his/her individual score and his/her team score. As displayed in Table 19.3, correlation analysis using Pearson's correlation yields that both the number of blog postings and the length of the blogs have a highly significant ($p < 0.01$) positive correlation with the students' individual and overall course score. There seem to be several possible explanations for this phenomenon; the most obvious one would be that students who perform well on their lab tasks (i.e., receive good score) also tend to comply with the requirement to keep a lab course blog. Another – more subtle – explanation could be that good students, particularly in technology-related and hands-on courses, are more explorative in their learning activities and thus have more interesting things (comments, obstacles, solutions, insights, etc.) to report in their blog.

**Table 19.3** Pearson correlations between students' blogging activity and lab scores

| | Overall score | Individual score (52% of overall score) | Team score (48% of overall score) |
|---|---|---|---|
| Number of blog postings | $r = 0.517, p = 0.000$ | $r = 0.603, p = 0.000$ | $r = 0.217, p = 0.091$ |
| Total length of blog | $r = 0.404, p = 0.001$ | $r = 0.427, p = 0.001$ | $r = 0.233, p = 0.068$ |

A more illustrative view in the form of a scatter plot of number of blog postings vs. the students' overall lab score is given in Fig. 19.2. The plot also includes a linear trend line fitting the data points. In the range between zero and seven blog postings per student, the data do not show any immediately obvious connection between blogging and score. However, it is evident that all students (with one single exception) who posted more than seven blog postings achieved an overall score of at least 75%. This would indicate that the number of blog postings is not a very reliable predictor within the lower posting range, but that it appears to be a good indicator to distinguish between poor to fairly good (up to 75% score) and very good to excellent (more than 75% score) students. In other words, the data show that students who post at least as frequently as the average blogger tend to be very good performers in the lab course as well.

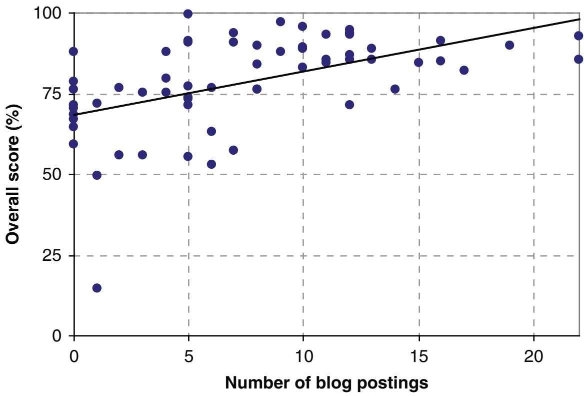


**Fig. 19.2** Plotting students' blogging activity against their overall score

## 19.5 Qualitative Analysis – The Student Perspective

We did a qualitative analysis on the use of blogs in the course on software architectures and web technologies. On the one hand, we performed a qualitative content analysis of student blogs, and on the other hand we distributed a survey among students in which we asked them to respond to questions about the content of their blogs and their opinions on the use of blogs in the course.

### *19.5.1 Qualitative Blog Content Analysis*

We used the qualitative content analysis (QCA) methodology proposed by Mayring (2007) to analyze the text of student blog postings. QCA is a systematic, rule-based and theory-guided qualitative text analysis method, aiming at enhancing objectivity, intersubjective reliability, and transferability of obtained results. The primary tool of QCA is the development of a category system used to allocate text structures (phrases, sentences, paragraphs, and blog postings) to categories.

In a first step, we created a category system based on the potential uses of blogs in education and on the use of blogs in the course on software architectures and web technologies in particular. We decided to look for information on the use of blogs as a documentation and reflection instrument as asked for in the blogging instructions (this includes documentation and reflection of individual work, team work, course-related issues, and blog-related issues); we also included categories relating to the networking and communication aspect of blogs, though we stated at the end of Section 19.3 that community building and communication were hardly possible, given the technological constraints of the tool we used. In a second step, all blog postings were analyzed for text structures that matched categories in our category system. As a result, some new categories were added. For instance, the category "Further plans and open tasks," was added as to the category groups "Individual work" and "Team work" during this step.

The leftmost column in Table 19.4 lists category groups, with concrete categories in the middle column. For each category the rightmost column shows the number of "hits." Note that a hit means that there was a blog posting that matched the category. Each blog posting was counted only once for each category regardless of whether the whole posting or only one single statement within the posting matched the category.

There were a total of 853 hits. The analysis shows that blogs were used by the students mainly to write about their individual and team work activities. Almost half of the hits (401) are accounted for by these two categories, with the majority (66.8%) concerning individual work. Some examples found in student blogs are[2]: "Final completion of the XPath task and submission via the wiki." – "Team 2 met the day after in the Ninth (district of Vienna) to pull two XML schemas out of the hat."

There are three other frequently occurring topics of discussion in the blogs, but they appear clearly less frequently than the two categories mentioned above. The first topic concerns problems related to an assigned task (66 hits). In these postings, students wrote about technical difficulties and problems during getting the work done. For example, "I always receive an error message ... well, 'always' is not correct ... the error comes and goes randomly and I don't know what causes it." Reflections on the requirements are collected in another category with many hits (47); in contrast to the problems, this category relates to the task requirements given

[2] Note that quoted postings have been translated and partly slightly shortened.

by the instructor. "I think that the requirements were easy, although they looked difficult." The third category relates to reflections on completed work, e.g., "I wasn't very imaginative in creating my own (web service) operation." Overall, the reflection categories account for 118 hits for reflection on individual work, 64 hits for reflections on teamwork-related issues, 7 reflections on the course, and 8 reflections on blogging, respectively. So the "reflective logbook" aspect envisaged for the student blogs seems to have surfaced perceivably, since there is a total of 197 hits that refer to reflections on requirements, course material, completed work, own learning, teamwork aspects, the course, and/or on the blogging activity itself.

**Table 19.4** Category system of the qualitative content analysis and the hits per category

| *Documentation and reflection instrument* | | *Hits* |
|---|---|---|
| Individual work | Activities | 268 |
| | Problems related to a task | 52 |
| | Reflections: on the course material | 20 |
| | on the requirements | 38 |
| | on completed work | 55 |
| | on own learning | 5 |
| | Further plans and open tasks | 36 |
| Team work | Activities | 133 |
| | Problems related to a task | 14 |
| | Reflections: on requirements | 9 |
| | on distribution of work in the team | 15 |
| | on completed work | 13 |
| | on concrete team work | 25 |
| | on team work in general | 2 |
| | Further plans and open tasks | 25 |
| Course | Activities | 5 |
| | Reflections on the course | 7 |
| | References: to lecture slides | 17 |
| | to the discussion forum | 13 |
| | to the lab course | 1 |
| | to the lecture course | 2 |
| | to the course wiki | 16 |
| Blog | Activity | 20 |
| | Problems with blogging | 13 |
| | Reflections on blogging in the course | 8 |
| *Networking instrument* | | *Hits* |
| Provision of information to others | Private information | 8 |
| | Information about course content | 15 |
| Communication with others | | 18 |

Other topics were discussed less frequently in the blogs. In some instances (20 hits), students discussed and reflected on the course material: "We found the task difficult due to the lack of (identifiable) components and because the lecture slides were not really sufficient/unambiguous as a source of information." Another finding is that there was only little reflection on the individual learning process (5 hits); an exception would be: "Everything worked well, because I had a lot of fun with PHP programming so I think I learned a lot." Surprisingly, the students often wrote about further plans and open steps to be taken (61 hits), such as: "Tomorrow I'll put more movies into my movies.xml file."

The blogs were seldom used as a means to communicate with other students or the instructor. Sometimes students brought up questions addressed to a specific person. In some other cases, the blogs themselves were the subject of a posting (20 hits). The students mostly wrote that they were currently writing a posting or they referred to technical problems that have occurred.

As a general finding, the QCA shows that the blogs were used by the students mainly in accordance with the blogging instructions given by the instructor. That is, they mostly documented and reflected on their activities and problems, wrote about team work and their individual work. The blogging activity was unable to contribute to community building and communication among students.

### *19.5.2 Student Survey*

After the semester break, we asked the students who participated in my lab courses to answer questions about their opinions on using blogs in the course. The survey was submitted via e-mail to participants. Unfortunately, only eight students took their time to provide detailed answers to these questions:

- Was blogging a new experience for you?
- Did you read blogs of your fellow students?
- Would you have liked to comment on the blog postings of your students (note: this feature was not implemented)?
- To what extent did you feel free in the use of your blog? To what extent did you consider it a duty?

Similar to feedback I already got in the lab kickoff meeting, blogging was a novel experience for most of the students. Most of them had never kept a personal blog: "I was subscribed for a couple of blogs. I've never had one of my own." – "No experience so far, neither as a reader nor as an author." – "I have never had the time to blog and I never knew what to write about." Only one student indicated that he had some experience as an author: "I've blogged over a couple of years, but I gave it up." Some students got in touch with blog in the context of their studies; they used them (as readers) mainly to gather information about specific topics.

The opinions on reading other students' blogs differed significantly. Generally, students did not read the postings of the other students: "No, I wasn't interested in reading them." – "No, I wasn't." – "No." However, some students indicated that they read their colleagues' blogs. Two students occasionally read the postings because they wanted to "To read about the problems other students had." – "Yes, because I was interested in the topics the other students were writing about."

Mostly, students had little interest in posting comments to the postings of their fellow students: "No." – "No, I didn't even read them." Only one student mentioned the opportunity of connecting to other students: "I think it's a good opportunity to share thoughts and experiences with others." Some students indicated that they preferred using the discussion forum to post questions and problems they had.

Another question asked in the survey was whether the students considered the use of their blog as a "duty" or whether they saw the use of the blogs as an opportunity for reflection and expressing thoughts and opinions. The answers differed considerably. On the one hand, for some students it was merely a duty to write postings: "For me it was just a duty." – "An annoying duty to show the instructor my activities." On the other hand, over the semester some students found it more and more interesting and fascinating: "In the beginning it was just a duty. But in the end it was very useful to see how much time I have invested into a task." – "It was very practical to reconstruct the solving of the problems and to look back on the activities."

To summarize, blogging was a new experience for most students. They were not particularly interested in the other students' blogs and just some of them partially read the postings of their fellow students. Also, they were not really interested in commenting other students' postings. A promising finding is that some students found the use of the blogs more interesting the more they had used them. This would suggest that it needs time and familiarity with using blogs until students experience benefits and meaning in this activity.

## 19.6 Reflections and Recommendations – The Facilitator's Perspective

In this section, I reflect on some of the most relevant lessons learned and draw some recommendations as related to my personal experience during the first-time use of blogs in the software architectures and web technologies course.

### *19.6.1 Drawing Information from Blogs*

The blogs offered valuable, sometimes unexpected, insights into how students approach and perceive the tasks given to them and on work distribution among members of a team. I was able to draw different "flavors" of hints from the blogs, as indicated in the following paragraphs.

In a team where all but one member frequently blogged their activities and time spent on the project tasks, I was able to actively seek face-to-face consultation with that team to reveal and try to clarify troubles. For example, consider the following posting: "Three project pages created. Sending them to team mates. We'll meet tomorrow to reach a consensus." Four days later the same student posted: "The meeting didn't happen, because Mr. (name of team mate) claimed he was 'sick'. But just two days ago he seemed to be in best condition during the lab meeting. . . ." Obviously, there were some issues with work distribution and communication in this team. The student who posted these notes was a frequent blogger, while the team mate who claimed to have been sick had zero postings relating to the team project. I was subsequently able to address this issue face to face.

From journal-like postings on time spent on and problems encountered during task activities, I was able to gain insight into the amount of time and work required for completing the tasks. As this was the first time this course was conducted, this should provide help in making adjustments to the course and task schedule (and also resources provided for tasks) while preparing for next year's course. As a simple example of a small issue being capable of causing lots of wasted hours, the following posting made me aware of problems that students have when they connect to our server using different client computers, text editors, and operating systems: "I did all the XML checking in our online tool and everything was valid. Then I uploaded the file onto the server. There were lots of long error messages and I had no idea what caused them . . . . I have a Mac, which seems to use a different default setting for character encoding, so the file was transferred in the wrong encoding. It took a long time before I noticed that encoding was the issue."

Bloggers who posted solutions to unexpected problems they encountered during their tasks and the resources they discovered on the web during their search for solutions provided hints to the most difficult stages in their problem-solving processes. Consequently, I was able to dedicate some time for addressing these issues in subsequent lab meetings. For example, solutions submitted by students were often flawed. However, particularly in exploratory learning the process of creating a solution should be considered with equal weight as the outcome, but it often turns out to be difficult and unreliable to estimate the effort a student put into finding a solution or remedy by assessing the outcome only. Postings like the following can offer help in this respect: "On Friday I started working on the XPath assignment. I took me 5 h to solve some of the queries, and still I do not have working solutions for all of them." The blogger then went on to explain the difficulties and his proposed solutions in more detail, so it was possible to resolve the problems (to the benefit of other students as well) in the upcoming lab meeting. Without such postings, it would be considerably more difficult to select critical task-related issues to be discussed face-to-face, since many students seem reluctant to show initiative in bringing up and discussing their problems and failures in front of the whole lab group.

### *19.6.2 Clearly Communicating Blogging Requirements*

From feedback and discussions on the blogs during the first lab meetings, it became evident that students were initially not completely sure what to post on their blogs, so I explained and clarified the requirements and my expectations during the lab meeting on multiple occasions. One problem was that even I was not completly sure about what to expect from the bloggers given the instructions they were given (cf. Section 19.2). Therefore, I recommend being open, transparent, and consistent in the elaboration and formulation of the blogging requirements both as posted on the virtual learning platform and as announced verbally during the lab meetings. It is also useful to explicitly seek feedback and thoughts from the bloggers during the initial phases of the course. This way, students are given the opportunity to co-create and help in refining the blogging requirements. This kind of involvement in setting goals is one key way of motivating students to participate in the prospective activities (Motschnig-Pitrik, Derntl, Figl, & Kabicher, 2008).

### *19.6.3 Reserving Time for Reading Blog Postings*

It is easy to underestimate the effort required to facilitate the bloggers. With an overall average of a little more than four blog postings per day and peaking at about 10–20 postings per day when deadlines and lab meetings were approaching, it took a considerable amount of time to review the new blog postings and scan them for issues to be addressed in the succeeding face-to-face meetings. The ragged profile of blogging activity distribution is clearly evident from Fig. 19.1 and should be considered accordingly. I therefore recommend dedicating a couple of hours (depending on the number of students) before each lab course meeting to read and consider the most recent blog postings.

### *19.6.4 Increased Responsibility of the Facilitator*

Occasionally, I failed to recognize issues of personal relevance to a student brought up in one of his/her blog postings. For instance, one student posted a brief complaint about my rating for one of his deliverables as part of one larger blog posting. The problem was that I had missed that sentence which had negative consequences: for the rest of the semester this student felt being ignored and his ratings considerably dropped over time due to lost motivation. This issue (and the reason for it) was brought up and resolved only at the final face-to-face meeting when I took some time to consult each student personally about his/her experiences during the course. Offering blogs creates an additional communication channel between students and instructor, which has to be considered with equal importance as the other communication channels, e.g., face-to-face dialog, discussion board, or e-mail. Generally, offering additional communication channels to students also adds to the overall workload and responsibility of the instructor.

### *19.6.5 Support of Community Features*

To enable community-building features of blogging services, we recommend to choose a service that allows posting comments to public blog postings. Additionally, if the service offers both public and private blog postings, we suggest setting public as the default value.

## 19.7 Conclusions and Further Work

In this chapter, we presented a case study on the integration of blogs as a means of student communication, reflection, and documentation of learning activities in an undergraduate computer science course on software architectures and web technologies. Quantitative analysis of data showed that the tool was not used excessively (on average about eight postings per student over the whole semester). Also, blogging activity was not distributed evenly over time but tended to accumulate before deadlines and meetings. This seems to be a relevant finding, because it usually leaves the facilitator with very little time to read and consider the blog postings for a subsequent meeting. Analysis of blogging and achievement data revealed some notable facts:

1. The number of blog postings and the blog length both had a significant positive correlation with the individual and the overall lab course score of the blogger.
2. Blogging behavior (number and length of postings) was gender-indifferent.
3. There was a positive correlation between the blogger's age and number of blog postings.
4. There were no significant differences in blogging behavior between the three lab groups.

The qualitative analysis of blog content showed that students used their blogs mostly for documenting and reflecting on activities and reporting problems they encountered during the assigned tasks. We found no evidence on the usefulness of the blogs as a communication or networking medium; however, this is most likely due to technological constraints in the blogging service, which (a) did not allow to post comments to other blogs and (b) allowed posting in private mode, leading to about 90% of the postings being kept private.

The chapter also included some personal reflections on the experiences from the instructor's or facilitator's point of view, intending to draw some practical recommendations for interested readers and practitioners. The most critical observations include the importance of clearly conveying to students the intent of using blogs in class and the necessity to reserve a considerable amount of time before face-to-face meetings to read the blogs in order to get a picture of the current state of the course's blogosphere and to identify critical issues to be addressed face to face.

Probably, the most notable conclusion we draw from the case as presented in this chapter is that as facilitators in exploratory learning we need to be aware of the fact that introducing another communication and contribution medium also introduces the additional responsibility of considering and addressing the content and meaning transported via that medium. As quoted in the introduction, we need to surpass the attraction radiated by the novelty of a support tool for learning and (a) strive to identify success factors for usage through experience and research, and (b) find and disseminate good practice cases. We hope this chapter contributes to making a step forward in this direction.

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# Chapter 20
# Self-Assessment: An Important Process in e-Training

## A Study Case

**Paola Nicolini, Tamara Lapucci, and Chiara Moroni**

**Abstract** This chapter discusses the concept of training as a process that entails a lifelong learning perspective, especially when it involves e-learning and online activities. Training is a complex process involving cognitive, affective, social, and cultural components. The evaluation of training outcomes is especially challenging. We stress the relevance of self-assessment in the context of the Workshop for Observing Children at School, an experience of e-training at the University of Macerata. In the formative design phase, it seems significant to plan for teachers sharing with participants their evaluation criteria. We show the differences, in terms of curricular results, between versions of the same online course. In the first version, we did not share the assessment criteria with participants, instead we gave that information at the end of the course; in the second, we dedicated a special time to the activity of building assessment criteria as one of the required tasks; in the third version, we asked student to construct a list of criteria to assess the required and then to negotiate their list with ours. The analysis of the three versions of the Workshop shows some differences in the outcomes; it is possible to argue that self-assessment is relevant to e-training effectiveness.

## 20.1 Introduction

Self-assessment is an important process in e-training course both for objectivist and constructivist approaches, however, with some relevant differences.

According to the objectivist point of view, in training processes teachers and trainers provide the useful path to reach one or more established goals. As "knowledge consists in correctly conceptualizing and categorizing things in the world and grasping the objective connection among those things and those categories" (Lakoff, 1987, p. 163), there is only a correct possibility to reach this kind of correspondence

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and only one correct understanding of any topic (Vrasidas, 2000). In this framework, the students are asked to make an active elaboration of knowledge or rather to achieve correspondence between abstract symbols and real world. Evaluation is goal driven (Jonassen, 1992a): The aims of the course and the behaviors expected to be reached by trainees are specified and the assessment is based mainly on learners' training products. Based on this viewpoint, assessment is very similar to a paper-and-pencil test (Bennet, 1998): Trainers ask students to do a final task, and then the students can compare their answers to the correct model. This is an easy way to do an auto-evaluation, which entails identify successful completion of a task. There are software able to provide this kind of control and even feedback (a discussion of this topic is provided in Pear, 2003; Pear & Crone-Todd, 2002; Pear, Crone-Todd, Wirth & Simister, 2002; Rafaeli & Tractinsky, 1989, 1991; Rafaeli, Barak, Dan-Gur, & Toch, 2003).

In a constructivist perspective, the structure of the world is mainly created by the human mind (Piaget, 1970) so that there are multiples realities and knowledge is mostly an interpretive process (Kuhn, 1996). Within this theoretical framework training is a complex process (Prawat & Floden, 1994). On the hand of trainees it has to be considered above all a progressive *conceptual change* (Mason, 2001), that is to say a re-organization of previous interpretations: not a simple growth of information, but a real cognitive and affective development in qualitative terms. The basic role of prior knowledge in training process is evident: Teachers and trainers have to deal with previous opinions, ideas, and judgments made by their students in order to activate new understanding and deeper awareness. The contents of a training course have to be translated into individual competence, which permits the trainees to adequately apply and creatively use their knowledge and expertise (Bednar, Cunningham, Duffy & Perry, 1992; Cunningham, 1992; Cunningham & Daffy, 1996; Gardner, 1991; Mitchell & Andrews, 2000; Resnick, Salmon, Zeitz, Wathen & Holowchak, 1993). In accordance with Bion (1961), the process of *change* can be achieved only on the base of *direct experience* and a *subsequent reflection* on the experience (Knowles, 1973). In addition, training is supposed to be an outcome of social and discursive interactions (Gee & Green, 1998; Hillman, Willis & Gunawardena, 1994; Lapadat, 2000), including both disagreement and agreement (Doise & Mugny, 1981). Furthermore, in the socio-constructivist approach knowledge is considered the result of *construction of meaning* and *negotiation* that happens within social exchanges (Bruner, 1990; Pontecorvo, 1993), so that teaching is not just a simple transfer of information, but it is an active building of data and understanding (Harasim, 1996) situated within authentic relationships and tasks (Scardamalia & Bereiter, 1996, 2002). Taking into considerations these elements, to evaluate means focusing attention not only on the final outcomes, but also and especially on the process through which the results are matched. It is necessary to understand how the students construct their knowledge and in which way they reach the final outcomes because "there is not one correct understanding and there is not one correct way of solving a problem" (Vrasidas, 2000, p. 10). The exclusive use of testing is clearly not adequate to individuate this kind of learning (Lesh & Doerr, 2003; Sternberg, 1997). Accomplishing a meaningful understanding is fundamental to a continued students self-monitoring of their own activities during all the course. Self-monitoring is strictly part of an active participation (Wenger, 1998) in the training process because it allows metacognitive process to run about the effectiveness of individual and collective knowledge construction. Constructivist teachers allow learners to have an active role in the evaluation process (Jonassen, 1992b). Letting learners evaluate their own work provides them with the opportunity to gain ownership of the evaluation process, making them accountable for their own learning (Lake & Tessmer, 1997; Posner, 1995). "Evaluation of one's own work promotes self-reflexive processes, which is another goal of constructivist learning" (Vrasidas, 2000, p. 12). Nevertheless, it is important that constructivist teachers offer a right amount of guidance, in order to avoid the possibility for the students to be completely lost in their learning process (Perkins, 1992; 1998).

Regarding distance education, Moore (1989) recognizes three kinds of interactions: learner–teacher, learner–content, and learner–learner. Because of the same nature and structure of the online courses, the last two elements are preferred. The traditional central role of teacher decreases. Furthermore, it is difficult to have immediate teacher feedback like it can happen for in presence lessons. For all these reasons it is fundamental for the trainees to achieve self-regulation. This process is enhanced by peer review and is made possible through the use of specific tools like forum or collaborative writing. Students both ask questions of and provide feedback to their peers, and should therefore be highly effective at fostering the development of higher-order thinking.

Synthesizing in a constructivist approach training requires at a minimum:

– letting the participants know the possible goals of the training course,
– allowing them to deal with their singular knowledge,
– giving them the opportunity to discuss and confront others' ideas,
– organizing different moments to reflect on their personal learning process, and
– programming times for self-monitoring and self-assessment.

We followed a socio-constructivist framework and those theoretical assumptions in different versions of the same course: the Workshop for Observing Children at School (Nicolini, Lapucci & Moroni, 2007; Nicolini, Moroni, Lapucci & Kinshuk, 2007). The Workshop is organized both in presence and in online modality, according to the same teaching–learning design. Within this training course we increasingly paid attention to the process of self-evaluation, taking into account both the analysis of the outcomes and the participants' contributions to the online activities. We will present the results of the adopted choices in terms both of the learning design and the obtained results.

The chapter is organized as follows. Section 20.2 outlines the characteristic of the Workshop. In Section 20.3, variations of the considered Workshop are illustrated. Section 20.4 provides and discusses some data about the reached outcomes. In the final part, we draw some general conclusions about the topic.

## 20.2 The Design of the Workshop for Observing Children at School

The Workshop for Observing Children at School is an obligatory practical course for students who are planning to be teachers in their professional future. Because observation is a specific competence required to teachers, the Workshop is intended to train competences in observation method. In fact, teachers are supposed to assume a correct approach when observing learners at school. It is clear that anyone can observe children using informal competences and this is the reason why it is important to learn the use of a proper methodology.

The Workshop consists of a system of progressive proposals, both subjective and collective. It is articulated in eight tasks related to specific goals. First of all, the students are asked to give a definition of the term "observation" (activity 1). The goal of this task is to promote the self-explanation process (Chi, de Leeuw, Chiu, & LaVancher, 1994; Pine & Messer, 2000). At this point, the participants are asked to write their first observation text, using the video available online (activity 2). The video represents a real school situation recorded by an external observer. This activity is intended to activate students' daily knowledge and informal competences. The students are then asked to discuss, within the online web forum, analogies and differences realized among the individual observation texts (activity 3). Peers' discussion is finalized to recognize potential limits and errors of the subjective point of view (Vosniadou, Ioannides, Dimitrakopolou, & Papademetriou, 2001). In the fourth activity, the students are asked to negotiate a shared list of indicators for child observation and look for a possible agreement (Doise, Mugny, & Pérez, 1998; Moroni, Smestad, & Kinshuk, 2006). At this stage, the students are invited to read the recommended books so they can have a confront with the theoretical contributions (activity 5). At this point, to come across scientific theories is supposed to be facilitated by the previous recognition and activation of naïve theories. On the basis of the accomplished activities and the apprehended concepts, in the 6th activity the participants have to write a new observation text related to a second school video, also available online. This activity aims to enable the students to experience professional practices in the light of the learned concepts and skills. The participants are then invited to speak about the concluded activity within their group in the web forum, expressing an assessment on the whole Workshop (activity 7). To end the program, the students are requested to send a personal dossier (activity 8) composed of every personal contribution such as forum's interventions, observation texts, assessment of the Workshop, and self-assessment. Collecting and composing a personal dossier is a further strategy planned to promote reflection and metacognitive attentiveness. It is also a way to support a general self-assessment, taking into account both the results and the way they were reached by every student. As it can be seen, all the activities follow in general a learning-by-doing approach (Table 20.1). Reflection on learning process (formative assessment) and learning results (summative assessment) plays an important role in the promotion of self-regulation and of learning process itself. For these reasons we suggest

**Table 20.1** Comparison among different versions of the Workshop

<table>
<tr><th>Activity</th><th>2004/2007</th><th>2007/2008</th><th>2008/2009</th></tr>
<tr><td>1</td><td colspan="3">Write down your idea of “observation” and then an observation text after downloading the videotape available at the URL . . . Publish it . . .</td></tr>
<tr><td>2</td><td colspan="3">First web forum: within your own group find analogies and differences in the individual observational text</td></tr>
<tr><td>3</td><td colspan="3">On the base both of your own observation written text and of the others’ ones, create an individual table containing the necessary and sufficient indicators to make a complete and correct observation written text</td></tr>
<tr><td>4</td><td>Read the recommended handbook</td><td colspan="2">Read the recommended handbook and consider the list of indicators provided by teachers</td></tr>
<tr><td>5</td><td colspan="3">Second web forum: in your own group discuss and negotiate a list of evaluation criteria. Publish it</td></tr>
<tr><td></td><td colspan="2"></td><td>Using the negotiated list of indicators, do an auto-evaluation of the observational text written as first task</td></tr>
<tr><td>6</td><td colspan="3">On the base of completed activities and apprehended concepts, make by yourself an observation text related to videotape available at the URL . . . Publish it . . .</td></tr>
<tr><td>7</td><td>Express a self-assessment of your work and write down an assessment of the whole Workshop, too</td><td>Consider the list of indicators provided by teachers and then express a self-assessment on your first and sixth work. Write down an assessment of the whole Workshop, too</td><td>Express a self-assessment of your first and sixth work using the evaluation criteria shared with both the trainers and the other students<br>Write down an assessment of the whole Workshop, too</td></tr>
<tr><td>8</td><td colspan="3">Send a personal dossier to the faculty composed by written texts of every task (exercises, forum interventions, observation texts, individual and collective tables, assessment of the Workshop, and self-assessment)</td></tr>
</table>

to employ activities of *reflection on the spot* immediately after every task such as discussions, exchange of opinion on the learning experience, and active listening of different points of view. A *final reflection* is also planned, in which the participants are asked to review the whole learning path and to self-evaluate their conceptual changes, if they occurred. The request to gather and organize the tasks, the contents, and the different stuffs related to the Workshop participation is a way to meet the different learning styles of the learners (Moroni & Nicolini, 2008). The final dossier is not really a portfolio, but it is a tool working in a quite similar way, that is to say to document and provide evidence of learning processes and outcomes.[1]

In each version of the Workshop, the students were asked to create a table containing the necessary and sufficient indicators in order to write a complete and correct observation text so that they can activate the possibility of self-monitoring their tasks. But in the first version of the Workshop, the self-assessment phase was simply organized as an individual restructuring of the entire path. The participants were requested to have a look at their own activities and then to write a free text in order to express their opinions about the reached outcomes and the learning experience. The teacher and the tutor made their final evaluation by comparing the first task (activity 2) with the last one (activity 6): If the course was effective, the second text would be better than the first one and it should contain the typical characteristics of an expert approach. The evaluation took in account also the quantity and the quality of the other kind of contributions, like the interventions in the web forums and so on. The result was expressed in the form of a curricular judgment and soon after communicated to the participants.

During the academic year 2007/2008, we tried to better involve the students in the evaluation process explicitly introducing in the seventh activity our assessment criteria. The students were allowed to know and to use the list by themselves in order to recognize their possible improvements or mistakes. In this way, the evaluation process became an important part of the learning process itself.

In the last academic year, we published our criteria of evaluation since the fourth activity. This change in the learning design allowed the students to conduct by themselves the comparison between their first observational text and the last one. This kind of exercise activates additional metacognitive processes on their own participation in the Workshop.

The table below (20.1) synthesizes the differences just discussed.

The kind of evaluation the Workshop needs is goal free (Scriven, 1983; Jonassen, 1992b), so that it is impossible to simply provide a correct model to which to refer in order to make a comparison (Linn, Baker & Dunbar, 1991).[2] Nevertheless, differences between naïve and expert way to conduct an observation task can be clearly outlined. We will now illustrate the necessary criteria to establish the changes from the first observation text, which is suppose to be written in a naïve way, and the last observation text, which should be written in a more expert style. The complete inventory is shown below (Table 20.2).

The evaluation criteria elaborated by trainees – as one of the requested task of the Workshop – are not so different from the ones found by trainers.[3] Two examples of observational texts are soon provided. They were elaborated by the same student respectively at the very beginning and at the end of the course.

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[1]Portfolio represents a curricular document where metacognition of students is indispensable to select and choose the relevant and significant documents of their educational experience, including evaluations and self evaluation.

[2]According with authors like Wiggins (1998) or Varisco (2004) we use a blended assessment system, applying both qualitative and quantitative evaluation strategies.

[3]The indicators are quoted from the students' works.

**Table 20.2** Differences between naïve observation text and expert observation text

| Naïve observation text | Expert observation text |
|---|---|
| **Text structure** | |
| Short and free | Long and structured (titles, paragraphs, bullet points, tables) |
| **Context** | |
| Absence of information about video tape duration and observational method adopted | Presence of information about video tape duration and observational method adopted |
| Absence of information about the focus of attention and the aim of the observation | Presence of information about the focus of attention and the aim of the observation |
| Mishmash of descriptive and interpretative data | Separation between descriptive and interpretative data |
| Absent or incorrect use of textbook references and quotations | Presence of textbook references and quotations |
| No references to concepts coming out from the book or the forum | References to concepts coming out from the book or the forum |
| **Linguistic expression** | |
| Presence of generalizations, abstractions, deductions without argumentations, and all-encompassing conclusions | Presence of analysis of events and concrete objects, with argumentations; conclusions supported by descriptive and concrete elements; references to details |
| Use of his/her own point of view as an absolute one | Use of his/her own point of view as a relative one |
| References to unobservable data such as thoughts, feelings, and intentions of the observed subject | References to observable data such as actions, verbal and nonverbal languages of the observed subject and observer's internal world |
| Use of impersonal linguistic forms | Use of personal linguistic forms |
| Lack of cognitive verbs | Explicit use of cognitive verbs |

### *20.2.1 Example 1: An Observation Text at the Starting Point*

This videotape presents two children playing together with a table, in a free context, in an Infant School. They establish a cooperative atmosphere, both of them are engaged and both are helpful, trying to attain the same result/success: to put some pieces in the table following a criterion. Actually it seems neither one dominates the other, although there is always a leader in every situation, in this case the child who adds the toy pieces. This kind of playing expresses cooperative intelligence, or rather the child skill of cooperating with others, of helping, of receiving help, and of accepting or asking for it, consequently respecting the other. This situation leads the children toward knowing themselves, since they can discover their limits. At the same time, it expresses bodily kinesthetic intelligence which is the skill of using the body to work with objects that require fine finger movements. Finally, there is an atmosphere characterized by joy, cheerfulness, curiosity, hope for mutual success, and empathy.

We consider the above text to be naïve because

- the student produces generalizations such as – *there is always a leader in every situation*;
- there is an incorrect use of text references – *This kind of playing expresses cooperative intelligence, or rather the child skill of cooperating with others, of helping, of receiving help, and of accepting or asking for it, consequently respecting the other*. In this case, with regard to the content, the theoretical citation is correct. Nevertheless, it is not coherent with the actions of the children in the video;
- the personal point of view is expressed as an absolute one – *there is an atmosphere characterized by joy, cheerfulness, curiosity, hope for mutual success, and empathy*. Actually, feeling an atmosphere is a very personal thing, which means that different people might experience a different atmosphere in the same situation;
- there are references to unobservable data such as thoughts, feelings, and intentions of the observed subject, like in the phrase – *joy, cheerfulness, curiosity, and hope for mutual success and empathy*;
- over all there is no separation between description and interpretation – *This situation leads the children to know themselves, since they can discover their limits*.

### 20.2.2 Example 2: An Observation Text at the End of the Course

Regarding the cognitive, social, and effective development of the children in the videotape, I could recognize the relationship between children and objects. Children are playing with a puzzle that they have to construct in order to compose a series. According to Piaget, the child forms concepts through action, even if the action is guided by the adult. One of the phases during which the relationship between children and objects develops consists of the identification of object functions and the attribution of meaning to them. Through the videotape I could understand:

*The Observer*: He/she doesn't participate in the activity, because he/she is engaged in video recording.

*Observation Subject*: Two children are present, engaged in a free-time activity, which in this case is completing a puzzle. The puzzle is composed of four kinds of figures: monkeys, bears, elephants, and giraffes.

*Scene*: The videotape is recorded in a section of *an infant school*, where I can see low yellow tables used by the children as a base for the puzzle. The floor is blue and behind the tables, on the wall, there are shelves with several toys and didactic objects.

*Observation Modality*: Video camera
*Observation Duration*: 1 min and 14 s
*Start/End Time*: I don't know the start/end time

*Contemporaneous Factors*: In the section I can see other children engaged in other activities. A child is disguised with a long skirt and a bag; other children are running in the room, and some are engaged at the yellow tables. I couldn't distinguish the dialog among the children, because there are voices and noises.

*Behavior Description*: At the beginning, the video camera frames only a child (A) with a light jumper. He's engaged in completing a puzzle. After a few seconds, a child with a red jumper arrives (B), holding a piece of the puzzle in her hand. She puts it in the first line. A observes the object placement, saying something and he places other figures. A collects all of the elephant figures in the third line, while B is moving to the left keeping in her hand three pieces. B observes the composition, waits a little and then shows the puzzle in his hand to A. B points to a place on the table, saying: "You have to put this figure here." A tries to take the piece that B is keeping in his hand [. . .]

*Hypothesis and Conclusions*: The atmosphere is positive, the children seem to appreciate the activities.

The above text can be evaluated as an expert one because

- It is a long and structured text.
- There are details about duration and observational method adopted.
- The focus of attention is intentionally declared – *I could recognize the relationship between children and objects*.
- There is a clear separation between description and interpretation of data.
- There is a coherent and correct reference to scientific theory, like in the quotation of – *Piaget.*
- There are particulars and conclusions supported by descriptive and concrete elements.
- There are references to observable data such as actions.
- The student uses overall personal linguistic forms.
- There are cognitive verbs such as in the expression – *I couldn't distinguish.*

## 20.3 Outcomes of Workshop for Observing Children at School 2006/2007

In this section, we will focus our attention on the outcomes of the 2006/2007 version of the Workshop. The sample was composed by 88 participants, all Italians, mostly from central and southern Italy, and already graduated (57). Thirty-one had only a high school diploma. The youngest student was born in 1985, while the eldest in 1961.

With regard to the final outcomes, we could observe that among 88 participants:

- 23 students, or 26% of the sample, had an excellent evaluation.
- 31 students, or 36%, had a good evaluation.
- 25 students, or 28%, had an average evaluation.
- 9 students, or 10%, had a sufficient evaluation.

In other words we can say that half of the participants received a good assessment, the third part reached an excellent appraisal, and the others were in the average or even less.[4]

We can also provide the results about the shift from the initial observation text and the final one (Table 20.3). Looking at the data, a general improvement can be observed, as in the second observation task the low-quality texts decreased and the high-quality texts increased.

**Table 20.3** Outcomes of the online workshop 2006/2007

| Online Workshop 2006/2007 | | |
|---|---|---|
| Initial observation text: tot. 88 | | |
| Low quality: 34 (39%) | Medium quality: 46 (52%) | High quality: 8 (9%) |
| Final observation text: tot. 88 | | |
| Low quality: 10 (11%)<br>–24 | Medium quality: 35 (40%)<br>–11 | High quality: 43 (49%)<br>+35 |

From a qualitative point of view, in the final dossier we found comments like the ones below.

> I think this Workshop was extremely useful because it provided us with some tools intended to correct potential errors in the interpretation of child behaviour. The starting point was the observation of a videotape to enable us to become aware of own way of observing. The exchange within small groups allows us to discuss the work and to deal with different points of view. In my opinion such a practical way allows the student to reflect and to correct his/her own errors, as theory on metacognitive didactics suggests.

In the above comment, the participant produces a general reflection on the course, showing an understanding of the aim of the whole activities.

> I consider it difficult to express what I learned because I often emphasize the absence more than the achieved objectives. Nevertheless I think the Workshop allowed me to put in practice what I knew only in a theoretical way.

In her remark, the student points out a very important fact: The assessment is often considered a way to underscore deficiencies and problems more than a method to appraise achievements and reached goals. This is a real problem for self-assessment too.

> I think that I learned different aspects of observation methods which I didn't know [. . .]. I want to be sincere: after a first moment of dismay, I began to think about what to do, how, in which way and with whom. The next task of videotape description required time in order to translate the images into language. I'd like to know if that description was correct, if there were errors and if so, of which kind, in order to be able to avoid them in the future.

[4]The evaluation was conducted by two blind researchers. The percentage of agreement was 93%. In the case of disagreement a third informed researcher was involved.

In the last text, the student enlightens the need to have precise instruments of self-assessment in order to comprehend her own errors and, above all, to correct themselves in the future.

## 20.4 Outcomes of Workshop for Observing Children at School 2007/2008

In this section we focus our attention on the outcomes of the 2007/2008 version of the Workshop. The sample's characteristics are very similar to the ones documented in the preceding version. In fact there were 125 participants, all Italians except 1 foreigner, 69 from south of Italy and 54 from the center. The birth year range was ample (1956–1985), and there was a big percentage of students who had graduated from college. Of the 125 students in this sample, 95 had a university degree, and 30 had only a high school diploma.

With regard to the outcomes we recorded an improvement compared to the preceding version. In fact, of 125 participants:

- 47 students, or 38% of the sample, had an excellent evaluation.
- 57 students, or 45%, had a good evaluation.
- 12 students, or 10%, had an average evaluation.
- 9 students, or 7%, had a sufficient evaluation.

The excellent results had a considerable increase: from the 29% of 2006/2007 to the 38%. At the same time the sufficient evaluations slightly decreased (from 10 to 7%). The table below illustrates the qualitative differences between the initial observation text and the second one.

Also, the comparison between the data presented in the Table 20.3 and those illustrated in the Table 20.4 shows better results in the observation task.

**Table 20.4** Outcomes of the online workshop 2007/2008

| Online Workshop 2007/2008 | | |
|---|---|---|
| Initial observation text: tot. 125 | | |
| Low quality: 39 (31%) | Medium quality: 65 (52%) | High quality: 21 (17%) |
| Final observation text: tot. 125 | | |
| Low quality: 8 (7%)<br>–30 | Medium quality: 49 (38%)<br>–17 | High quality: 68 (55%)<br>+47 |

It can be hypothesized a positive correlation between the general results of the students and the choice related to the self-assessment we already discussed. In fact, in the academic year 2007/2008, in the final phase of the course, we added the list of indicators in which we distinguished between typical expressions of a naïve approach and typical expressions of an expert approach to observation. The list was provided in order to help the students to accomplish a more specific and punctual self-assessment of their learning products. The list is the same one that we used to express the evaluation in the form of a final curricular judge (see Table 20.1). The list of indicators also contains examples to contextualize and make them understandable.

Using the table of indicators, the students are able to identify their own errors and, in some cases, to propose a correction or an alternative, as the following comment illustrates:

> Reading the indicators, I actually realized that in my last observation text the indicators of adequate linguistic translation were not present. Through the discussion with my colleagues, I was convinced that a correct observation was an observation without interpretation, instead the interpretation has to be done, but expressed in a correct linguistic way.

The student clearly appreciates having the criteria as a resource for self-evaluation, because she could find indicators and examples of naïve and expert approaches through which to analyze and understand errors in her own works. Metacognitive activity is also evident in another dossier, in which a student gives details of her judgment of the Workshop.

I used the following criteria to evaluate this workshop and to assess my personal learning course:

- coherence between aims and results,
- evaluation of my personal will, and
- evaluation of team work with my colleagues.

She continues with interesting hypotheses about the aims of the workshop design.
I think the aims of this workshop were:

- orientating reflection with spontaneous observation,
- improving existing abilities, and
- helping the change from naïve approaches to systematic approaches to observation.

In addition, she declares that she connected new information with her previous knowledge and speaks about her personal vision about the expert way to write an observation text.

The central topic [of this Workshop] is observation. We can better state "meta-observation," that is to say observing how you observe. In my opinion, to observe in a systematic and competent way, every teacher needs

- knowledge of theories and techniques,
- a lot of practice, applying the theory,
- exchanges with colleagues, and
- exchanges with experts.

She goes on using the indicators schemata to distinguish some limits in her final observation text.

> I believe that I didn't recognize the context indicators in the final observation text. I didn't define the observation focus, since the task did not specify. . ..

Finally, she analyzes the teaching–learning methodology, underlining the positive points of the Workshop and focusing her attention on her personal learning.

I appreciated:

- the videotapes, the possibility to put in practice the observation techniques [. . .],
- the activity of sharing with the colleagues, the realization of a common tool, even if in my opinion it is more the result of a sum of opinion than a true shared construction of knowledge.

I learned:

- I noted that fundamental for a future teacher is observing, communicating, listening, and interpreting, because the teacher has not only a cultural power, but she/he plays a role in the transmission of life principles and in the development of identity of students [. . .].

In these statements, the importance of self-evaluation can be noted: The student seems to produce a deep reflection, in which she considers not only her own results, but also her participation in the whole process. She shows understanding of the role of the obtained competences, linking them to professional future.

Another participant's final reflection is provided below:

> Using the indicators table I noted that in my final observation text some characteristics of the expert approach are present. At the same time I believe that this product does not have all the adequate elements. In fact, my first observation text was built using an unstructured text, because I couldn't connect the several parts of my work. Instead, in the second text I used some of indicators of the shared table created within my team group. Nevertheless, I didn't specify the aim of my observation, and I didn't propose hypotheses, because I believed that it wasn't necessary. Reading again my final text, I noted that I persisted in using an impersonal linguistic form ("The presence of adults is not visible". . .) mixed with personal ones ("I can't speak with certainty").

The participant confirms the importance of knowing the criteria of evaluation to achieve informed self-assessment. The criteria offer a way to create a bridge between cognition and metacognition to attain an effective conceptual change: In fact, using the schemata to compare his works, this student seems to understand his improvements and his mistakes. He provides quotations of his text, showing evidence of correct and incorrect linguistic expressions. At the same time, beginning with the use of the criteria schemata, he does not limit his analysis to the observation text: He tries to understand the reasons for his progress and his continuing errors, reflecting on the learning process and recognizing the useful role of the group.

Finally, we quote the last part of another dossier:

> The self evaluation was another opportunity for reflection, especially because the schemata of criteria orients our thinking. When I read the table that distinguishes between naïve and expert approaches, I thought "I didn't hit the aim of the workshop with my final observation text". If I could do the observation text now, certainly my text could be different! I judge the Workshop in a positive way, because of tangible evidence of an improvement in my competences [. . .]. Many of us claimed the teacher's direct supervision [. . .]. I realized that the table offers several examples about expert approach, so everyone can understand his/her own errors, even if this happened at the end of the course. Reflecting about my mistakes, I realized the importance of working in a group. The individual work was useful as an input to help the content to develop, but the development occurred through the peers' discussion.

## 20.5 The Outcomes of Workshop for Observing Children at School 2008/2009

We now show the outcomes of the 2008/2009 version of the Workshop. Because of the gains in the previous version, in 2008/2009 we decided to anticipate self-assessment and we shared our evaluation criteria in advance with trainees. We thought it could be useful to engage them in the task of writing a complete and correct observation text providing them with the list of our criteria.

The course ended only in February 2009 and we are still collecting the data so that our analysis is preliminary. It is based on a sample of the texts produced by the students. Of the 220 participants, we have now analyzed the work of 135 subjects. Like in the previous versions, we note very similar characteristics in the composition of the virtual class of students: most of them are adults, already employed, with a university degree.

The improvement of observation skills among this group is evident. The percentage of students who reach an excellent curricular evaluation is higher than in the previous years.

Of 135 participants:

- 102 students, or 75% of the sample, had an excellent evaluation.
- 25 students, or 19%, had a good evaluation.
- 4 students, or 3%, had an average evaluation.
- 4 students, or 3%, had a sufficient evaluation.

The comparison between the initial observation text and the final one also shows some changes illustrated in Table 20.5 .

The high-quality observation texts highly increase with respect to the other version of the Workshop and the low quality continue to decrease. To share the evaluation criteria in the first part of the course with the students seems to be useful to engage them in the task of writing a complete and correct observation text. In addition, from a qualitative point of view, some students clearly affirmed in their final dossier that they could understand their errors along the time of the course:

**Table 20.5** Outcomes of the online workshop 2008/2009

| Workshop 2008/2009 | | |
|---|---|---|
| Initial observation text: tot. 135 | | |
| Low quality: 62 (46%) | Medium quality: 57 (42%) | High quality: 16 (12%) |
| Initial observation text: tot. 135 | | |
| Final observation text: tot. 135 | | |
| Low quality: 4 (3%) | Medium quality: 18 (13%) | High quality: 113 (84%) |
| –58 | –39 | +97 |

Comparing the observation text done at the beginning of the course with the one done at the end, I noted a lot of differences. I understood these differences using both the indicators negotiated with my group and the indicators offered by the trainers (I noted several common points between the two lists). I believe that the second text is better than the first one because I can identify the typical indicators of an expert approach. For example, using the Structure indicators I can see that my final observation text is long and structured. At the same time I can answer the questions negotiated in my group (Who observes? What do you observe? How do you observe? When do you observe? Why do you observe?)
Through the self-assessment and the comparison between the two texts, I discovered by myself the difference between a naïve observation and an expert one, and understand how my own thinking change.

## 20.6 Conclusions

Our research provides some arguments about a constructivist way to evaluate learning processes. We intended to stay away from a single-way communication flowing from teachers to students. At the same time, we tried to avoid using constructivism as a low-structured framework, in which predefined learning goals or a learning method is considered somehow interfering with students' construction of meaning (May, 1975). As we anticipate, we changed our way to conduct the Workshop along the last academic years, trying to progressively involve students in the evaluation of their own activities. In fact, it could be a difficult process as well as the problem solving is goal free, that is to say there is not only one correct way to match the results of a training course.

The study case seems to yield two outcomes. On one hand, the production of a clear negotiated list of criteria seems to enable students in the identification of their changes from the beginning to the end of the training course. The changes can be considered by trainees themselves in terms both of acquired knowledge and over all of gained competences in the observation method. The list of criteria represents a point of reference, not a closed and absolute evaluation tool, because the knowledge is not unique and absolute but continually constructed and negotiated by the interactions among trainers, trainees, and the contents provided through the suggested readings.

On the other hand, the work underlines the importance to share with students the criteria of evaluation used by trainers as soon as possible along the learning path, maybe from the starting point. In fact, this strategy seems to allow an aware involvement of the students in the whole training process. In addition, they are enabled to recognize by themselves their own possible conceptual changes. In this way, the divergence between trainers and trainees, who usually have different structures of knowledge and competences, seems to decrease (Nicolini, Lapucci, & Moroni, 2008a) and the teaching–learning process can develop in a more collaborative figure.

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# Chapter 21
# A Design Framework for an Online English Writing Course

**ChanMin Kim, Anne Mendenhall, and Tristan E. Johnson**

**Abstract** This chapter proposes a design framework that applies Merrill's first principles of instruction to an online college English writing course. The framework consists of five interrelated principles grounded in learning and instructional theories and research; it emphasizes task-centered instructional design. In addition, as a way of learners' practice and evaluation of writing within a task-centered approach, the use of peer review is articulated in the framework. Moreover, the measurement of learners' mental models is also described with its benefits on the provision of feedback on individual learning progression. The framework provides solid directions for research and development for the improvement of English writing.

## 21.1 Introduction

Teaching college students to acquire essential writing skills is a critical requirement but often quite challenging. Professors acknowledge pervasive and persistent writing deficits, but they are often hesitant to teach remedial writing skills as it is very time-consuming and typically not related to core course objectives (Fallahi, Wood, Austad, & Fallahi, 2006). In spite of the recognized need to improve students' writing skills, general college students are required to take one or two composition writing courses, which is insufficient to prepare them for successful communications in other courses and for the workplace (McCannon & Crews, 1999). While this chapter addresses this problem in the context of American colleges and universities, our review of the literature suggests that this is a common problem in other countries as well. The solution we present here involves a task-centered approach in an online course environment.

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Many college writing courses tend to incorporate *a topic-centered approach* teaching separate elements of writing skills (Campbell, Smith, & Brooker, 1998). That is, the courses tend to teach the topics of grammar, syntax, use of punctuation, spelling, and so on as isolated skills. Such a topic-centered approach emphasizes discrete skills rather than the integration of skills into the purposeful, content-focused writing. However, deficits in college students' writing are less related to problems of mechanics and basic skills (Campbell, Smith, & Brooker, 1998) and more related to holistic writing issues. Typically, deficits arise from the inability of students to put basic writing skills into the context of coherent and well-reasoned essays and papers. For example, even without grammatical errors, students' argumentative essays could be weak because of their incapacity to contextually make use of the mechanics and basic skills required to develop extended arguments and provide supportive evidence for their arguments.

An alternative to the discrete grammatical skill approach is *a task-centered approach* that teaches writing skills in the context of meaningful tasks that are relevant to students' academic, social, and personal needs (e.g., writing a lab report, participating in political blogs, writing a letter of interest for a job, summarizing the current personnel situation in an organization, etc.). There have been a few attempts at task-centered instructional strategies that enable students to retrieve, apply, and transfer writing skills introduced in course assignments to post-college situations (Friedman et al., 1995; Warfield, Johnstone, & Ashbaugh, 2002; Weber, 2001).

Friedman and his colleagues (1995) used controversial social problems (e.g., abortion debates) as writing tasks in a college composition writing course. The researchers aimed to help students improve their abilities to find information, use it for their arguments, and write and support their positions, in addition to teaching writing skills and techniques while working on such tasks. Weber (2001) utilized a task-centered approach in an English legal terminology course. Actual model legal essays were used not only to facilitate law undergraduates' active involvement in essential tasks that they are given in professional practices but also to teach genre-specific lexical expressions, grammatical constructions, and structural features. However, these studies provide little theoretical or empirical foundations to explain their instructional strategies; rather, they report intuitive practices, which are difficult to replicate and confirm in other contexts. Moreover, none of these studies involve the use of any educational technologies.

Warfield, Johnstone, and Ashbaugh (2002) compared the effects of contextual-writing experiences (i.e., a task-centered approach) with general-writing experiences on the development of college students' writing skills. They found that contextual-writing experiences providing practices in an academically and professionally relevant task domain, which was accounting in their study for the participants from the school of business, improved students' writing skills than general-writing experiences. Although the researchers explain their theoretical foundations with expertise development and a cognitive process theory, they do not seem to articulate how their task samples for the contextual-writing experiences are related to the theoretical foundations. Thus, it is difficult to apply their conceptual basis of a task-centered approach to the design and development of college English writing courses in other contexts, except for the case of accounting with the exact same tasks given to their study participants. Moreover, none of this research has been applied in an online course environment.

Given these gaps, the purpose of this chapter is to present a design framework pertaining to a conceptual basis that can be applied to an online college English writing courses within a task-centered approach. The design framework is constructed based on Merrill's (2002, 2007a) first principles of instruction. The framework consists of five interrelated principles grounded in learning and instructional theories that emphasize task-centered instructional design. Considering learning and instruction theories are "a source of verified instructional strategies, tactics, and techniques," the framework is expected to answer for the decisions of researchers and practitioners on the design and development of college English writing courses for purposeful learning (Ertmer & Newby, 1993, p. 51). In addition, since Merrill's first principles of instruction aim to integrate "component knowledge and skills acquisition with the doing of complex tasks" (Merrill, 2007b, p. 34), his task-centered approach is appropriate to be implemented for teaching English writing, which is too complex to be done only with knowledge and skills acquisition without the actual doing of writing.

Another purpose of this chapter is to illustrate how to apply a task-centered approach to online learning and instruction environments. The focus here is on an online English writing course; in the past, such courses have been almost entirely focused on drill and practice of basic skills without much emphasis on holistic, coherent writing skills. There is a need for guidelines to design and develop online English writing courses that enable students to learn and practice basic skills in the context of the overall writing process and not as mere rules to be followed. The design framework grounded in Merrill's (2002, 2007a) first principles of instruction responds to this need, partly because the design framework is easily adapted for online contexts. Although the design framework presented here is for online environments, as Spector & Merrill (2008) argue, the general design principles for online and classroom instruction remain the same when the focus is on designing effective, efficient, and engaging instruction; consequently, the framework could be useful also in classroom and hybrid settings as far as practitioners and researchers aim effective, efficient, and engaging instruction for college English writing.

In brief, this chapter proposes a framework that applies Merrill's (2002, 2007a) first principles of instruction to an online college English writing course. The framework consists of five interrelated principles grounded in learning and instructional theories and research; it emphasizes task-centered instructional design. In addition, as a way of learners' practice and evaluation of writing within a task-centered approach, the use of peer review is articulated in the framework. Moreover, the measurement of learners' mental models is also described with its benefits on the provision of feedback on individual learning progression. In the following sections, the framework will be presented according to the five principles along with design examples of a college online writing course that the authors of this chapter with their team preliminarily designed within the framework along with the description of peer review and measurement of mental models. It is expected the framework will provide solid directions for research and development for the improvement of English writing, especially in online learning environments.

## 21.2 A Design Framework for the Application of a Task-Centered Approach to an Online English Writing Course

### *21.2.1 The Design Framework Highlight #1: A Cycle of Interrelated Instructional Phases*

The design framework for an online English course is described in terms of Merrill's (2002, 2007a) principles and their applications that form a cycle of interrelated instructional phases (i.e., activation, demonstration, application, and integration) implementing real-world tasks. The following sections introduce each of the principles and elaborate it with the rationales and examples of an online English writing course preliminarily designed by the authors and their team.

#### 21.2.1.1 Principle 1: Task-Centered

Learning is promoted when learners are engaged in solving real-world tasks (Merrill, 2002).

Merrill (2002) argues that tasks relevant to real-world situations should be provided for learning and instruction. As mentioned in the previous section, this principle is beneficially applicable to an English writing course, which needs to move to a task-centered approach implementing problems or tasks relevant to students' academic, social, and personal needs. Research has shown that the context of real-world tasks could effectively motivate students and help them retrieve and apply their acquired skills and knowledge to other contexts as well (Mendenhall et al., 2006).

In fact, motivation and knowledge transfer are critical in the education of English writing for college students (Pugh & Bergin, 2006). Even when college students are extrinsically motivated by the credits and grades, they often lack intrinsic motivation. Typically, students view most college writing courses as an academic hurdle to be overcome since they are required for most majors; typically, courses are designed as academic hurdles and not designed to cater to specific interests of students (Kim & Keller, 2008). The provision of relevant tasks to students' academic, social, and personal interests could intrinsically motivate them by drawing their attention and highlighting the usefulness of the skills and knowledge taught in the course (Bruning & Horn, 2000; Lepper & Cordova, 1992; Martens, Gulikers, & Bastiaens, 2004). For example, students could get highly motivated to learn about the effective organization of writing when they are taught using tasks they know that they are likely to encounter such as producing lab reports, writing a letter of interest for a job, creating attractive blogs, etc. In addition, it is more likely to retrieve prior knowledge for learning with authentic tasks than with unfamiliar tasks. Moreover, learning within a task-centered approach would facilitate the application and transfer of the skills and knowledge that they acquired to the actual tasks that they need to accomplish for other courses, jobs, and everyday lives (Merrill, 2002; Warfield, Johnstone, & Ashbaugh, 2002; Weber, 2001).

What, then, could be appropriate real-world tasks for college students in an English writing course? According to Merrill (2007b), the first principles of instruction address *a content-first approach* unlike the traditional design of a course that identifies objectives without actual content specified at its early stage. Within *a content-first approach*, there are three steps to identify real-world tasks for the application of his first principles of instruction. The first thing to do is to identify *a whole task* (a typical real-world task) that encompasses all the learning components necessary to achieve the goal of a course (van Merriënboer & Kirschner, 2007). The second is to identify *a series of similar tasks of increasing complexity*. The last is to identify *component skills and knowledge* that are commonly necessary to accomplish all the tasks.

Along this line, we identified *whole tasks* as well as *component skills and knowledge* throughout (a) interviews with the instructors of college English writing courses, (b) research on the content and structure of the courses, and (c) literature review on English writing education. These were confirmed with a subject matter expert as well. The first step of the content-first approach identified five *whole tasks* as follows: (1) a procedural essay, (2) a narrative essay, (3) an analytical essay, (4) an argumentation and persuasive essay, and (5) a proposal, as shown in the tabs across the top of a course screen capture (see Fig. 21.1). According to the specific focus of an English writing course, the whole tasks could be differently identified. These examples are to illustrate the design framework in a concrete way.

The proposal task for students does not limit the kind of proposal to academically oriented proposals such as a research proposal or conference proposal. It could be any proposal. For instance, in an organization, a person who is in charge of human resources needs to write a proposal to open a new job position. In order to produce an effective proposal, a person should also know how to effectively write the other four essays since the proposal should contain the descriptions of (1) an employee search process (a procedural essay); (2) a current status of the organization (a narrative essay); (3) required skills, knowledge, and experience for satisfactory job performance (an analytical essay); and (4) rationales to convince the organization to fund for the position (an argumentation and persuasive essay).

In addition to increasing complexity for the five whole tasks (i.e., from a procedural essay to a proposal), *a series of similar tasks of increasing complexity* for each whole task have been identified through the second step of the content-first approach. Due to space limitations, only the whole tasks for a procedural essay are given here. As shown in Fig. 21.2, there are a series of three similar tasks of increasing complexity (i.e., A, B, and C) and each of them has also two or three tasks with different levels of scaffolding. For example, suppose the theme of the whole task of a procedural essay is adding a family-oriented life style to my college years. Task A is to write essays to explain how to use email to my grandma, Task B is to write essays to explain how to play different kinds of games to my nephew, and Task C

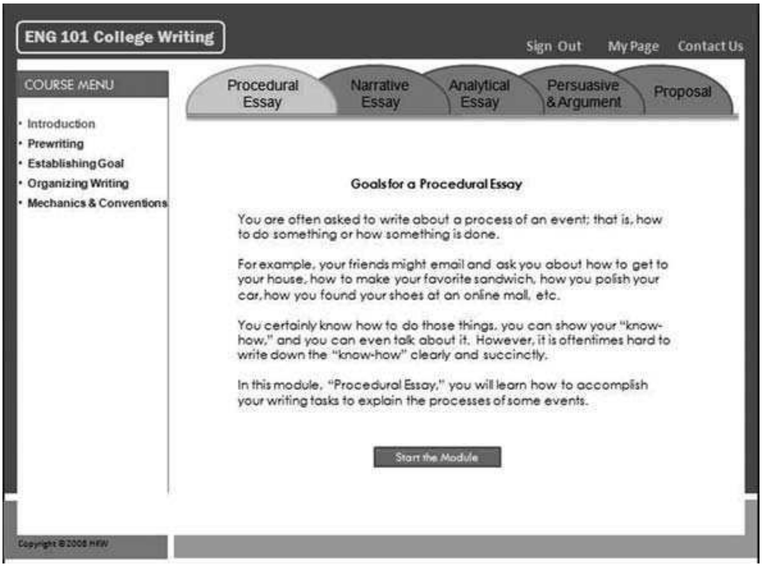


**Fig. 21.1** Procedural essay introduction screen

is to write essays about family trip planning. Within Task A, the first learning task (A1) comes with the most scaffolding (e.g., writing an essay to describe how to open an email); the second learning task (A2) comes with medium scaffolding (e.g., writing an essay to describe how to open a picture attached in an email and save it to your computer); and the last learning task (A3) has the least scaffolding (e.g., writing an essay to describe how to send an email with an attachment of a picture). While working on the learning tasks, students practice the whole task of writing a procedural essay and acquire necessary writing skills and knowledge. As a result of increasing complexity and decreasing scaffolding as students progress through the sequence of instruction, students are able to integrate acquired skills and knowledge into other contexts (van Merriënboer & Kirschner, 2007).

As the last step of *the content-first approach, the four component skills and knowledge* that were common across all the tasks were identified as follows: (1) prewriting, (2) establishing goal for writing, (3) organizing the piece of writing, and (4) mechanics and conventions of effective writing. Subcomponents of each were also identified. For example, communication needs, target audience, and research on additional information are subcomponents skills and knowledge to accomplish prewriting. Again, for the space limit, the examples of other subcomponents are not illustrated in this chapter.

The following sections describe how the tasks as well as component skills and knowledge are taught and learned throughout various activities according to the next four principles repeated throughout the course with interactive technologies.

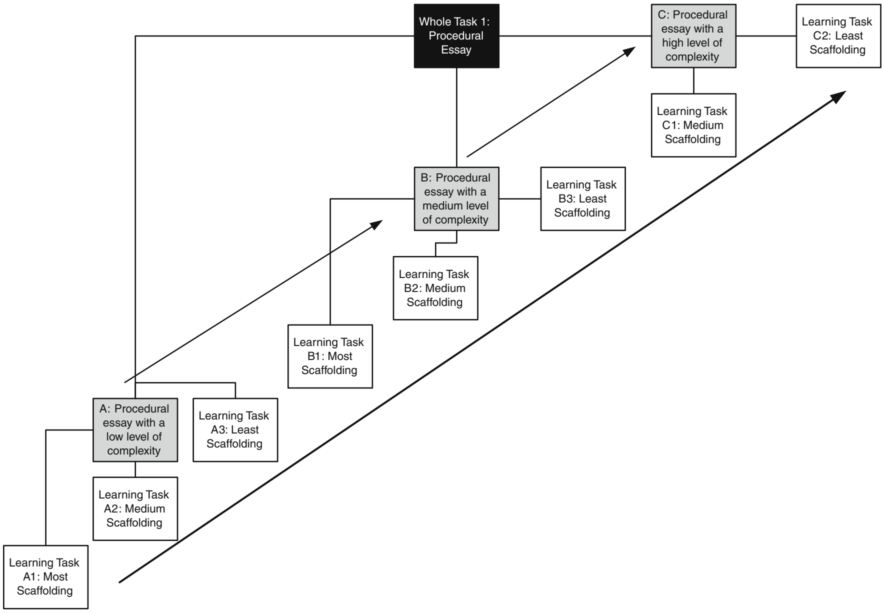


**Fig. 21.2** A series of similar tasks of increasing complexity within the whole task of a procedural essay

#### 21.2.1.2 Principle 2: Activation (Tell Me)

> Learning is promoted when existing knowledge is activated as a foundation for new knowledge (Merrill, 2002).

Merrill (2002) argues that instruction should facilitate students' recall, retrieval, relation, and application of prior knowledge to new knowledge. To support this principle, the complexity and difficulty increase as students progress through the course, so that the writing skills learned from previous tasks are foundations for later tasks. For example, the very first learning task in the whole task of a procedural essay is to write an essay to describe how to open an email since students can easily recall a process of the event, which is critical for prewriting, from their everyday experience. The skills and knowledge that students learn from the first learning task are taken into account for a basis of the next task. This activation phase should include the ways to trigger their recall and retrieval of prior knowledge when it tells new knowledge.

#### 21.2.1.3 Principle 3: Demonstration (Show Me)

> Learning is promoted when new knowledge is demonstrated to the learner (Merrill, 2002).

Merrill (2002) argues that information should not be just told to students; instead, portrayals of the information should be shown so that students can see how the information is applied to a certain context. For example, in order to teach how to do prewriting planning (the first of the four component skills and knowledge) for the whole task of a procedural essay, the course within the design framework of this chapter shows an actual email appropriately addressing the subcomponents of prewriting (i.e., identification of communication needs, understanding of target audience, and research on additional information). The course shows nonexamples as well, where prewriting planning is not performed or inappropriately performed. In this case, as shown in Fig. 21.3, the course first shows an email with flaws; second, when students click the Continue button, it shows where the flaws are by highlighting them, and then it illustrates the flaws resulted from the lack of prewriting. If students click on the More button, the course provides various *Show Me* with different levels of complexity and difficulty.

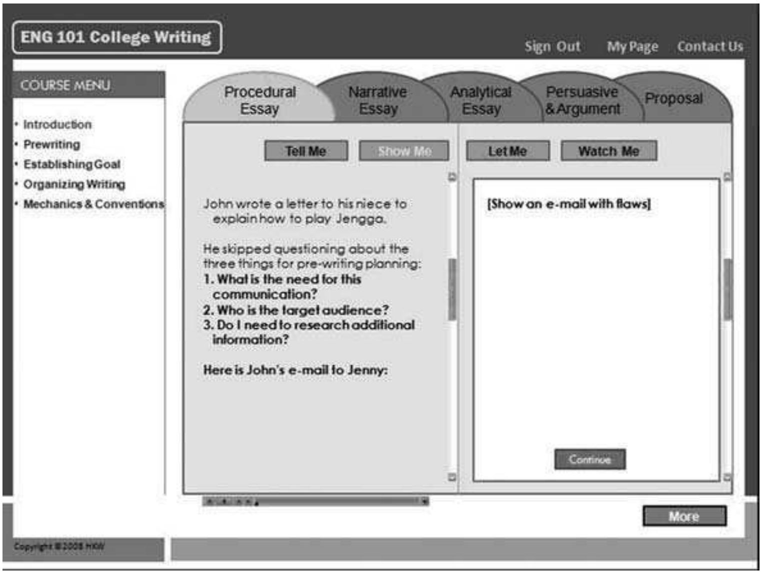


**Fig. 21.3** An example screen of the demonstration phase

#### 21.2.1.4 Principle 4: Application (Let Me Do It)

Learning is promoted when new knowledge is applied by the learner (Merrill, 2002).

According to Merrill (2002), students should not be asked to remember the skills that they learned. Rather, they should be asked to complete specific tasks requiring them to apply the skills to. For instance, students are asked to do prewriting planning for the whole task of a procedural essay. Prompts can be provided for their recalls, retrievals, and applications of previously learned skills and knowledge. For example, a question "what is their level of knowledge in the particular area or issue you are writing about?" can be given to let them understand target audience. Also an evaluation of someone else's writing can promote students' application of component skills and knowledge. That is, this application phase does not ask students what needs to be done for prewriting, but let them perform it.

#### 21.2.1.5 Principle 5: Integration (Watch Me)

> Learning is promoted when new knowledge is integrated into the learner's world (Merrill, 2002).

Merrill (2002) emphasizes that students should have a chance to demonstrate newly learned knowledge and skills in their everyday activities. For example, the course lets students write about how to play and enjoy a game, a plan for a family reunion trip, a letter of interest for a job application, and so on. These tasks require them to integrate the component skills and knowledge, which learned from what they have been told during the activation phase, what they have seen during the demonstration phase, and what they have done during the application phase, to their writings. Figure 21.4 illustrates an example that students should integrate prewriting skills and knowledge into a writing task within the context of the online English course.

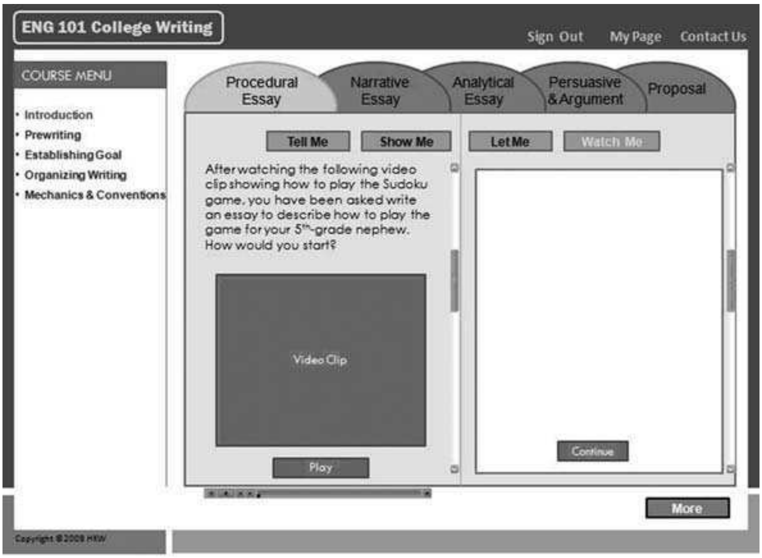


**Fig. 21.4** An example screen of the integration phase

### 21.2.2 The Design Framework Highlight #2: Peer Review for Practice and Evaluation

Since students learn from doing real-world whole tasks, their achievement should be evaluated and measured through their completion of such tasks. Thus, specific criteria for the evaluation of students' writing within a task-centered approach should be studied to improve the design framework. Peer review, evaluation, and critique of the tasks emulate a real-world environment therefore enhancing the authentic experiences. Employers regularly expect employees to be able to engage in team and collaborative environments (Damashek, 2003). Increasingly real-world problems are being solved in teams and among colleagues instead of individuals (Merrill & Gilbert, 2008).

Peer review, evaluation, and critique activities, if administered appropriately using a task-centered approach, are engaging collaborative exercises that enable students to interact instead of individually providing one-sided feedback. Peer interactions are more effective when they are centered on a progression of real-world problems needing to be solved. Furthermore, the interaction between peers nurtures the development of mental models (Merrill & Gilbert, 2008). Merrill and Gilbert (2008) conclude that when students engage in collaborative and review activities with their peers "they are required to test their mental model of the phenomena against the process or product resulting from the mental model of a peer" (p. 202). During the interactions and reviews when there are inconsistencies between the peers' mental models, they need to critically evaluate their own mental models and determine if they need to defend their interpretations or adapt their current mental model to incorporate the new points of view (Merrill & Gilbert, 2008).

Often in academic English writing courses, peer review methods are employed to provide students with feedback on written work before achievement is measured by instructors. Peer evaluation, review, and critiques provide both the writer and the reviewer opportunities to acquire additional knowledge relating to the component skills. These component skills not only include the grammar and mechanics but also more in-depth alternative perspectives of the generation of ideas, subject matter, and writing process (Lundstrom & Baker, 2009; Hansen & Liu, 2005). Additionally, peer reviewers develop an ability to critically evaluate others' work and in return they acquire skills necessary to self-review like identify gaps and illogical sequences in their own writing and ultimately execute more refined drafts of their work (Lundstrom & Baker, 2009; Rollinson, 2005). Furthermore, motivation to succeed is cultivated through the presence of a peer. When students know their work will be reviewed by their peers and people other than the instructor and themselves the quality of work increases.

Peer review, in an online environment, provides the necessary social interaction for learners. One of the biggest criticisms with online learning environments is the lack of social presence or sense of community (Palloff & Pratt, 2005). Social interaction brings a sense of community, but according to Vygotsky (1981) it is the nexus of cognitive development (Conrad & Donaldson, 2004; Hansen & Liu, 2005; Min, 2005).

Peer review activities should be centered on iterations of the whole tasks and at different stages of the progression of problems. As stated previously, the first principles of instruction take a content-first approach. Students are able to see completed artifacts in the beginning, enabling them to develop a mental model of the artifact and the expectation of what the completed product should be. This is particularly beneficial for reviewers to retrieve the knowledge of the completed artifact when evaluating others' written work. In order for peer reviewers to accurately and effectively articulate valuable feedback and critique, they need to receive instruction and guidance before, during, and after peer review activities. Since peer reviewing is complex, careful training is essential to the success of both the reviewer and the writer (Lundstrom & Baker, 2009; McGroarty & Zhu, 1997; Paulus, 1999). To avoid exchanging inaccurate information and to ensure the course and activity goals are being met, it is essential to instruct students on core concepts, evaluation techniques, rubrics, and how to probe responses that help generate and progress thoughtful ideas. Instructors need to provide guidance and facilitate the learning of peer reviewers (Min, 2006). In addition, instructors need to foster an open collaborative environment that establishes trust and support among peers. Successful interactions leading to increased cognitive development and shared mental models happen in a comfortable environment where students can discuss and negotiate meanings and share points of view with one another (Hansen & Liu, 2005).

In the design framework presented in this chapter, instructors provide training and guidance to new peer reviewers and writers; each writer will also be a peer reviewer. Peer review activities will be broken down into iterations. For one whole task, papers will be reviewed three times by peers and the final review and assessment will be done by instructors.

According to Merrill's (2002) content-first approach, peer reviewers are given completed artifacts of the whole task to read thoroughly and review. These artifacts are part of the online instruction and will be revisited throughout the whole task. For whole task one, the end artifact is a completed procedural essay. Students will receive instruction on peer review procedures and concepts in the *activation* phase.

Demonstrations will be provided for each of the peer review procedures and concepts. For example, just as in the initial instruction, the peer review training shows students how to generate ideas, identify inconsistencies in sequences and voice, identify and correctly respond to grammar and mechanics, using the rubric, etc.

In the *application* phase, peer reviewers will be given an iteration of the previous artifact (i.e., procedural essay) that has several errors. Reviewers will go through and practice the skills and concepts they were taught and shown. Since this is an online training, computer-generated feedback and self-assessment techniques are incorporated in addition to instructors' guidance and feedback. If the reviewer hasn't demonstrated an ability to appropriately review others' written work, they will have an opportunity to go back and practice again.

In the *integration* phase, peer reviewers are now able to evaluate and critique other students' work on their own with no guidance. However, instructors will be able to monitor and provide assistance if necessary. This phase requires peer reviewers to apply the skills and knowledge not only of the peer review techniques but also of the English writing content component skills they learned while creating their own essays.

In short, each student will engage in peer review activities at least three times per whole task. Not only will they be critically evaluating and reviewing, but their own work will be evaluated by a peer giving them an opportunity to correct and revise their papers. With practice evaluating and engaging in collaborative review assignments, students' own writing will improve not only because of the feedback but also because of their improved ability to self-review (Lundstrom & Baker, 2009; Rollinson, 2005).

There is real potential for peer review methods to be unsuccessful if instructors are unaware and not involved in training and guiding students. There are several things that need to be considered when using peer review, even if the system has been set up and implemented previously. Varying cultural beliefs regarding the role of students and instructors can have an impact upon communication, how cooperative peers are with one another, and levels of trust. Some students may disregard the feedback from peers because the peers' knowledge is perceived as less than equal and invaluable compared to instructors (Carson & Nelson, 1996). Thus, effort needs to be made in fostering collaborative environment, especially virtual environments that build trust, employ social interactions, enhance cultural sensitivity, and promote knowledge sharing (Palloff & Pratt, 2005).

### *21.2.3 The Design Framework Highlight #3: Measurement for Learners' Mental Models*

One of the key factors for successful learning is the coupling of the learning strategies with assessment strategies (Bransford, Brown, & Cocking, 2000). To measure learning, there are three measuring techniques for assessing individuals: (1) measuring direct actions, (2) measuring actions indirectly by stopping the action and then measuring, and (3) measuring outcomes from the individual's task actions (Johnson & O'Connor, 2008). While there are various techniques to assess learning, English writing involves a high level of conceptualization and development of mental models. Due to the complexity, typically it is best to measure the outcomes that reflect the learner's progress. The products created by learners can be used as task mental models. "Acquiring this skill (the component skills) in the context of whole tasks makes it more likely that learners will form mental models for how these individual skills are integrated into a complete performance" (Merrill, 2007b, p. 15). These mental models are embodied in the performance outcomes – their written assignments. As such, these assignments can be use to examine the learners' task mental models and serve as a measurement of learning.

There are two assessment tools to measure mental models in complex learning and instruction environments such as English writing. These tools – part of an online assessment toolset called Highly Interactive Model-based Assessment Tools and Technologies (HIMATT) – include (1) Surface, Matching, and Deep Structure (SMD) Methodology (see Ifenthaler, 2006; Seel, Ifenthaler, & Pirnay-Dummer, 2006) and (2) Model Inspection Trace of Concepts and Relations (MITOCAR) Methodology (see Dummer & Ifenthaler, 2005; Seel, 1999). These tools analyze structural and conceptual aspects of the learners' mental models and then use analytical methods to compare the mental models with a specific target model in order to assess the level of conceptual and structural similarity of the two models. The HIMATT toolset provides a mechanism to automatically compare mental model structure and semantics embedded within a given written text document.

Specifically, the SMD and MITOCAR assessment technologies can take a text model from an expert and compare it to the learner's text model. It compares two models using six different measures. These tools take a text document (mental model) and create an associated graph. The graph is then used for the model comparisons as follows:

- Propositional Matching (SMD) – compares identical propositions (semantic similarity) between two mental models graphs.
- Concept Matching (MITOCAR) – compares the sets of concepts (vertices) within a mental model graph to determine the use of terms. This measure determines differences in language use between the models.
- Surface Structure (SMD) – compares the number of vertices within two graphs. This represents the values for surface complexity.
- Graphical Structure (SMD) – graphical matching compares the diameters of the spanning trees of the mental model graphs, which is an indicator for the range of conceptual knowledge. This is a good measure for complexity only.
- Density of Vertices (MITOCAR) – density of vertices describes the quotient of terms per vertex within a graph. Medium density models are considered good models. Weak models include both graphs that connect every term with each other term and graphs that only connect pairs of terms.
- Structural Matching (MITOCAR) – compares the complete structures of two mental model graphs without regard to their content. This measure is necessary for all hypotheses that make assumptions about general features of structure (e.g., assumptions which state that expert knowledge is structured differently from novice knowledge).

In developing learner assessment, these two assessment techniques are useful in providing the learners with quick feedback related to their mental models used in English writing. Thus, in the design framework presented in this chapter, these two techniques, while not able to provide grammatical nor logic feedback, do provide the learners with a sense of how developed their thinking is compared to the expert model. This provides a quick assessment related to their overall development as well as an evidence of individual learning progression. Using these tools, instructors and learners can quickly include analytical comparisons that are useful in representing differences and changes in cognitive problem-solving functions.

## 21.3 Conclusion

Up to now, this chapter described the design of an online English writing course within a task-centered approach. Grounded in the five interrelated principles of Merrill's (2002, 2007a), the examples of whole tasks and component skills and knowledge were illustrated. These principles are demonstrated in Figs. 21.1, 21.2, 21.3, and 21.4 in an online context, although it is clear that they can be applied in a face-to-face context as well. The most interesting aspect of the online context is the fact that the artifacts created by students are digital in nature and can then be easily edited by an instructor or by peers, shared progressively for peer review, and potentially suitable for automated assessments (Spector & Koszalka, 2004; Seel, Ifenthaler, & Pirnay-Dummer, 2006) to measure learners' mental models. Although the design framework of this chapter is based on theories that were developed with rigorous procedures of experiments, its feasibility for development and effectiveness on learning need to be validated in empirical studies. The design framework of this chapter is expected to provide theoretically sound foundations for research and development.

**Acknowledgments** This chapter is based on our work presented at the IADIS international conference on cognition and exploratory learning in the digital age (see Kim, Mendenhall, & Johnson, 2008).

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# Chapter 22
# Catering for Different Learning Styles in e-Learning

**Vatcharaporn Esichaikul and Clemens Bechter**

**Abstract** For online learning to be effective, it should be adapted to the personal learning style. Kolb's learning style inventory (LSI) is a methodology to assess such individual learning styles. The quantitative findings of this study demonstrate that differences between the four learning types exist, namely, in preferred type of discussion board posting, communication tool, and problem-solving approach. Accommodators and Divergers contribute to an online discussion by challenging point of views, whereas Assimilators and Convergers like to put content into a model/framework. Accommodators like to communicate with their peers via email and Assimilators via general discussion board. Divergers prefer email exchange with the tutor if faced with a problem. These findings have implications for delivery of online learning material. No single e-learning approach will be suitable for all learning styles.

## 22.1 Introduction

The role of personal learning style is very important for online learning process and outcome (Claxton & Murrell, 1987). In most e-learning environments, all students are exposed to same exercises, discussions, and delivery of content depending on preference of institution or tutor. As commercial online entities demonstrate (myCNN, myYahoo!, myAmazon, etc.), consumers like personalized offerings taking into account personal, often hidden, preferences. Personalization in e-learning is the use of technology and student information to tailor interactions between a tutor and individual students in a way that students achieve better learning outcomes. Studies relating to personalization in e-learning concentrate on two main aspects: first, the management of learning materials and other information; second, the learning process, with a strong focus on the people engaged in learning activities (Mor & Minguillon, 2004; Sehring, Bossung, & Schmidt, 2004).

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## 22.2 Literature Review

### *22.2.1 Learning Styles*

There are several models describing learning styles (Paneva & Zhelev, 2007). Basic learning styles are visual "learning by seeing," aural/audial "learning by hearing," reading/writing "learning by processing text," and practical "learning by doing" (Kolb, Rubin, & McIntyre, 1974). Multimodal learners are people who have more than one learning style (Bransford, Brown, & Cocking, 1999). One of the most popular learning style models is Kolb, Rubin, and McIntyre (1974) learning style inventory (LSI). The LSI model (see Fig. 22.1) is built upon the idea that learning preferences can be described using two continuums: active–reflective and abstract–concrete. The result is four types of learners: active–abstract (Converger), active–concrete (Accommodator), reflective–abstract (Assimilator), and reflective–concrete (Diverger). The LSI is designed to determine an individual's learning preference.

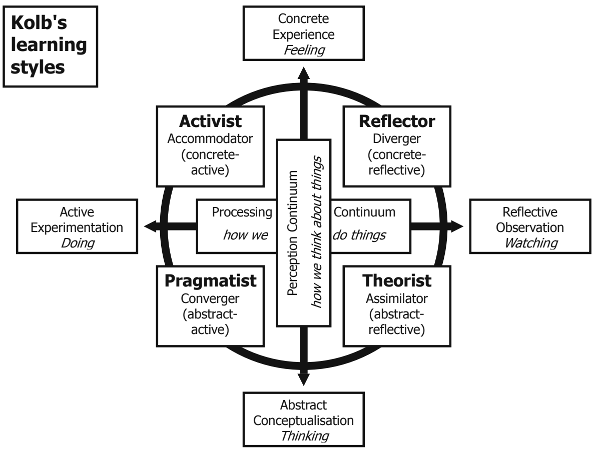


**Fig. 22.1** Kolb's learning style model

The four positions on the two dimensions describe four learning modes.

- Feeling (concrete experience) – perceive information. A high score in the concrete experience dimension represents a receptive experience-based approach to learning that relies on feeling-based judgments. Thus, people tend to be empathetic.
- Watching (reflective observation) – reflect on how it will impact some aspect of life. A high score in reflective observation indicates a tentative, impartial, and reflective approach to learning. Learners prefer learning situations such as lectures that allow the role of impartial objective observers.
- Thinking (abstract generalization or conceptualization) – compare how it fits into own experiences. A high score in abstract conceptualization indicates an analytical, conceptual approach to learning that relies heavily on logical thinking

and rational evaluation. They learn best in authority-directed impersonal learning situations that emphasize theory and systematic analysis.

- Doing (active experimentation) – think about how this information offers new ways to act. A high score in active experimentation indicates an active "doing" orientation to learning that relies heavily on experimentation. These individuals learn best when they can engage in such things as projects, homework, or group discussions.

Kolb's LSI measures student learning style preference in two bipolar dimensions. The first dimension, as shown in the Fig. 22.1, is based on task. Left end corresponds to doing the tasks (performing), while the right end is watching the task (observing). The second dimension runs vertically and is based upon thought and emotional processes. The top of the dimension is feeling (responsive feelings), while the bottom of the dimension is thinking (controlled feelings). The two lines intersect each other and form four quadrants. These quadrants form the personal learning styles (Kolb, Rubin, & McIntyre, 1974).

- Assimilators like to learn using abstract conceptualization and reflective observation (lecture, papers, and analogies) and like to ask such questions as "How does this relate to that?"
- Convergers like to learn using abstract conceptualization and active experimentation (laboratories, field work, and observations). They ask "How can I apply this in practice?"
- Accommodators like to learn using concrete experience and active experimentation (simulations, case study, and homework). They tell themselves "I'm game for anything."
- Divergers like to learn using reflective observation and concrete experience (journals, brainstorming). They like time to think about the subject.

While there are plenty of studies done on learning styles, there does not seem to be any agreement or approval of any one theory (Keegan, 2003). A research report from the Learning and Skills Research Center (Coffield, Moseley, Hall, & Ecclestone, 2004; Coffield, 2008) studied many learning style models and did a critique of experimental learning style theories. This research questions the reliability, validity, and implication of learning styles in general. In addition, the authors have criticized some of the research that has used these models including the Kolb's learning style model and disagreed with the way researchers came to their conclusions. Questions regarding the reliability of Kolb's LSI have also been raised by other researchers (Newstead, 1992). They point out that the instrument may capture a learner's style at a particular moment in time but does not apply to different learning situations. Since student performance was not significantly different between the Convergers and Divergers, the reliability of the instrument was also questioned (Garner, 2000) or empirical research showed no significant differences between the four groups (Bechter & Esichaikul, 2005). Polhemus, Danchak, and Swan (2004) found that by adding the word "online" into each of the LSI 12 items, people found themselves in different learning quadrants. In contrast, Manochehr (2006) found the four learning types confirmed through his empirical research.

### *22.2.2 Discussion Board*

Interaction between students has an impact on achieving learning objectives and overall satisfaction with online learning (Bechter & Esichaikul, 2005). Other authors see benefits in a more indirect way. It has been argued that discussion board participation of participant increases (online) self-confidence and makes a course in the broadest sense more "fun" (Coppola, Hiltz, & Rotter, 2002). In a traditional classroom setting, many students are reluctant to raise their opinion or ask questions. This fear is well documented by research (Chickering, Gamson, & Barsi, 1987; Fassinger, 1995). An online discussion board lowers the bar by not demanding an instant reply; instead, there is time to ponder about an answer before posting (Dagger et al., 2007). Consequently, fearful students are more likely to expressing themselves in an online environment than in a traditional classroom (Garrison & Kanuka, 2004). However, the area of synchronous and asynchronous communication as alternative to face-to-face interactions in traditional classroom interaction has received little attention (Garrison & Kanuka, 2004).

Research on the motivation to post and share knowledge on a discussion board shows two distinct groups: one group that wants to share in the spirit of "open source," while the second cluster is mainly motivated by being competitive, i.e., grade. Such competitive attitudes were found predominantly not only in Chinese cultures (China, Hong Kong, and Singapore) but also in the United States (Hwang, Kessler, & Francesco, 2004; Tang, 1999). In the viewpoint of cultural differences, collaborative behavior may be a deep-rooted expression of competitive behavior. Additionally, such behavior might also be a result of learning style.

## 22.3 Objective and Methodology

The purpose of the study is to analyze learning styles related to e-learning preferences. Research questions are:

1. Are there differences between Kolb's four learning styles in the usage of e-learning tools?
2. What e-learning behaviors are influenced by learning styles?

The objectives are to identify links between Kolb's learning styles and

1. type of discussion board contribution,
2. preferred communication tools, and
3. differences in problem-solving approach.

In 2008, 180 MBA students from four sections of an online business simulation course at one university have been asked to fill in Kolb's LSI questionnaire. A further eight questions have been added to evaluate preferred communication tools (chat, email, and discussion board) and type of discussion board contribution.

Students were also asked about their preferred support channel (discussion with peers, teacher, and reading the handbook). The word "online" was added to all 12 LSI items as suggested by Polhemus et al. (2004).

## 22.4 Data Analysis and Findings

### *22.4.1 Differences Diverger vs. Converger*

Two polar opposite learning types Divergers (Dive) and Convergers (Conv) show significant differences in their preferred learning approaches. Out of synchronous and asynchronous communication tools, Divergers prefer chatting more than Convergers do (see Table 22.1). A t-test shows the difference is significant and the 95% confidence interval is between 0.349 and 1.109 on a 1–4 scale. The 1–4 ranking scale is adopted from Kolb's scale used to determine the learning style. Students of the various sections of the same online business simulation course were asked to rank how they learn best and choice of communication tools.

**Table 22.1** Differences between Diverger and Converger

| | LSI | N | Mean | Std. deviation | Std. error mean |
|---|---|---|---|---|---|
| Chat | Dive | 23 | 2.74 | 1.176 | 0.245 |
| | Conv | 100 | 2.01 | 0.732 | 0.073 |
| Challenge | Dive | 23 | 3.52 | 0.790 | 0.165 |
| | Conv | 100 | 2.51 | 1.133 | 0.113 |
| Feelings | Dive | 23 | 3.09 | 1.203 | .251 |
| | Conv | 100 | 2.05 | .626 | .063 |
| Ask teacher | Dive | 23 | 2.30 | 1.259 | 0.263 |
| | Conv | 100 | 1.48 | 0.659 | 0.066 |
| Model | Dive | 23 | 1.87 | 0.869 | 0.181 |
| | Conv | 100 | 2.53 | 1.201 | 0.120 |
| Research | Dive | 23 | 2.13 | 1.325 | 0.276 |
| | Conv | 100 | 3.94 | 0.239 | 0.024 |
| Play | Dive | 23 | 1.61 | 0.891 | 0.186 |
| | Conv | 100 | 3.46 | 0.892 | 0.089 |

Divergers compared to Convergers prefer to (see Table 22.1):

- challenge a point of view on the discussion board,
- rely on feeling when making simulation game decisions, and
- tend to ask the teacher (and not peers) for help.

In contrast, Convergers prefer to:

- put things into a model/framework,
- like to analyze (market research) data, and
- play with the software.

### *22.4.2 Differences Accommodator vs. Assimilator*

Accommodators (Acco) differ from their Assimilator (Assi) peers in numerous preferred learning tools, namely, they prefer to (see Table 22.2):

**Table 22.2** Differences Accommodator and Assimilator

| | LSI | N | Mean | Std. deviation | Std. error mean |
|---|---|---|---|---|---|
| Challenge | Acco | 26 | 3.31 | 1.087 | 0.213 |
| | Assi | 31 | 2.58 | 0.992 | 0.178 |
| Model | Acco | 26 | 1.92 | 0.796 | 0.156 |
| | Assi | 31 | 2.74 | 1.210 | 0.217 |
| Research | Acco | 26 | 2.96 | 1.183 | 0.232 |
| | Assi | 31 | 3.87 | 0.499 | 0.090 |
| Offline | Acco | 26 | 2.12 | 0.711 | 0.140 |
| | Assi | 31 | 2.81 | 1.223 | 0.220 |
| Email | Acco | 26 | 2.62 | 1.098 | 0.215 |
| | Assi | 31 | 1.71 | 0.864 | 0.155 |
| New Perspective | Acco | 26 | 1.73 | 0.919 | 0.180 |
| | Assi | 31 | 2.42 | 1.089 | 0.196 |
| DB | Acco | 26 | 2.73 | 1.116 | 0.219 |
| | Assi | 31 | 3.29 | 0.783 | 0.141 |
| Handbook | Acco | 26 | 3.15 | 0.881 | 0.173 |
| | Assi | 31 | 2.58 | 1.119 | 0.201 |
| Relate | Acco | 26 | 3.08 | 0.744 | 0.146 |
| | Assi | 31 | 2.19 | 1.223 | 0.220 |
| Do | Acco | 26 | 2.65 | 1.231 | 0.241 |
| | Assi | 31 | 1.06 | 0.250 | 0.045 |

- challenge a point of view (something they have in common with Divergers). Both learning types share the "concrete experience" dimension in Kolb's model. However, online discussion boards (DB) in general seem less attractive to them. This finding points to the conclusion that they like discussion as long as they are provocative.
- Like reading the handbook.
- Exchange email as communication tool.
- Relate things to own experience and "just do it."

Assimilators like to:

- Put things into a framework/model and analyze market research data, something they have in common with Convergers. Both learning types show high abstract conceptualization in Kolb's model.
- Offline team discussions (phone, personal meetings), which might be a result to their focus on "watching."

- Introduce new perspectives to a discussion and like the discussion board in general.

### 22.4.3 *Perceptions on Simulation Course*

Students were asked whether they wish to have more support from their peers (note: simulation game is a group assignment) or from the professor on a Semantic Differential (1–10). Divergers show the lowest mean, i.e., they want more support from their peers than the other three groups. Assimilators find the simulation course most interesting (on a scale with 1: interesting, 10: boring). Although all students find the course interesting, relatively, Accommodators find it more boring than others.

According to Kolb's model, Accommodators will look for concrete experience. The rating of 3.42 of the simulation, being practical rather than theoretical (10), reflects the fit between simulation as a learning tool and learning style (see Table 22.3).

**Table 22.3** Accommodator

| | N | Mean | Std. deviation |
|---|---|---|---|
| Support | 26 | 5.69 | 2.839 |
| Interest | 26 | 3.50 | 1.631 |
| Practical | 26 | 3.42 | 1.858 |
| Valid N | 26 | | |

Theoretically, Assimilators (see Table 22.4) should not like a simulation, but their tendency to abstract conceptualization makes the game interesting for them. In fact, it makes it so interesting that they give a 1.87 out of 10 (boring).

**Table 22.4** Assimilator

| | N | Mean | Std. deviation |
|---|---|---|---|
| Support | 31 | 5.45 | 3.375 |
| Interest | 31 | 1.87 | 1.258 |
| Practical | 31 | 3.23 | 2.486 |
| Valid N (listwise) | 31 | | |

Convergers are similar to Assimilators. They find a simulation game interesting because they can apply what they have learned (see Table 22.5).

Divergers should not like the game because they learn by reflection and concrete experience. Maybe the simulation game's possibility to make decisions based on feelings, rather than analysis, makes it attractive to them or the concrete

**Table 22.5** Converger

| | N | Mean | Std. deviation |
|---|---|---|---|
| Support | 100 | 5.53 | 2.086 |
| Interest | 100 | 2.17 | 1.334 |
| Practical | 100 | 3.38 | 2.039 |
| Valid N (listwise) | 100 | | |

experience (see Table 22.6). For the overall perceptions on the online simulation course, the results show that Convergers and Assimilators have similar perceptions as they mainly focus their learning on "abstract conceptualization" or the North side of a learning style model. In the same way, Accommodators and Divergers have similar perceptions as they mainly focus their learning on "concrete experience" or the South side of a learning style model.

**Table 22.6** Diverger

| | N | Mean | Std. deviation |
|---|---|---|---|
| Support | 23 | 4.91 | 3.175 |
| Interest | 23 | 2.35 | 1.071 |
| Practical | 23 | 3.17 | 2.516 |
| Valid N (listwise) | 23 | | |

### *22.4.4 Associations*

Students were presented with the question "if the simulation game was a person who would it be?" A few weeks prior to the game, students were asked whom they associate with a "doing feeling" "watching," and "thinking" profession. On the thinking dimension "teacher" ranked highest, football (soccer) player on feeling (concrete experience), singer on doing, and monk on watching (see Table 22.7).

Most Divergers and Accommodators think the game is a football player. Both types have the "concrete experience" dimension in common. Convergers and Assimilators think the game is best represented by teacher. Both have the thinking or "abstract conceptualization" dimension in common. This shows that the perception on the game, asked indirectly via an association test, is in line with the learning type, i.e., a Diverger or Accommodator sees in it a concrete experience, whereas Convergers and Assimilators as more theoretical exercise. In short, each group sees what they want to see. This might also explain the positive results on perceptions, e.g., Assimilators, they see in it "abstract conceptualization" and not "reflective observation." Consequently, they associate the simulation with the "teacher" and not with the "monk."

**Table 22.7** Associations

| LSI | | Football player | Teacher | Monk | Singer |
|---|---|---|---|---|---|
| Acco | N | 26 | 26 | 26 | 26 |
| | Mean | 2.69 | 2.54 | 1.23 | 2.38 |
| | Std. deviation | 1.123 | 1.140 | 0.652 | 0.983 |
| Assi | N | 31 | 31 | 31 | 31 |
| | Mean | 3.00 | 3.42 | 1.71 | 1.87 |
| | Std. deviation | 1.183 | 0.720 | 0.824 | 0.619 |
| Conv | N | 100 | 100 | 100 | 100 |
| | Mean | 3.08 | 3.15 | 1.63 | 2.20 |
| | Std. deviation | 1.061 | 0.880 | 0.872 | 0.876 |
| Dive | N | 23 | 23 | 23 | 23 |
| | Mean | 3.09 | 2.04 | 2.70 | 2.17 |
| | Std. deviation | 0.793 | 1.186 | 1.428 | 0.650 |
| Total | N | 180 | 180 | 180 | 180 |
| | Mean | 3.01 | 2.97 | 1.72 | 2.17 |
| | Std. deviation | 1.062 | 1.030 | 1.003 | 0.836 |

## *22.4.5 Discussion – Qualitative Insights*

There are two schools of thought if it comes to the effectiveness of discussion board threads. First, some evidence suggests that focused questions lead to more effective discussion (Roblyer & Wiencke, 2003). Other researchers have reported that discussion questions should be broad because peer discussions are more effective than educator messages at stimulating a discussion and that a too focused discussion can shut a discussion down (Li, 2003; Mazzolini & Maddison, 2003). Following sample postings represent two different discussion threads ranging from focused to broad topic. Despite the variance in question, the answers given by students reflect their learning style. The philosophy of the teacher in this course was to allow students to construct their own knowledge. Below sample postings are in their original format, i.e., unedited. In following section, quotes from participants are used to illustrate learning style differences in responding to discussion threads.

### 22.4.5.1 Sample Postings: Focused Question – Ryanair Case Study

The Ryanair case study (Ryanair: The "Southwest" of European Airlines case, Case Code: BSTR059) provided some background on the company and students were asked to discuss the airline's success factors.

REPLY BY Carlos: Accommodator

*...how would you define Ryanair's marketing strategy and its CEO Michael O'Leary? opportunistic? irritating? is he a clown? is he a marketing specialist? a marketing innovator? Do they practice the "selling concept"? (in my opinion it seems they do)*

*My feeling is that he's really intelligent and has found the way to put Ryanair on everybody's mouth with little investment in marketing... Low-cost marketing I guess.*

REPLY BY Arnaud: Diverger

*Well, Carla Bruni lawyers sue Ryanair as they use her image without her consent. The French president did the same asking for only 1 euro compensation. An opportunist marketing Strategy. Due to the legal consequences they had to stop. However, it was a smart move to target its low budget customers. In fact, the French President popularity polls are shrinking, due to the dissatisfaction of his policy related to Purchase power of the poorest. The lower class had a good laugh I believe, when they saw these ads, i.e. it touched the targeted customers! Bravo! I can imagine the Joke among the French customers: "hey, where are you traveling to? ...to Sarkozy's wedding". It sounds a good way to build a community! Don't you agree?*

REPLY BY Sandra: Assimilator

*I wonder if these campaigns are ethical. The marketing associations in each country have developed their own ethical guidelines but they are roughly the same internationally. It would be interesting to check if the Ryanair marketing stunts are in line with these guidelines or if they cross a line. These basic values of the American Marketing Association (AMA) include honesty, responsibility, fairness, respect, openness and citizenship. As stated by the AMA these values are aspirational and the exact meaning is always debatable.*

*The AMA formulates this as follows:* (followed by AMA's ethical norms).

REPLY BY Arno: Diverger

*When I read your article and mainly this part "These basic values of the American Marketing Association (AMA) include honesty, responsibility, fairness, respect, openness and citizenship".*

*As we all know the former American presidency campaigns were not that ethical, honest, fair or whatever. In my opinion, the bottom line is, is the campaign effective? Even if you have to apologize that it wasn't according to the AMA rules.*

REPLY BY Sandra: Assimilator

*The US election campaigns are indeed very nasty and I'm sure that before spilling dirt to the media about an opponent the people involved won't take time to first carefully check if they follow the AMA ethical guidelines. They want to book results no matter what.*

As above examples demonstrate, Accommodators and Divergers contribute to an online discussion by challenging point of views, whereas Assimilators like to put things into a framework.

#### 22.4.5.2 Sample Postings: Broad Question – Branding and Innovation

REPLY BY Remco: Accommodator

*Sometimes branding is used to the extent that it even does replace innovation. Think for instance about all those nice cosmetic creams with all those fancy brand names (Source Therapie Superactive/Biotherm, Prodigy/Helena Rubenstein) that always promise to make your wrinkles disappear with the next innovation of cosmetics. Unfortunately they never do (believe me, I tried them all:-).*

*Sometimes companies even create a new brand, independent from their own and with no visible links. Toyota for instance did this with Lexus because they wanted to create a new innovative car with a luxury image and luxury was not an association consumers made with the original brand. Rather than to work on the image of the existing brand, they decided to create a new one. (Nissan recently did the same with INFiNITI).*

REPLY BY Gert: Assimilator

*It can be one of the complementary assets to make the innovation successful. Going back to David J. Teece, only in a soft appropriability regime, the success depends on the complementary assets. Important complementary assets can be: production facilities, distribution, infrastructure, marketing, etc. Critical complementary assets are those that are 'specialized' or, in other words depend on each other.*

REPLY BY Patrick: Accommodator

*A brand could give a product this extra feature which makes it exceptional and distinguished from its competitors and could create large exposure for the company, James Surowiecki stated in 'The New Yorker' that Gurus talk about building an image to create a halo over a company's products. But these days, the only sure way to keep a brand strong is to keep wheeling out products, which will in turn cast the halo. (The iPod has made a lot more people interested in Apple than Apple made people interested in the iPod.)*

REPLY BY Francis: Converger

*If you come up with an innovative product, one of the factors to ensure long term success is branding. Innovations must go along with a branding strategy otherwise will be copied and the follower will take the credit of the resources and time invested to come up with the innovative product or service.*

*If the customers have the brand well positioned in his/her mind and the brand is well recognized and distinguished as the pioneer or the one who provides the innovative product or service, the competition and followers will find their way more difficult to overcome this advantage. Also the owner of the brand acquires some prestige (if the innovation is a success) so when introducing new products or line extensions this brand will warrant the product.*

REPLY BY Michael: Diverger

*. . .it would appear that Shrek shares the eating habits of many Americans, often reaching for fat-free Apple Dippers with one hand while grabbing a fistful of 'ogre-sized' Peanut-Butter M&M's with the other. Ethics aside, character promotions serve to turn traditionally overlooked (exercise, for example) activities or seemingly standard (M&M's) products into trendy desirables for their target audiences. I recently ventured to my local McDonald's to see what all the fuss was about. Initially seeking to purchase a Happy Meal, complete with apples and milk, I was drawn instead towards a Swamp Sludge Milkshake. Upon completing my order, I was handed a gigantic cup filled with no less than 32 ounces of minty-green frappe. The question is would I have selected such a drink had it simply been marketed as a gimmick-free mint shake? I think not.*

REPLY BY Lucas: Diverger

*I do not fully agree. As a consumer I am only interested in the product itself. That it tastes nice, that it fits or that it works the way I want. I do not have to know whether it uses X technology or has an Y innovation. This could even cause confusion. The fact that the product is produced by a well known company is enough reason for people to buy.*

Again, these examples show how the four types differ in the dimension of abstract vs. concrete experience. Above postings by Accommodator and Diverger express own experiences whereas Converger and Assimilator rely more on abstract concepts no matter whether the DB question is focused or broad.

## 22.5 Conclusion and Future Work

The study has shown that there are significant differences between the four learning styles (see Table 22.8). Accommodators and Divergers contribute to an online discussion by challenging point of views, whereas Assimilators and Convergers put things into a model/framework. Accommodators like to communicate with their peers via email and Assimilator via general discussion board. Divergers prefer email contact with the tutor if faced with a problem. These findings have implications for delivery of learning material. No single e-learning approach will be suitable for all learning styles. Common behavior of Assimilators and Convergers leads to the conclusion that the North–South divide, abstract vs. concrete (Fig. 22.1), is more important than East–West, Active vs. Reflective. Selective attribution dampens the negative effect of a "nonmatching" teaching approach. Nonetheless, future e-learning delivery has to cater for different learning styles, especially for the two opposite dimensions of concrete experience and abstract conceptualization.

**Table 22.8** Learning styles and online behavior

| Learning type | Preferred type of DB posting | Communication tool | Problem solving |
|---|---|---|---|
| Accommodator | Challenging a point of view<br>Share own experience | Email | Own criteria |
| Assimilator | Introducing a new perspective | Offline meetings<br>General discussion board | Put things into a framework/model.<br>Analyze quantitative data |
| Diverger | Challenging a point of view | Ask teacher | Imaginative ability |
| Converger | All | Not significant | Put things into a model/framework.<br>Analyze quantitative data |

A student-centered recommender system should recommend case studies and articles to "Northern" Accommodators and Divergers. For Convergers and Assimilators, it should provide models and frameworks. Assessment criteria as well as learning material will need a wider array of flexibility to cater for students' learning preferences. Students should have the final verdict on personalized content and assessment. For the future work, collaborative filtering should be considered as a method to provide a solution to personalize content and communication, by finding learning style neighbors and predict what preferences a user has, for different learning hemispheres. One size does not fit all.

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# Chapter 23
# Learning and Instruction in the Digital Age

## Epilog

**J. Michael Spector**

**Abstract** The Cognition and Exploratory Learning in the Digital Age (CELDA) conference brings together researchers from computer science, education, instructional technology, and psychology each year to discuss critical issues in making effective use of technology to support learning and instruction. The exchange of different perspectives and cutting-edge applications at conferences such as CELDA are vital parts of this dynamic professional community. The chapters in this volume are expanded versions of the best papers presented in Freiburg at CELDA 2008. Collectively considered, they address a wide range of issues and innovative applications involving technology-facilitated learning and instruction. This brief chapter is intended to provide a kind of reflection on where we have been and seem to be going with regard to digital learning technologies.

## 23.1 Where We Have Been

It is no longer a surprise that technology changes rapidly. Educational developers and instructional technologists continue to be challenged to keep up with the emergence of powerful devices that can support learning and instruction. We can and should take an occasional break and look back over several generations of educational technology and reflect on what we, as a professional community, have done and where we have been. Some will find remarkable examples of innovative applications of technology and their potential impact on learning and instruction (Merrill, 2002; Spector & Anderson, 2000). Others argue that we have not come nearly as far as technology enthusiasts and advocates have predicted (Spector, 2000). What might be said about advances in technology-facilitated learning and instruction?

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At the 2008 International Conference on Advanced Learning Technology conference held in Santander, Spain, the conference closed with a panel of six people who were all asked the same question: What in your judgment is the most significant advance in educational technology in the last 100 years and why? (Spector, 2008). The answers were not altogether unexpected. One panelist cited the personal computer as the technology that has had a major impact by putting a powerful tool in the hands of individual learners. Another panelist argued that the Internet was the most significant technology to be introduced into learning and instruction, as it empowers individuals and groups not previously possible or even imagined. The other answers were somewhat similar and generally upbeat and positive for various technologies.

I offered a somewhat different response. I said that I thought the slide rule was the most significant educational technology that I had seen in my lifetime (Fig. 23.1). The slide rule was developed in the 17th century and was a kind of mechanical analog calculating device used for multiplication, division, square roots, logarithmic and trigonometric functions, and more. Slide rules were in common use in engineering programs prior to the introduction of powerful digital scientific calculators in the 1970s. My reason for mentioning the slide rule was simple. I had used it in my undergraduate education. I knew from practical experience that it was very easy to make a huge mistake if the scales were not properly aligned or if they were moved ever so slightly just prior to taking a reading. This knowledge forced me to estimate a reasonable range for the answer to the problem I was trying to solve with the slide rule prior to using it. In other words, the technology forced me to think about the problem and a reasonable answer. In my simple mind, that was an effective technology as it promoted reflection on the problem. Naturally I thought this was a brilliant response.

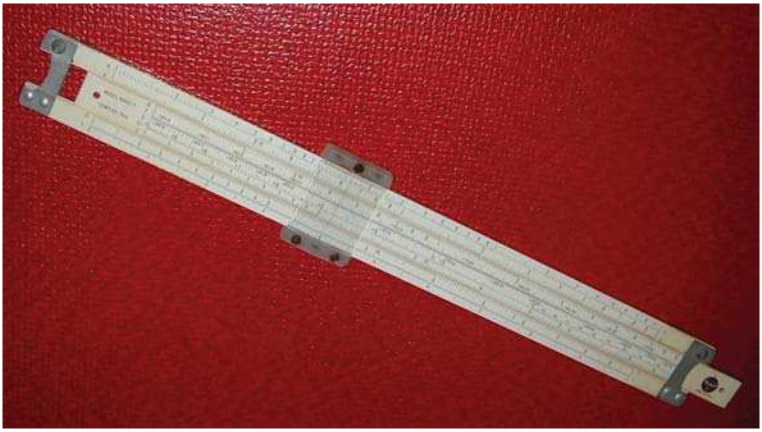

**Fig. 23.1** A typical 10 inch student slide rule (from Wikipedia Commons – see http://en.wikipedia.org/wiki/Slide_rule)

After I completed my explanation, someone in back of the auditorium raised a hand and asked, "What's a slide rule?" The pride I had taken in my answer quickly turned into complete embarrassment. I had not taken my audience into consideration when answering. Nearly everyone there had a college education but most had completed their undergraduate studies in the 1980s or 1990s when slide rules not so common on campus. I was struck dumb but thankfully my colleague and co-organizer of the conference, Demetrios Sampson (also a co-organizer of CELDA and co-editor of this volume) patiently explained to the audience what a slide rule was.

I have shared this story as I believe it illustrates three important things about where we have been with educational technology. First, it suggests that one ought to take learner and audience characteristics into account when planning instruction and presentations. Of course we all know this, but it is easy to overlook this critical aspect of effective planning and assume that everyone is like oneself and has had similar life experiences. This is a terrible assumption to make when planning learning and instruction.

Second, it suggests that the best and brightest people in our community are not thinking about what has been done, what mistakes have been made, what innovations failed and why, and so on. History is often viewed as a boring subject, especially for technologists who are more naturally oriented to what is new and the future. We have much yet to learn from our history. Historically, when a new technology is being adopted in education and training on a large scale, attempts are made to use it to replace things done with previous methods and technologies, rather than rethink the educational or training context from a systems perspective. A replacement strategy often does not make good use of the affordances of a new technology, and it tends to focus early use on operating the device rather than using it to advance learning and instruction. A recent example of this would be the way that the graphing calculator has been introduced into secondary education in the United States with little regard for proper teacher preparation or meaningful integration into the curriculum (Gogus, 2006). New tools can be wonderful, but we know from past experience that training in proper use of the tool is critical and rethinking the entire process affected by the tool is often necessary to gain the full advantage of the tool.

Third, the notion of using technology to encourage or even provoke critical thinking is largely ignored in mainstream uses of educational technology. All too often, it seems as if technology advocates are convinced that just introducing a particular technology will magically transform learning and instruction. This magical transformation has simply never happened, so far as I can tell. The business of effective technology integration is hard work and necessarily involves a willingness to change and make adjustments as evidence on effective use is collected. The shameful truth is that, apart from the contributors to this volume, too many technology advocates simply do not collect or otherwise ignore evidence of effectiveness or efficiency. Too many technology enthusiasts want to make education fun, when we ought to be provoking our students to do the hard work called thinking (Dörner, 1996; Jonassen, 2004; Seel, 2006).

## 23.2 Where We Might Be Going

I urge others to reflect on where our professional community has been. I want to close this epilog with a few remarks about where we might want to see the profession go. These remarks will come as no surprise, as they are tightly coupled with my perception of where we have been. First, I think we should insist that the introduction of digital technology into learning and instruction should be guided by an *educratic oath* based on the notion that we ought to do no harm – that is to say that our innovations should not systematically disadvantage a group of learners (Spector, 2005). This principle implies that a certain restraint should accompany our natural enthusiasm for new technologies.

Additionally, we ought to promote the use of those technologies and techniques that systematically produce improved learning and instruction. It is often the case that a simple technology proves to be more effective in terms of learning outcomes than a complex technology. In any event, it is incumbent on educational technologists to conduct empirical research to determine which technologies and methods work best with different learners and learning tasks and situations. We have an obligation to be scientific if we wish to see the discipline mature. Moreover, we need to ensure that our scientific findings make their way into classrooms and workplaces where they can make a positive difference. Our task as educational technology researchers is not to pile up academic credits in the form of publications and grants. Rather, our task is to contribute to the improvement of society through improved learning and instruction based on effective use of new technologies.

Finally, I would personally like to see a more clear-headed discussion of the foundations and frameworks upon which we base our innovations. As an example, I select constructivism to make this point. Constructivism is a naturalistic epistemology, in contrast with a deductive epistemology. The fundamental notion behind constructivism is that people create internal representations as they experience the world and they use these internal representations to make sense of their experiences. Several of the contributors to this volume refer to these internal representations as mental models; these internal constructs are a vital to learning, so it is very appropriate to develop new technologies to indirectly measure how these internal representations change over time and through experience and instruction. Constructivism is inherently descriptive – it describes what individuals do in the course of making sense of their experience. People will construct internal representations regardless of what their teachers and trainers do. As Wittgenstein (1922) said in the *Tractatus Logico-Philosophicus*, we picture facts to ourselves – we create internal representations. We cannot stop that naturally occurring process. So it is wrongheaded to talk about a constructivist learning environment, since learners are always constructing internal representations. What teachers and instructional designers can do is to create support for the effective construction of internal representations. These are likely to be different for different learners. Therefore, it makes much more sense to talk about student-centered learning environments (see the Chapter 2 by Hannafin & Hannfin, in this volume).

Unfortunately, what has happened within the professional community is an arbitrary and false division between self-proclaimed advocates of constructivism and everyone else. The version of constructivism described previously is nearly uniformly accepted by cognitive psychologists, educational researchers, and instructional designers. There is no battle and there is no need to create imaginary opponents to push a personal agenda. Simply said, we need to get on with the business of helping people learn.

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Note: The letters ‘f’ and ‘t’ following the locators refer to figures and tables respectively.





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