Implementation of pedagogical principles into the software design process of e-learning applications

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Abstract

E-learning in higher education faces challenges related to variation and personalization, after a decade of attention to learning objects and computer-supported collaboration. The main objective of the thesis is to investigate how to assure the quality of the development process of e-learning applications by the implementation of pedagogical principles into the software design process. Specifically this includes the pedagogical principles of individualization, variation, meta-learning and best practice.

This thesis contributes to the field of e-learning by four main contributions (C1-C4):

C1: Design pattern-based wizards to implement best practice
The first main contribution of the thesis is the idea of using pedagogical design patterns as a basis for the development of wizards in e-learning applications. Design patterns are archetypes on well-used solutions and enable the implementation of best practice and the expertise of experienced online teachers into the application. In the process of a pedagogical and technological configuration of an application, the design pattern-based wizard provides an interface presenting pedagogical opportunities, hints and comments to novice online teachers.

C2: The E-learning Circle
The E-learning Circle is a software design tool, assuring the quality of the design process of e-learning applications, focusing on variation, individualization and meta-learning. It consists of a number of concentric circles, which are divided into three sectors; student, teacher and learning objectives. The inner circles cover pedagogical considerations, while the outer circles specify how the pedagogical theories may be implemented with technology. The strengths of the E-learning Circle are the compact presentation combined with the overview it provides. It is also useful in dealing with complexity, providing a common language and embedding best practice. The E-learning Circle is not a prescriptive method, but is useful in several design models and processes. It represents a holistic approach to the design of e-learning applications and prevents the overexposure of e.g. learning objects or assessment in an e-learning system.

C3: The E-learning ontology
The E-learning ontology is a contribution to the need of a formal representation of a set of concepts and the relationships between those concepts within the e-learning field. This is necessary when planning to use topic maps as a HCI-solution within e-learning. The E-learning ontology suggests a representation of topics useful for developing topic maps and illustrates an approach how to develop personalized e-learning applications.

C4: The PLExus prototype
The PLExus prototype is a working prototype of a personal learning environment based on the semantic technology of topic maps. PLExus provides a student interface allowing customized views of learning objects and learning activities. The customized views are mainly based on pedagogical methods, learning objective types and proficiency stages. PLExus provides a wizard for the teacher in the process of adding and structuring learning objects into the topic map.

The research method of this thesis is Grounded Theory. This inductive, theory discovering approach allows the grounding of theory in empirical data and is appropriate for the exploratory nature of this thesis. The empirical data of the thesis were collected through 21 interviews, three focus groups, and three expert groups.

Preface

This thesis is submitted to the Norwegian University of Science and Technology (NTNU) for partial fulfillment of the requirements for the degree of philosophiae doctor.

This doctoral work has been performed at the Department of Computer and Information Science, NTNU, Trondheim, with associate professor Arvid Staupe (NTNU) as main supervisor and with co-supervisors professor Torbjørn Skramstad (NTNU) and associate professor Lars Vavik (The University College of Stord / Haugesund).

Acknowledgements

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Definitions of main terms

Ambient learning	A personal learning environment with access to learning resources anytime, anywhere and anyhow (Kofod-Petersen et al, 2008). Ambient intelligence is the European version of the UK term 'ubiquitous computing' (Conole & Oliver, 2007).
Application	Computer software designed to perform a specific task.
Best practice	A process or activity, which is believed to be more effective at delivering a specific outcome than any other process / activity when applied to a particular condition.
Blended learning	The integration of online learning into more traditional methods of learning.
Design pattern	"Description of a problem which occurs over and over again in our environment, and then a description of the core of the solution to that problem in such a way that you can use this solution a million times over, without ever doing it the same way twice" (Alexander, 1977).
Differentiation	Providing learning experiences (learning content, process, product and environment), which are matched to the needs, capabilities and previous learning of individual students.
Eclecticism	"The practice of selecting doctrines from different systems of thought without adopting the whole parent system for each doctrine" (Encyclopædia Britannica, 2009).
E-learning	"The use of computer and information technologies to create learning experiences" (Horton, 2006).
Formative assessment	"Assessment for learning, used to improve a student's learning process and learning outcome" (Lauvås, 2003).
Framework	An abstract structure to support complex tasks.
Grimstadmodellen	A design approach for computer lessonware developed in the 1980s (Crossley and Green, 1985; Minken & Stenseth, 1992).
Individualization	A focus on the individual person instead of the group(s), which the person belongs to. In this thesis 'individualization' is used to describe the educational strategy considering the student's individual needs in a learning situation.
Information systems	The academic field concerning the interaction between processes and technology.
Instructional design	"Instructional design contributes theories about how human beings

learn, strategies for applying these theories, and methodologies to carry out the strategies" (Horton, 2006).

Learning management system	"A software system that combines a number of different tools that are used to systematically deliver content online and facilitate the learning experience around that content" (Weller, 2007).
Learning theory / ies	"Learning theories are descriptive. They describe how learning occurs" (Reigeluth, 1999).
Learning activity	"The interaction between a learner and an environment, leading to a planned outcome. It is the planned outcome which makes learning a purposeful activity" (JISC, 2007).
Learning design	"The application of learning design knowledge when developing a concrete unit of learning, e.g. a course, a lesson, a curriculum, a learning event" (Koper, 2005).
Learning object	"Any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning" (IEEE, 1990).
Lifelong learning	Ongoing learning in formal, non-formal and informal ways.
Meta-learning	Meta-learning is the state of "being aware of and taking control of one's own learning" (Biggs, 1985).
Ontology	A formal representation of a set of concepts within a domain and the relationships between those concepts.
Personal learning environment	There is no common understanding of what the term means (Johnson et al, 2006), but the thesis uses the following definition: An online learning environment where the student is able to customize his/her learning environment based on pedagogical and personal choices.
Personalization	The use of technology to offer user-specific customization.
Semantics	The study of meaning.
Site	A place for fieldwork in research.
Software engineering	"Using the knowledge of computers and computing to help solve problems" (Pfleeger & Atlee, 2010).
Summative assessment	Assessment of learning
Theory	"A set of well-developed concepts related through statements of relationship, which together constitute an integrated framework that can be used to explain or predict phenomena" (Strauss & Corbin, 1998).

Tool	"An instrument or automated system for accomplishing something in a better way. This 'better way' can mean that the tool makes us more accurate, more efficient, or more productive or that it enhances the quality of the resulting product" (Pfleeger & Atlee, 2010).
Toolkit	"Toolkits are sets of related, reusable classes that provide well-defined sets of functions" (Pfleeger & Atlee, 2010).
Topic map	"A topic map is a technology for knowledge integration, describing concepts and their relations" (Garshol, 2006). ISO standard ISO/IEC 13250:2003.
Virtual learning environment	"A software system that combines a number of different tools that are used to systematically deliver content online and facilitate the learning experience around that content" (Weller, 2007).

Abbreviations

CMS   Content management system

CSCL   Computer-supported collaborative learning

CSCW   Computer-supported Collaborative Work

CVE   Collaborative virtual environment

E-LEN   The E-LEN project was funded by the European Union under the Minerva program (ref.nr. 101421-CY-2002-1-CY-minerva-mmp)

EML   Educational Modelling Language

FAQ   Frequently asked questions

GIS   Geographical information systems

HCI   Human-computer Interaction

HEI   Higher Education Institutions

IEEE   Institute of Electrical and Electronics Engineers, Inc.

ICT   Information and Communication Technology

ID   Instructional design

IS   Information systems

ISO   International Organization for Standardization

ISD   Instructional System Design

IM   Instant messaging

IMS   IMS Global Learning Consortium, Inc.

LAMS   Learning Activity Management System

LCMS   Learning Content Management System

LIKT   Læring med IKT (Learning with ICT)

LMS   Learning Management System

LOM   Learning object metadata

LA   Learning activity

LD   Learning Design

LO   Learning object

MCQ   Multiple Choice Questionnaire

PLE   Personal learning environment

PSI   Published subject indicator

QUIS   Quality, Interoperability and Standards. The QUIS project was funded by the
            European Union under the E-learning programme (project nr 2004-3538/001-
            001-ELE-ELEB14)

QAS   Quality assurance system

RDF   Resource Description Framework

RLO   Reusable learning object

RUP   Rational Unified Process

SCORM   Sharable Content Object Reference Model

SMS   Short Message Service

VLE   Virtual learning environment

WP   Work package

XML   Extensible Markup Language

XP   Extreme programming

1. Introduction

This chapter outlines the motivation and context for the research presented in this thesis. The problem statement and research questions are presented. Limitations relevant for the research are described, and finally a thesis outline is presented.

1.1 Motivation

The motivation for research in the e-learning field is based on three different perspectives; the student's perspective, the online teacher's perspective and the software developer's perspective.

The student's perspective
The expected advantages of e-learning for the student include the opportunity of flexible learning, meaning learning anywhere and anytime, and the opportunity of communication and collaboration in virtual environments. E-learning should also target the specific needs of the individual student, e.g. by supporting different learning approaches and different intellectual levels. The demand for individualization of e-learning also entails a demand for variation.

E-learning, from the higher education student's perspective, should cover different stages in a course, e.g. administrative tasks, learning situation, communication and assessment. The e-learning applications should provide learning situations where different types of learning objectives (knowledge, skills and attitudes) are covered. In a setting of life-long learning, 'learning to learn' is also important to the student. The e-learning applications therefore must take this into account, and provide possibilities for meta-learning awareness (Biggs, 1985).

The technology must be easy to learn and easy to use, and the technology should support and provide opportunities in the learning situation, not be restrictive and complicated to learn and use.

The teacher's perspective
E-learning courses and blended learning courses for higher education are usually based on a VLE / LMS (Virtual Learning Environment / Learning Management System) e.g. Blackboard, WebCT, Moodle, Fronter and It's Learning. The weaknesses of these systems are that they give too much attention to online administration and too little attention to pedagogical concerns (Britain & Liber, 2004). The LMS forces the teacher to use only a few pedagogical methods. Teachers are used to finding the best methods of teaching their subject, and online teachers also should have the same opportunity. Most online teachers do, however, still need systems that help them discover the different pedagogical methods to use in a computer-based learning environment.

Online teachers have typically adopted the pedagogical methods of pioneer online teachers. They have also been dependent on and limited by the learning system used. "Many first-time

users of VLEs (Virtual Learning Environments) seek to adapt the way that they work to the way that the software needs things to be done" (Britain & Liber, 2004).

Variation has been regarded as an important principle within teaching and learning. This principle seems lost on the road to the online university. Many online teachers use a few pedagogical methods over and over again: This is convenient for inexperienced online teachers. Britain and Liber concluded in 1999 that the majority of VLEs (Virtual Learning Environments) were designed to support an education model based on information transmission (Britain & Liber, 2004). However, a model based on information transfer alone does not take into consideration the pedagogical challenges facing teachers and students in online communities.

The IMS Learning Design is a contribution to the software design process of e-learning applications, but teachers often experience difficulties trying to use IMS-LD (see chapter 2.6); "a number of teachers and learning providers have voiced their opinion that a methodology is required for the first stage of analysis and the creation of the didactical scenario" (Griffiths & Blat, 2005).

The software developer's perspective
There have been many experiments conducted the last decades, when it comes to developing software based on pedagogy. Often the experiments base their work on one learning theory, which means there is one application for Problem-based learning, one application for CSCL (computer-supported collaborative learning), one application for drill and practice etc. If we want an e-learning environment with variation, we need to integrate the experiences from the different systems into one. The learning management systems often provide a simple user interface, which enable such integration to a certain point. "This richness of information and tools, whilst having the advantage of creating a much more challenging and stimulating environment, often results in the well-known problem of information overload" (Roda & Nabeth, 2005). Information overload is connected to information management and is a challenge the software developer must take into consideration.

Blinco et al. (2004) claim that "rarely are technologies used in e-learning developed specifically for the learning community" and they classify web-accessible technologies and services useful to learning, education, and training into three categories; infrastructure specifically purposed to support learning, education, and training; infrastructure that is not specifically purposed to support learning, education, and training but is still essential in enabling it; and, more widely deployed infrastructure that may be useful for learning, education, and training. In the software development process of e-learning application there is a demand for software developing tools, which provides a common language for software developers and teachers.

A lot of research and development within e-learning has been done concerning standardization, and specifically standardization of content reuse. Standards to ensure the reusability of learning objects, and the term RLO (Reusable learning objects) are used extensively. Examples of standards for content are SCORM, IMS, IEEE LOM and DublinCore. The main problems of the standards mentioned are the amount of metadata connected to each learning object in addition to the learning object granularity. Some consider an entire curriculum as a learning object (Wiley, 2005), while others consider a picture (e.g. .jpg-file) as a learning object. This is of course a problem regarding reusability. "From an "efficiency" point of view, the decision regarding learning object granularity can be viewed as

a trade-off between the possible benefits of reuse and the expense of cataloguing" (Wiley, 2005). There is software based on these standards (authorware), made to produce learning objects possible to integrate into different learning management systems. Just the fact that there are many standards concerning learning content, that authorware has to adapt to, shows how difficult reusability in e-learning is. It is also important to have access to solutions on how to retrieve the learning objects, without the danger of information overload for the student.

1.2 Objective

The specific activity being studied in this project is the design of e-learning applications for use in higher education. The main objective is to investigate how to assure the quality of the development process of e-learning applications by the implementation of pedagogical principles into the software design process. The specific pedagogical principles, which the study will consider are variation, individualization, meta-learning and best practice.

The objective of the research is to contribute to e-learning design methodologies with components in the software design process. Components in a software design process might be e.g. tools, models, theories, techniques, toolkits, guidelines, patterns or frameworks that will assure the quality in an early stage of the software development process of an e-learning application. This will in turn improve the quality of learning applications for both teachers and students.

1.3 Research questions

The specific research questions of the thesis are:
1. How to implement the pedagogical principle of ***variation*** into the design process of e-learning applications?
2. How to implement the pedagogical principle of ***individualization*** into the design process of e-learning applications?
3. How to implement the pedagogical principle of ***meta-learning*** into the design process of e-learning applications?
4. How to implement the pedagogical principle of ***best practice*** into the design process of e-learning applications?

Research question 1 focuses on variation. Britain (2004) describes variation as a success criterion in e-learning. "Whilst learning is an effortful and active process of knowledge construction that humans perform quite naturally, not all learners are equally capable of effective and efficient learning on their own. Indeed, most if not all, benefit from some level of guidance and support. Successful teaching involves a *variety* of strategies and techniques for engaging, motivating, and energizing students over and above merely presenting them with well-designed learning materials" (Britain, 2004). The thesis will through empirical data investigate what 'variation' should include in an e-learning setting, and how variation can be implemented in the software design process.

Research question 2 concentrates on individualization. The perceived advantage of e-learning to target the specific needs of the individual student, is a challenge in today's e-learning. The heterogeneous student group means that assuring the quality of individualization in e-learning

is a large task. This task should be considered in early stages of e-learning software design, and this thesis will try to contribute to ensure early consideration of individualization in the design process of e-learning applications.

The main focus of research question 3 is meta-learning (learning to learn). Meta-learning is the "state of being aware of and taking control of one's own learning" (Biggs, 1985). Based on empirical data, the research will suggest how meta-learning can be applied into the design of e-learning applications.

Research question 4 focuses on the pedagogical principle of best practice. A best practice is a process or activity, which is believed to be more effective at delivering a specific outcome than any other process / activity when applied to a particular condition. Implementation of best practice into the design process of e-learning applications will be a contribution to assure the quality of e-learning. This will be one of four major concerns of this thesis.

The problem statement and the research questions are exploratory and open-ended. The research questions focus on bridging pedagogical theories and software design. By focusing on the pedagogical principles of variation, individualization, meta-learning and best practice, the goal is to contribute to the further development and quality assurance of e-learning applications.

Main concepts
Horton's definition of e-learning is "the use of computer and information technologies to create learning experiences" (Horton, 2006) and is deliberately open-ended, without mentioning any system or the term 'course'. The empirical work of this thesis will include people with experiences from different e-learning systems and a variety of courses.

The concept of 'individualization' is not used as contrast to collaborative learning, but is seen as important in learning and teaching situations without regards to the pedagogical method used to reach the learning objective, which means it also includes collaborative learning.

It is within the e-learning field an unstructured use of concepts such as application, software and system. Software is a general concept, which can be understood as both system software and application software. The concept 'system' typically is used to describe basic software as operating systems, file systems etc., but in the e-learning field 'system' is also used to describe applications like 'Learning management system', 'Learning Content Management System' and 'Learning Activity Management System'. This thesis will mainly use the concept 'application' or 'software' in the meaning of 'application software', but also the concept 'system' in settings were this concept is agreed upon in the field, e.g. learning management system.

1.4 Research context

The research presented here is conducted within the framework of three projects, two EU-projects, called E-LEN and QUIS, and an internal NTNU-project within Programme for Learning with ICT (LIKT). E-LEN was running in 2002-04, and QUIS was running for two years (2005-06). The LIKT project was running from March 2007 until January 2008.

E-LEN
The E-LEN project was partially funded by the European Union under the Minerva programme (ref.nr 101421-CY-2002-1-CY-minerva-mmp). The project brought together researchers and practitioners from 11 institutions across Europe. The goal of E-LEN was to include the development and dissemination of design knowledge tailored to the needs of people professionally involved in e-learning. The approach was to involve the production of design patterns, laying the foundations for an e-learning pattern language (E-LEN, 2003).

QUIS
The QUIS project was funded by the European Union under the E-learning programme (project nr 2004-3538/001-001-ELE-ELEB14). The activities in the QUIS project were directed towards *QU*ality in e-learning, *I*nteroperability and reusability of e-learning material and development of *S*tandards, as well as cost effectiveness in e-learning. The QUIS project was divided into 9 work packages (WPs), where I mainly contributed to WP 4 and WP 5 in addition to administrating, developing requirements, use cases and prototypes, and writing up the work of WP 6. The outcome of WP 6 was a requirement specification of a next generation e-learning system and a prototype of the PLExus prototype, which was based on the architecture of topic maps. This thesis includes work from work package 6. The evaluation report from EU comments that "The QUIS project has developed some interesting activities for the continuation of the project. This concerns the maintenance of the website, the online evaluation tool, the further work on PLExus and the ongoing research work in the field of user requirements" (E-learning programme, 2007).

LIKT
The LIKT project consisted of three research components; a quantitative study of the usage logs in the "It's learning" LMS, a quantitative study of the learning object types used in an LMS and a qualitative study of 18 interviews with instructional staff and students at the Norwegian University of Science and Technology, and representatives from It's learning Ltd. This thesis includes parts of the qualitative study from the LIKT project.

Combining several different projects (E-LEN, QUIS and LIKT) in a doctoral thesis entail both advantages and disadvantages. Advantages include the opportunity to cooperate with international researchers, and that deadlines of the different projects ensure the progress of the doctoral project as some of the work packages in the projects act as mile stones. The combination of several projects fits well with the Grounded Theory's technique of theoretical sampling- "[the] process of data collection for… generating theory whereby the analyst jointly collects, codes, and analyses his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges" (Glaser & Strauss, 1967). It was possible to select data collection sites in e.g. the QUIS project based on the needs of the doctoral project. The disadvantages of combining several projects include that time must be spent to finish reports not possible to use as part of the doctoral thesis and that the timetable of the doctoral project was dependent of the different projects' time tables. In addition, my focus of the work had to fit the smaller work packages in the different projects. All in all, my experience of taking part in several projects was however positive and fruitful.

1.5 Limitations

Theoretical limitations:
The aim of the study is to investigate how to assure the quality of the development process of e-learning systems by the implementation of pedagogical principles into the system design process. It is of course not possible to cover all pedagogical principles in one study. It was necessary to limit the pedagogical principles to the principles of variation, individualization, meta-learning and best practice. The main reasons why these pedagogical principles were chosen are; 1) The research showing that online teacher are dependent on and limited by the technological tools when teaching online courses (Britain & Liber, 2004) show the importance of variation and best practice, 2) A student-centered view on e-learning, where individualization, personalization and flexible learning are important factors, and 3) The notion of life-long learning, which revives the importance of meta-learning. The pedagogical principles of variation, individualization, meta-learning and best practice are important in campus education, but are also important within e-learning.

Empirical limitations:
The target group of my study is users of learning systems in *higher education*, both system developers of e-learning systems within higher education, and end-users like higher education teachers and students.

1.6 Outline of the thesis

The thesis is structured as follows:

Chapter 2: In this chapter the state of the art of the e-learning field is presented. Based on the interdisciplinary problem statement of the thesis, the literature necessarily includes both pedagogy and computer science issues.

Chapter 3: This chapter gives the methodological foundations for this study. Reasons for choosing the Grounded Theory method are given and the research process is described. Finally reflections on the research method of this study are provided.

Chapter 4: The chapter presents the main contributions of the thesis. A summary of each paper is presented, and each paper is connected to the research questions it answers.

Chapter 5: This chapter evaluates the research questions and the main contributions. Each contribution is discussed and linked to the theories and the state of the art. Finally the trustworthiness of the study is evaluated and some reflections on interdisciplinary research are provided.

Chapter 6: The chapter concludes the thesis by providing conclusions and an overview of further work.

Chapter 7: References.

Appendices:
Appendix A contains the published papers, which this thesis is based upon.
Appendix B includes the abstracts of published papers not found relevant for this thesis.

2 State of the art

The e-learning field includes the combination of instructional design and software design. This chapter first introduces e-learning in higher education based on several quantitative studies. Then the chapter will briefly present the background of both instructional design and software design. The challenge of combining instructional design and software design is presented through an overview of the IMS Learning Design and a learning design toolkit. Finally, in order to provide an overview of the context of this study, design patterns are briefly described. The theories from this chapter will be reflected upon in chapter 5 when discussing and evaluating the contributions of the thesis.

2.1 E-learning in higher education

The use of e-learning and blended learning (here understood as the blending of e-learning with traditional learning) in today's higher education is naturally hard to generalize, but this is an attempt to describe some experiences with educational technology in higher education courses. There exist several quantitative studies of the use of ICT in schools, but there are only a few studies covering e-learning and blended learning in higher education. In the USA the ECAR study (Caruso & Salaway, 2008) provides information on the technology behaviors, preferences and attitudes of undergraduate students related to academic experiences. In Norway the survey "Norgesuniversitets Monitor" (Wilhelmsen et al, 2009) documents the use of information and communication technology in higher education. In addition the LIKT study (Kolås et al, 2008) provides information on the use of a specific LMS at the Norwegian University of Science and Technology.

The ECAR study (Caruso & Salaway, 2008) of undergraduate students and information technology analyzes the responses of 27,317 freshmen, seniors, and community college students at 98 colleges and universities in the United States to a web-based survey, as well as findings from focus-group discussions. Respondents report spending an average of 19,6 hours per week actively doing online activities for work, school or recreation. 93,4 % use the university library website and 91,9 % use the presentation software. Also used by most students are spreadsheets (85,9 %), social networking sites (85,2 %) and text messaging (83,6%). Younger students report much greater use of social networking, text messaging, and instant messaging than older students. 82,3 % use course management systems, and most of these respondents use CMS (content management system) several times per week or more often. The respondents generally like using a CMS – 57,8 % say their CMS experience is positive, and an additional 11,7 % go so far as to say their experience is very positive. Only 5,3 % report an overall negative experience with CMSs (Caruso & Salaway, 2008).

The ECAR study (Caruso & Salaway, 2008) also reports that 59,3 % of the respondents prefer a moderate amount of IT in their courses. Most respondents report a preference to learn by running Internet searches (80,2 %), and more than one-third like to learn through text-based

conversation over e-mail, IM, text messaging, or through contributing to websites, blogs, wikis, and the like. A solid half (50,8 %) like to learn through programs they can control such as video games and simulations. ECAR reports that 45,7 % of the respondents agree on the statement "The use of IT in my courses improves my learning", while 31,8 % agree on "I get more actively involved in courses that use IT", and 65,6 % agree on the statement "IT makes doing my courses more convenient" (Caruso & Salaway, 2008).

The study "Norgesuniversitetets IKT-monitor" (Wilhelmsen et al, 2009) is a survey answered by 188 leaders, 701 teachers and 5686 students at Norwegian universities and university colleges. The study reports that Norwegian students use the computer on the average 10,4 hours per week working on personal tasks, 9,4 hours per week for study related activities and only 1,7 hours per week in the classroom. Concerning learning management systems (LMS) the teachers use the LMS to publish messages and lecture notes, while the students use the LMS to read messages and lecture notes published by others, and the majority of the students also submit exercises via the LMS. Just below 10 % of the students participate in the LMS discussion forums. Students and teachers do not make much use of digital learning resources. ICT is primarily used for word processing and Internet searches, but not as much for wiki, blogs and discussion forums. SMS is the most common communication channel, followed by social networks and chat. E-mail is used weekly or more often by only half of the students.

The Norwegian University of Science and Technology (NTNU) has used the learning management system (LMS) "It's learning" since 2002. The LIKT study (Kolås et al, 2008) is based on the statistical data generated by the "It's learning" system. The results from the LIKT study cover all courses in the spring semester of 2007 at NTNU, a total of 1456 courses. The results show that 7 of 7 faculties are using the LMS to some degree; the most frequent use of the LMS is at the Faculty of Natural Science and Technology (63 % of the courses) and the least frequent use of It'learning is at the Faculty of Architecture and Fine Art (33 % of the courses). The results also document that file uploading is the LMS functionality used most; more than 50 % of the courses have uploaded at least 1 file during the semester, 39 % of the courses have uploaded more than 10 files. Only 30% of the courses have uploaded on the average 1 file pr week during the semester.

The LIKT study (Kolås et al, 2008) also documents how many courses use the It's learning tools in the LMS, see Table 1.

It's learning tools	Percentage of courses using the LMS tools (n= 1456)
Discussion forums	12 %
Conferences	1 %
Notes	19 %
Hyperlinks	17 %
Exercises	21 %
Surveys	7 %
Text collections	1 %
Explanation sequences	0,2 %

Table 1: The percentage of courses at NTNU using the LMS tools.

The LIKT study also documents differences in use of functionality based on different course types (introduction courses, basic bachelor courses, advanced bachelor courses, master courses, professional degree courses, graduate courses, and continuing education courses).

The study shows that continuing education courses on the average use the functionality of notes, hyperlinks, files, exercises, text collections, explanation sequences and conferences most. Discussion forums are most used in bachelor courses, and tests are most used in professional degree courses. Surveys are evenly divided between the course types.

The qualitative results from the LIKT study, based on 20 interviews, shows that text-, image- and video-based presentations are the pedagogical method most familiar to teachers using the LMS. Discovery and problem solving are also methods that to some extent are used. Other methods, such as gaming, simulations and collaborative learning, are not extensively used (Kolås et al, 2008).

2.2 Trends in e-learning

Activity based e-learning
The focus on activity-based learning rose with the introduction of learning design. Karampiperis and Sampson (2005) are some of the researchers who have been focusing on e-learning transforming from content-based learning to activity-based learning. The focus on activity-based learning was a reaction to the overemphasis of research and development of reusable content, in order to focus more on pedagogical challenges in e-learning.

Personalization
The e-learning field has spent much effort on standardization (of learning content, learning activities etc), and as an answer "personalization is often portrayed as the next big thing in e-learning" (Weller, 2007). Johnson et al. (2006) describe how individuals have different understandings of the concept "PLE" (Personal learning environment), from "empowering users of informal learning resources away from institutions" or "an extended portfolio" to "a superfluous accessory to the technologies of the desktop operating systems and the World Wide Web". The variety of interpretation illustrates how diffuse the PLE concept still is. Weller (2007) describes personalization as following; "Personalization is often a short-hand for saying 'customization and personalization', where customization is changes made by the user to their learning environment or content, and personalization is changes or choices made by the system" (Weller, 2007). "With regards to VLEs, there are two flavors of personalization. The first is personalization of content and information, and the second is personalization of tools and services. The second of these has led to the concept of a personal learning environment (PLE)" (Weller, 2007). The definition of PLE offered in this thesis is "an online learning environment where the student is able to customize his / her learning environment based on pedagogical and personal choices".

 "The personal learning environment (PLE) problem include the desire for greater personal ownership of technology, the desire for more effective ways of managing technological services, the desire for the integration of technological activity across all aspects of life, not just institution-based learning, the removal of barriers to the use of tools and services and the desire to facilitate peer-based working" (Johnson et al, 2006).

With personalization as a goal, several projects use Artificial Intelligence (AI) techniques to develop adaptive applications. The VICE project (Acquaviva & Benini, 2005) describes how adaptive strategies in web-based learning systems are presented in several systems. The VICE project draw upon the semantic web technology and the use of Artificial Intelligence techniques, in order to cope with the adaptive aspects of the educations contents fruition,

where contents are modified according to a model of the learners. Other adaptive systems are AHA! / MOT, the Dynamic Assembly Engine, ELENA and ELeGI (Acquaviva & Benini, 2005). Popescu et al. (2009) have proposed WELSA, an adaptive web-based educational system aimed at adapting the courses to the learning preferences of each student.

Mobile learning
Mobile learning means learning outside a restricted physical location. Portable devices, such as mobile phones, PDA (personal digital assistants) and laptop computers, opened the possibilities within mobile learning. New mobile technology can be used within learning and teaching, communication and collaboration and are now to some extent being adopted within educational institutions. Dye et al. (2005) argue that mobile learning is the next generation of learning.

Ambient learning
Ambient intelligence is defined as human beings surrounded by intelligent artifacts, supported by computing and network technology embedded in everyday objects and the environment should be aware of the presence of a person, perceive the needs of this person and respond intelligently to them in a relaxed and unobtrusive manner (Ducatel et al, 2001). Flexibility of e-learning gets another dimension with the introduction of ambient learning, as learning is moved away from the computer to the everyday life.

Immersive learning
Kickmeier-Rust et al. (2007) propose the idea of immersive digital games as the interfaces for next-generation learning. Immersive learning provides, in contrast to traditional 2D user interfaces (e.g. website interfaces, flash animations), a 3D virtual learning environment and advanced computer applications that enable realistic simulated environments. "Immersive learning technologies in the form of realistic simulations are widely used in 'high stakes' learning settings such as space training, medical education, and piloting. However, because these types of simulations are very expensive and resource intensive to produce, their use in education generally has been limited" (Herrington et al, 2007).

Since the millennium, the use of CVEs (collaborative learning environments) for educational purposes has grown, with a variety of metaphors behind the visual design, such as replication of real universities, art museums, scientific labs to and non-existing fictitious places (Prasolova-Førland et al, 2006).

The trends described above are not to be understood as different directions of e-learning development, as the trends described e.g. mobile learning and personalization, are not mutually exclusive. Some of these trends will together create new e-learning environments.

2.3 Software design

The definition of "design" in the IEEE glossary is "the process of defining the architecture, components, interfaces, and other characteristics of a system or component" (IEEE, 1990). 'Software design' can therefore be defined as following; the process of defining the architecture, components, interfaces, and other characteristics of a software system or software component".

Pfleeger and Atlee (2010) describes eight fundamental notions that form the basis for an effective discipline of software engineering are; abstraction; analysis and design methods and notations; user interface prototyping; software architecture; software process; reuse; measurements; and finally tools and integrated environments. This thesis is mainly concerned about design methods, software architecture, user interface prototyping and software process.

Many software process models are described in the software engineering literature. Software process models include system requirements as input and a delivered product as output (Pfleeger & Atlee, 2010). One of the first models to be proposed was the Waterfall model, a linear progression of development activities (e.g. requirement analysis, system design, program design, coding, unit & integration testing, system testing, acceptance testing or operation & maintenance) where one development stage should be completed before the next begins. "The biggest problem with the waterfall model is that it does not reflect the way code is really developed…software is usually developed with a great deal of iteration" (Pfleeger & Atlee, 2010). The waterfall model is best suited in projects where requirements can be clearly defined. A variation of the Waterfall model is to add a subprocess of prototyping to the Waterfall model in order to ensure that the requirements are consistent, feasible and practical and to assess alternative design strategies (Pfleeger & Atlee, 2010). An additional variation of the waterfall model is the V-model, which demonstrates how the testing activities are related to analysis and design (Yeates & Wakefield, 2004; Pfleeger & Atlee, 2010).

In contrast to the Waterfall model, the Spiral model introduced an evolutionary or iterative approach to systems development (Boehm, 1986). The Spiral model involves carrying out the same activities over a number of cycles in order to clarify the requirements, issues and solutions, and in effect amounts to repeating the development life cycle several times (Yeates & Wakefield, 2004).

The software process model called the Prototyping model allows all or part of the system to be constructed quickly to understand or clarify issues. The requirements or design require repeated investigation to ensure that the developer, user, and customer have a common understanding both of what is needed and what is proposed (Pfleeger & Atlee, 2010). "Prototyping is often used in system development to clarify user requirements in imprecise systems (Hawryszkiewycz, 2001). "Prototyping means building a small version of a system, usually with limited functionality, that can be used to help the user or customer identify the key requirements of a system and/or demonstrate the feasibility of a design or approach" (Pfleeger & Atlee, 2010). The prototyping process is often iterative; building a prototype, evaluate it, consider changes and then build another prototype.

The Unified Process (Booch et al, 1999) is an extensive process framework for software development projects. It is an iterative and incremental process framework, which should be customized for specific organizations or projects. The framework is use case driven, risk focusing and architecture-centric. The unified process can be broken into four major phases; inception, elaboration, construction and transition.

Many software process models used in the period 1970-2000 are rigor formulated, and opposing this Agile methods were formulated in the late 1990s. "Agile development is the ability to develop software quickly, in the face of rapidly changing requirements" (Martin, 2003). "The overall goal of Agile development is to satisfy the customer by early and continuous delivery of valuable software" (Pfleeger & Atlee, 2010). The 'Agile manifesto' values individuals and interactions over processes and tools, working software over

comprehensive documentation, customer collaboration over contract negotiation and 'responding to change' over 'following a plan' (Beck et al, 2001). Examples of agile processes are extreme programming (XP), crystal, scrum and adaptive software development (Pfleeger & Atlee, 2010).

Participatory design stresses the importance of actively involving the users at all stages of development as a principal of good design practice. The idea of participatory design is that active involvement of all stakeholders in the design process will help ensure that the product designed meets the stakeholders' needs and is usable. Participatory design was developed in Northern Europe and has been closely connected to the user and their work life (Hoffer, 2004).

It is also appropriate to mention 'Grimstadmodellen', a design model for designing learning resources described in Crossley and Green (1985) and in Minken and Stenseth (1992). This design model emphasizes the contribution of teachers and other educationalists in the design process, and is characterized by thorough educational planning, iterations and prototyping. The model early integrated pedagogical ideas and interaction into the design process. 'Grimstadmodellen' provides design tools such as the use of scenarios, activity tables and the 'market metaphor'. 'Grimstadmodellen' was an early attempt to bridge instructional design and software design, but primarily focused on helping teachers becoming software designers.

2.4 Instructional design

The concept of instructional design (ID) is used in a variety of understandings. Newby et al. belongs to the group looking at instructional design in a general way. "Instructional design is the process of translating principles of learning and instruction into plans for instructional materials and activities. The emphasis is on creating a plan for developing instructional materials and activities that increase an individual's learning" (Newby et al, 2006). Others include technology into the understanding of instructional design, and Reiser and Dempsey (2002) acknowledge this and introduce the concept 'instructional design and technology' in order to clarify the use of the concepts.

"It is important to note that there is some confusion in the literature on instructional design because the term *instructional development* also has been used to describe the entire process" (Gustafson & Branch, 2002). When instructional development is used to describe the overall process, the term *instructional design* is often understood as the design element of ADDIE (Analysis – *Design* – Development – Implementation - Evaluation), where design includes writing objectives in measurable terms, classifying learning as to type, specifying learning activities, and specifying media (Gustafson & Branch, 2002).

Gustafson and Branch (2002) describe the history of ID. Historically the origins of instructional design can be traced back to the 1960s, where Silvern published what might be the first ID model of how general systems theory could be used to create effective and efficient aerospace and military training. By the early 70s, the use of instructional systems design (ISD) methods had become common in all branches in the military and during the 1970s, ISD became accepted as a standard training methodology in many large organizations throughout the world (Gustafson & Branch, 2002). "A factor that did have a major effect on instructional design practices in the 1980s was the increasing interest in the use of microcomputers for instructional purposes" (Reiser, 2002). Many instructional designers

turned their attention to producing computer-based instruction. During the 1990s, the performance technology movement, the growing interests in constructivism and the rapidly increasing interest in using the Internet for distance learning had significant impact on instructional design principles and practices (Reiser, 2002).

The Waterfall Model of Software development and The Spiral Model are examples of the rationalistic approach in system design, while the rationalistic approach in instructional system design have gone through four generations; the first generation behavioral model (identify objectives, conduct a pre-test, develop and deliver instruction, administer a post-test), the second generation computer flow-chart model (more specific activities identified and related), the third generation phased model (specific activities collected into 4 or 5 phases; analysis, design, production, implementation and evaluation) and the fourth generation model emphasizing the iterative nature of the design process (Tennyson in Vavik, 2000). Vavik (2000) further describes the changing perspectives on instructional design in a discussion of the implications of situated learning and constructivism for instructional design. "Although some have argued that 'traditional' instructional design practices and constructivist principles are antithetical, in recent years numerous authors have described how consideration of constructivist principles can enhance instructional design practices" (Reiser, 2002).

An ID model describes how to conduct the steps of an instructional design. Practically all early ID models were based on behaviorism. Examples of instructional design models are the ADDIE model, A.S.S.U.R.E (Heinich et al, 2002), and rapid prototyping.

Instructional design theory is defined as following; "A theory that offers explicit guidance on how to better help people learn and develop" (Reigeluth, 1999). "Instructional design theory differs in important ways from learning theory, instructional design process, and curriculum theory…Learning theories are often confused with instructional design theory, but learning theories are descriptive. They describe how learning occurs… In contrast to learning theories, instructional-design theories are more directly and easily applied to educational problems, for they describe specific events outside of the learner that facilitate learning, rather than describing what goes on inside a learner's head when learning occurs" (Reigeluth, 1999). Instructional design theory is also confused with instructional design process. "Instructional design-theory concerns what the instruction should be like, not what process a teacher or instructional designer should use to plan and prepare for the instruction (Reigeluth, 1999).

Pogrow in Reigeluth (1999) is calling for the need for design theory rather than descriptive theory; "It is far more difficult to figure out how to implement [descriptive] theory than it is to generate it". Reigeluth expresses the importance of instructional design theory compared to learning theories; "To really help educators to improve education, it is essential that more people …devote their efforts to generating design theories" (Reigeluth, 1999).

The concept of instructional design does not originally include any technological solutions. An instructional design will create a need for technology if it is supposed to be used within e-learning. E-learning technology will offer tools to an instructional designer, but immature e-learning technology will narrow the possibilities of the instructional designer.

2.5 Learning design

The differences between instructional design and learning design in the literature are not always clear. "Reigeluth uses learning design knowledge as a synonym for instructional design theory and defines it as knowledge that offers explicit guidance on how better to help people learn and develop" (Koper, 2005). The broad concept of learning design, however, is reflecting the change of focus on learning instead of instruction during the last decades.

Conole and Fill (2005) define learning design as an application of a pedagogical model for a specific learning objective, target group and a specific context or knowledge domain. The learning design specifies the teaching and learning process, along with the conditions under which it occurs and the activities performed by the teacher and learners in order to achieve the required learning objectives.

Learning design focuses on activity; "It is the activity that the learner engages in, and the outcome of that activity, that are significant for learning… Design for learning should therefore primarily focus on the activities and only secondary on e.g. the tools or materials that support them" (Beetham, 2007).

Learning design is a concept, which is strongly connected to the e-learning field, as the developers and users of the concept belong to this field. "The central ideas behind learning design represent new possibilities for increasing the quality and variety of teaching and learning within an e-learning context; The first general idea behind learning design is that people learn better when actively involved in doing something (i.e. are engaged in a learning activity). The second idea is that learning activities may be sequenced or otherwise structured carefully and deliberately in a learning workflow to promote more effective learning. The third idea is that it would be useful to be able to record 'learning designs' for sharing and re-use in the future" (Britain, 2004).

According to Koper (2005) "there are several ways to capture learning design knowledge, one which is the instructional design approach. Here, knowledge is encapsulated in theories consisting of a set of design principles. Another approach is to identify best practices in teaching and learning, and yet another is to capture the knowledge in pedagogical design patterns. Such patterns take up a position in between theory and best practices in that they are abstracted from best practices. What a teacher believes about good teaching and learning is influenced by one or more sources. These are: prescriptions taken from instructional design theory; concrete examples of best practices; and patterns of experience. In each case, we will call the representation of this knowledge learning design knowledge".

2.6 The IMS Learning Design Specification

IMS Learning Design Specification (IMS, 2003) is IMS' contribution to standardization of pedagogical methods and is now being tested all over the world. According IMS Global Learning Consortium the IMS–LD specification supports the use of a wide range of pedagogies in online learning, by providing a generic and flexible language (IMS, 2003).

IMS Learning Design was based on the Educational Modelling Language (EML), which is "a notational system intended to provide a way of describing teaching and learning interactions at a level of abstraction above the specific instance of the context in which it was created"

(Britain, 2004). The idea behind EML is that "Learners perform Activities in an Environment with Resources" (Britain, 2004).

After EML modifications and the inclusion of XHTML, allowing both web content and XML extensions, the IMS LD 1.0 Specification was approved in 2003. The specification is a very detailed document intended primarily for software developers who create the tools and systems that implement LD. However, it is also intended to be understood by technically aware learning and instructional designers to enable them to determine its suitability for their purposes (Olivier & Tattersall, 2005).

IMS Learning Design uses the script as a metaphor to model learning design methods, with the following components; metadata, roles, acts, environment, role-part, sequence of activities and conditions (Koper, 2005). The IMS-LD is pedagogically neutral. The IMS Learning Design specification is concerned with articulating learning design processes, developed to shift attention from a focus on content to process (Conole & Fill, 2005).

"To enable a learning designer to search for, share and reuse learning design methods, a standard notation must be available and used" (Koper, 2005). The IMS Learning Design specification provides a concrete syntax and semantics, in order to enable computers to use it.

Several software tools supporting learning design are under construction. The most significant contribution is Dalziel's 'LAMS' – learning activity management system, see Fig. 1. "Although LAMS does not implement the IMS-LD specification, it does embody the core ideas behind the specification in terms of a focus on creating sequences of activities, rather than content" (Britain, 2004). Other software tools supporting the IMS Learning Design specification are 'RELOAD' and 'EduBOX' (Britain, 2004). The following are the tools created by the RELOAD project; The Classic RELOAD Editor (supports IMS Metadata, IEEE LOM, IMS Content Packaging 1.1.4, SCORM 1.2, and SCORM 2004), The Eclipse-based RELOAD Editor (supports IMS MD, IEEE LOM, IMS CP and SCORM), the Learning Design Editor (supports IMS Learning Design), the SCORM Player and the Learning Design Player (Reload, 2009), see Fig. 2.
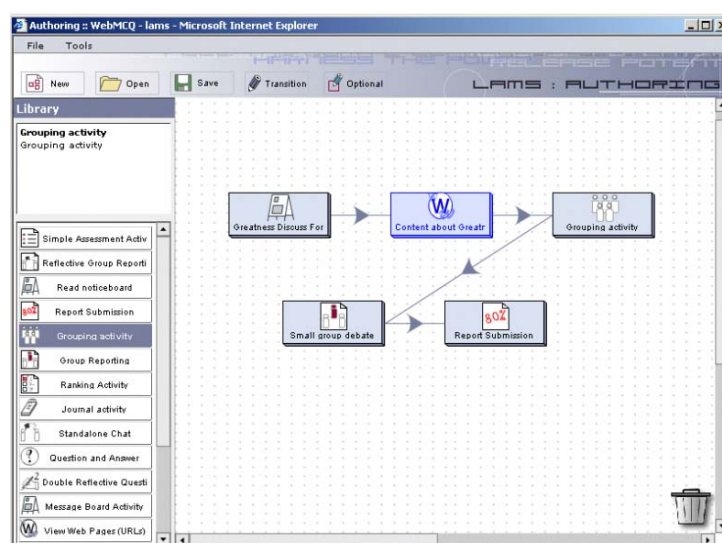
Fig. 1: Screenshot from the LAMS system (LAMS, 2005)
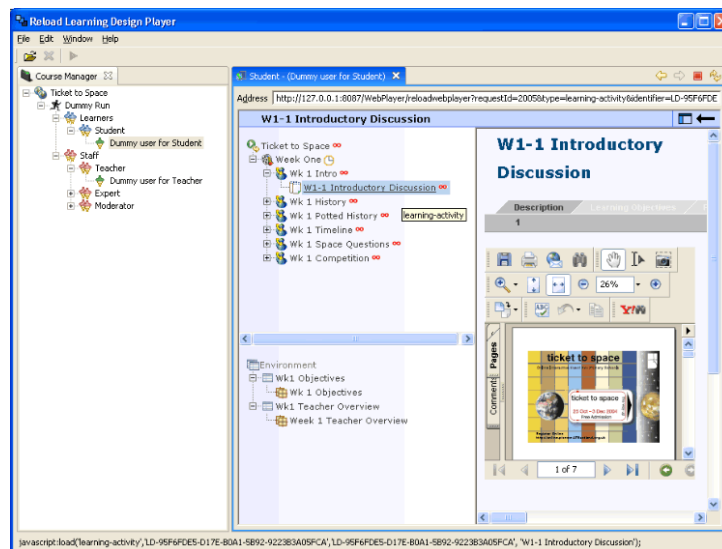
Fig. 2: Screenshot of the Reload Learning Design Player (Reload, 2009).

Critics of the IMS-LD specifically concerns reusability and the teachers' difficulties to use the specification. Downes is criticizing IMS Learning Design, claiming "In order to use a learning design with a set of objects, the learning design must specify the objects to be used, and if the objects to be used are specified, then the learning design is not reusable" and he continues "Design requires specificity, and specificity prohibits reusability. Or conversely, reusability requires generality, and generality prohibits design" (Downes, 2003). As Robson stated it shortly; "Context is the friend of learning and the enemy of reuse" (Robson, 2004).

Another problem with IMS-LD is that it is not bridging the gap between teachers and software developers, as it is based on specifications from the software engineering field. "UML is a powerful and relatively easy to understand graphical language, but it is intended for use by software developers and requires a degree of familiarity with its vocabulary and grammar to properly interpret the diagram" (Griffiths & Blat, 2005). "The IMS Learning Design specification brings many pedagogic benefits when compared with earlier open specifications for eLearning. It is not, however, easy for teachers to understand and work with… it is clear that new tools and representations are needed if teachers are to intervene in editing and creating units of learning (UOL)" (Griffiths & Blat, 2005).

2.7 A learning design toolkit

Conole and Fill (2005) have developed a learning design toolkit which guides teachers through the process of creating pedagogically informed learning activities which make effective use of appropriate tools and resources. "Toolkits are decision-making systems based on expert models, positioned between wizards and generic conceptual frameworks which can provide a theoretical overview of an area and hence be used as a point of reference for decision making" (Conole & Fill, 2005). The toolkit is made to provide guidance, but is not prescriptive. The toolkit is designed to be adaptable and easy to customize to the local context, and to provide a comprehensive resource of relevant material.

The learning design toolkit can be used for three main purposes; first, as step-by-step guidance to help teachers make theoretically informed decisions about the development of

learning activities and choice of appropriate tools and resources to undertake them. Second, as a database of existing learning activities and examples of good practice, which can then be adapted and reused for different purposes. Third, as a mechanism for abstracting good practice and metamodels for e-learning (Conole & Fill, 2005).

The heart of the learning design toolkit is the notion of a learning activity, consisting of three elements; the context (e.g. the subject, level of difficulty etc), the learning / teaching approaches (e.g. apprenticeship, collaborative learning) and the tasks (e.g. techniques, interaction, assessments, tools etc) (Conole & Fill, 2005).
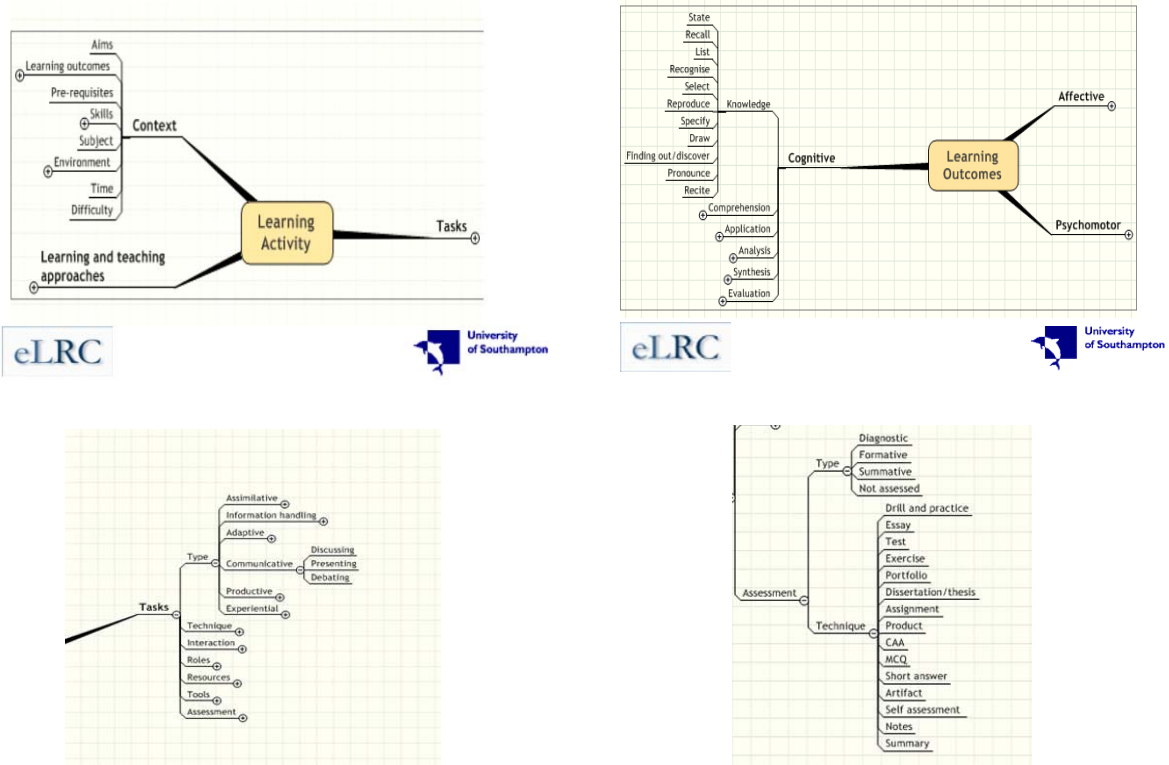
Fig. 3: Examples from the learning design toolkit (Conole & Fill, 2005)

The learning design toolkit assumes that a learning activity has one or more learning outcomes associated with it. Learning outcomes are what the learners should know, or be able to do after completing the learning activity. In order to achieve the intended learning outcomes there is a sequence of tasks which must be completed. When undertaking tasks the participants in the learning activity (teachers and learners) are assigned roles. Some tasks are assessed. Resources and tools may be included (Conole & Fill, 2005).

Connected to the learning design toolkit there is developed an online tool called the Dialog Plus Toolkit (http://www.nettle.soton.ac.uk/toolkit/userarea/default.aspx) where one can find and create nuggets (the Dialog Plus Toolkit's term for learning activities).

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2.8 Design patterns

To make the design process more effective and of course cost-effective we need to have tools to simplify the process. Carstensen and Schmidt (2002) consider flexibility as one specific challenge for CSCW (computer-supported cooperative work) systems design;"we have to establish basic building blocks and platforms so that the actors themselves can establish a CSCW system fulfilling their needs". Design patterns can be examples of building blocks to ensure such flexibility in e-learning systems.

The origin of design patterns is found in the research of C. Alexander in the field of architecture. Alexander's definition of a design pattern is that it "describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem in such a way that you can use this solution a million times over, without ever doing it the same way twice" (Alexander, 1977). The patterns are systematically described using a pattern language.

In 1994 the "Gang of Four" published the book "Design Patterns: Elements of Reusable Object-Oriented Software" (Gamma et al, 1994), which made use of design patterns in software engineering. The idea of design patterns originated in work with buildings and towns was also useful as object-oriented design patterns, "expressed in terms of objects and interfaces instead of walls and doors" (Gamma et al, 1994).

The idea of design patterns have later been introduced in several fields, including education. The intention of pedagogical design patterns is to capture pedagogical strategies and good design practices. The pedagogical patterns project (Bergin et al, 2009) is one of the contributors of pedagogical patterns.

Design patterns have throughout the years been used for different reasons. "Some used them to clarify and communicate design experience and to re-use and transfer this experience in new 'design settings', others to bridge the gap between 'theory' (research) and 'practice' (implementation) and again others to introduce novices into a certain knowledge domain. Other aims might be the clarification and ordering of your own design experience and concepts and to express them in an action-oriented format" (Rusman et al, 2005).

Frizell and Hübscher (2002) claimed that design patterns can be used to effectively support novice designers of web-based courses. E-learning design patterns were one of the main focuses of the E-LEN project, where a pattern language for e-learning was introduced and a repository of e-learning design patterns were produced (Rusman et al, 2005).

As an example of a design pattern and a pattern language, parts of the design pattern 'Moderation of an asynchronous on-line group' (Vesseur, 2004) are presented in fig. 4.

Name: *Moderation of an asynchronous on-line group*
Problem: *What should a moderator do in order to facilitate effective learning in asynchronous on-line groups?*
Analysis: *Three key-roles*
   1) *Organizational moderating activities: setting the agenda, objectives, timetable, procedural rules, netiquette, encouraging the participants to introduce themselves, etc.*
   2) *Social moderating activities: sending welcoming messages, thank you notices, prompt feedback, set a positive tone.*
   3) *Intellectual moderating activities: asking questions, probing responses, refocusing discussion.*
Solution: *In general all of the activities mentioned above should be performed; how and how often depends on the case. It is not necessary that only the moderator is responsible for all of these activities. It is often possible to delegate part of the activities to group members. This should be agreed on because it has to be clear to every member of the group who is responsible for what.*
Known uses: …
Context:…
References:…
Related patterns:…
Author(s): Antoinette Vesseur (Learning Lab Universiteit Maastricht)
Type:…
Domain specific:…
Date: 2004-06-16

Fig. 4: Example of a pattern language and a design pattern 'Moderation of an asynchronous on-line group'

The thesis is covering an interdisciplinary problem, which means that the state of the art of the thesis includes topics from both the educational field and the software development field. This chapter has presented some quantitative research of e-learning in higher education. Then some trends within the field are described. The concept of 'design' in e-learning is specified by describing software design, instructional design and learning design. The state of the art-chapter ends with the presentation of some specific tools already known within e-learning; the IMS learning design specification, the learning design toolkit and design patterns. These will be furthered discussed when discussing and evaluating the contributions of this thesis, in chapter 5.

3 Research method

The main objective of this thesis is how to assure the quality of the development process of e-learning applications by the implementation of pedagogical principles into the software design process. This chapter describes how this objective is reached.

The chapter describes and gives reasons for the chosen research method, and the implications of the choices made during the research process. First I clarify the methodological position and research strategy used, then I describe the research process of theoretical sampling, data collection, data analysis and theory development. The researcher's role and ethical issues of the project are then discussed, and finally reflections upon weaknesses and strengths of the research method are provided.

3.1 Exploratory design

Exploratory design fits the research questions of this thesis, where there is no hypothesis to test, but a need to explore (Hellevik, 1991). There exist several methodological approaches for exploratory research designs, and I start describing some underlying methodologies, which have been important in this thesis; pragmatism, empirical grounding, interpretivism and social constructivism.

Pragmatism
Alvesson and Schiöldberg (2008) describe pragmatism as an "anti-theoretical philosophy – what matters is to stay as close to the practical, empirical reality as possible." Pragmatism emphasizes usefulness; "Within pragmatism, truth should be found in human practice and the truth criterion is social usefulness" (Alvesson & Schiöldberg, 2008). Usefulness is important within software development and the main objective of the thesis is grounded in the need of useful solutions.

Hevner et al. (2004) define two paradigms within the information systems discipline; behavioral science and design science. "The behavioral science paradigm seeks to develop and justify theories that explain or predict organizational and human phenomena surrounding the analysis, design, implementation, management, and use of information systems". "The design-science paradigm seeks to create innovations that define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, and use of information systems can be effectively and efficiently accomplished" (Hevner et al, 2004). The problem statement of this thesis can be seen to belong within the paradigm of design science, a paradigm which fit into the philosophy of pragmatism.

Empirically grounded design
This thesis focuses on closeness to empirical data, not a distance approach to the research questions and empirical data. Distance to the research situation would not have provided the

needed data. The positivistic ideal of minimizing and preferably eliminating the researcher's effect on the studied object is neither suitable nor preferable, and the aim of the research project is not to provide 'objective' data. Rather, the goal is to look for deep insight in the field between software engineering and pedagogy. In this process the experiences of the user groups (students, teachers and system developers) are valued, and the research questions are replied to by empirical data.

The thesis uses an inductive, not deductive approach. Deductive reasoning is usually based on work from the more general to the more specific, and conclusions follows logically from available facts. An inductive approach is open-ended and exploratory as it moves from specific observations to broader generalizations and theories (Patton, 2002). The problem statement of the thesis required an exploratory study, and the choice of an inductive approach is appropriate to answer the research questions.

Interpretivism
The study adheres to the theoretical perspective of interpretivism (Denzin & Lincoln, 2005). Klein & Myers (1999) emphasize in their definition of interpretive research that the word 'interpretive' is not a synonym for qualitative. Qualitative research may or may not be interpretive, depending upon the underlying philosophical assumptions of the researcher. Klein & Myers (1999) further describe how IS (Information systems) research can be either positivist, critical or interpretive."IS research can be classified as positivist if there is evidence of formal propositions, quantifiable measures of variables, hypothesis testing, and the drawing of inferences about a phenomenon from a representative sample to a stated population… IS research can be classified as critical if the main task is seen as being one of social critique". Finally, "IS research can be classified as interpretive if it is assumed that our knowledge of reality is gained only through social constructions such as language, consciousness, shared meanings, documents, tools, and other artifacts" (Klein & Myers, 1999). The choice of an interpretive research strategy of this thesis was suitable based on the exploratory research design, with focus on pragmatism and an empirically grounded approach.

 "Interpretive research can help IS researchers to understand human thought and action in social and organizational contexts; it has the potential to produce deep insights into information systems phenomena including the management of information systems and information systems development" (Klein & Myers, 1999). The research questions of this thesis concern an exploratory approach to information systems development, which made the choice of an interpretative research strategy appropriate.

Interpretive methods of research in IS are "aimed at producing an understanding of the *context* of the information system, and the *process* whereby the information system influences and is influenced by the context" (Walsham, 1993). This thesis uses interpretive methods to understand the learning context and the process whereby an e-learning system influences and is influenced by a learning context.

Alvesson and Schiöldberg (2008) describe that exploration, pragmatism and empirically grounded methods are central characteristics of symbolic interactionism found in Grounded Theory.

Social constructivism
Based on the research questions and the exploratory design, the project is positioned within social constructivism (Sohlberg & Sohlberg, 2004). The implementation of pedagogical

principles in e-learning is dependent on how people construct their reality as teachers and students in an e-learning setting. As people construct their reality in a certain way (maybe unconsciously), it influences how they use the technology. The technology both limits and provides possibilities concerning pedagogical processes. Reality is not objective, but dependent on the interaction between humans and technology, and therefore this study is concerned about social constructions of pedagogical processes and there is not taken for granted that one reality exist.

3.2 Research strategy

The research strategy of this thesis is based on the qualitative research paradigm, defined as "any type of research that produces findings not arrived at by statistical procedures or other means of quantification" (Strauss & Corbin, 1998). E-learning applications include not only the IS field but also the pedagogy field, and the problem statement of the thesis and the use of a qualitative approach recognize the importance of bridging the two fields and recognize that e-learning systems are socio-technological systems. Recognizing information system as a socio-technological system means that "the information system designer considers the design of organization structures in addition to the design of information technology. To accept the inclusion of organizational context in information system design means that the designer must have an understanding of the context or situation before she or he can begin to solve technical problems" (Trauth, 2001).

Grounded Theory
The research strategy used in this thesis is based on a Grounded Theory approach (Glaser & Strauss, 1967). This approach is chosen because the research questions (how to assure the quality of the development process of e-learning applications by implementing the pedagogical principles variation, individualization, meta-learning and best practice into the software design process) not mainly could be answered by testing theories, but by the generation of theory. The Grounded Theory approach originated in the book "The Discovery of Grounded Theory" of Barney Glaser and Anselm Strauss, published in 1967.

The research questions are open-ended and exploratory, and Grounded Theory "is an inductive, theory discovery methodology that allows the researcher to develop a theoretical account of the general features of a topic while simultaneously grounding the account in empirical observations or data" (Glaser & Strauss, 1967). The research questions of this thesis require an exploratory and inductive approach to the data, and in such cases the Grounded Theory approach is applicable and appropriate.

The aim of the research project is to contribute with useful theories at a practical level, this is also important within Grounded Theory. "Grounded Theory emphasizes that theories should be 'grounded' in empirical research and generated by a systematic analysis of the data. The researchers should start out with an open mind and the selection of people, instances etc. to be included in the research reflects the developing nature of the theory and cannot be predicted at the start. The theories should be useful at a practical level and meaningful to those 'on the ground'" (Denscombe, 2003).

Research often is a process where all data is collected before starting analysis, and all analysis is completed before the conclusions are drawn. This is not the case when using Grounded Theory, analysis can start with the first interview (Allan, 2003). Grounded Theory is iterative

and comparative (Orlikowski, 1993), iterative in the sense that the method requires the researcher to move back and forth between data collection and data analysis until the point of 'theoretical saturation', and comparative in order to constant compare emerging codes, categories and concepts. This is important features in an exploratory research project. "Grounded Theory methods consist of simultaneous data collection and analysis, with each informing and focusing the other throughout the research process" (Charmaz, 2005). An exploratory approach means that one does not necessary know in advance where to end up, and the Grounded Theory approach allows the exploratory researcher to work both systematically and creatively in order to develop new theory.

Denscombe (2003) claims that Grounded Theory is well suited for four kinds of research; qualitative research, exploratory research, studies of human interaction and small-scale research. This study covers three of four kinds of research described. The research questions are demanding an exploratory research approach with emphasis on discovery, since there are e.g. no predefined answer categories to put into a quantitative survey. The use of qualitative methods which emphasizes details, richness of nuances and the uniqueness of each respondent will be useful in this project. The project also fits into small-scale research.

Urquhart discusses philosophical issues of using Grounded Theory in Information Systems, and concludes that "perhaps we should view the ontology of Grounded Theory method, as proposed in 1967, as being a product of the political and historical context of the time. The various indicators of philosophical position from the literature since may be seen as a product of more recent shifting ideas and epistemologies in qualitative research. Above all it is a *method*, and as such, can be used comfortably in most paradigms" (Urquhart, 2001).

The Grounded Theory divergence
Since the Grounded Theory approach originated with the work of Barney Glaser and Anselm Strauss in their book "The Discovery of Grounded Theory" in 1967, not only the two originators of Grounded Theory have moved in slightly different directions, but also other researchers have adopted and adapted the Grounded Theory, which has lead to alternative versions of Grounded Theory (Denscombe, 2003).

Smit (1999) describes the divergence between Glaser and Strauss, the two originators of the Grounded Theory method. "Strauss and Corbin mention that they set out to provide clear, straightforward, and basic information on the knowledge and procedures needed by researchers who want to build their first theory at a substantive level" (Smit, 1999). "Glaser argues that what Strauss and Corbin describe will not produce a Grounded Theory, but rather 'a forced, preconceived, full conceptual description, which is fine, but is not Grounded Theory' (Smit, 1999).

Locke (1996) notes that there are no differences between Glaser and Strauss's positions on the key analytical procedures (constant comparison and theoretical sampling) involved in Grounded Theory methodology. "However, they do write subsequently different renditions of researchers' relationships to the worlds they study" (Locke, 1996). "With the Glasarian approach the researcher allows the theory to emerge from the data, whilst the Straussian approach the researcher interrogates the data in order to arrive at a theory" (Smit, 1999).

Denscombe (2003) describes how Glaser's version is positivistic, while Strauss' version is interpretive. "Glaser's version rest on the belief that: (a) the researcher should maintain a distance and independence from the data; and (b) the meaning of the data will emerge

inductively from the data if studied using a suitably neutral methodology... Contrasting with this, there is Strauss's version, which is more in line with interpretivism, in that the role of the researcher is to go looking for the meaning that the data hold, possibly probing beyond their superficial meaning" (Denscombe, 2003).

Smit (1999) investigated the different use of Grounded Theory in IS research and claimed that "Grounded Theory, along with the surging interest in qualitative research, is becoming a popular research strategy in the Information Systems field. At the same time however, the method seems to be changing in its essence as researchers adapt it, use it alongside other methods, or rely on some of its principles in their quest to explain the world".

This thesis is inspired by the Strauss's version of Grounded Theory, based on the interpretive approach and the interrogation with the data. The thesis has however not used all of the techniques describes in Strauss and Corbin's book "Basics of Qualitative Research: Grounded Theory Procedures and Techniques, e.g. the micro-analysis. The main procedures and techniques have however been useful in the process of analyzing the empirical data.

3.3 The research process

The research process has passed through several phases, and the process is similar to Pandit's process description. Figure 5 illustrates the iterative process of Grounded Theory building (Pandit, 1996), and also how the data is collected, not only as a starting point of the study but throughout the course of the research.
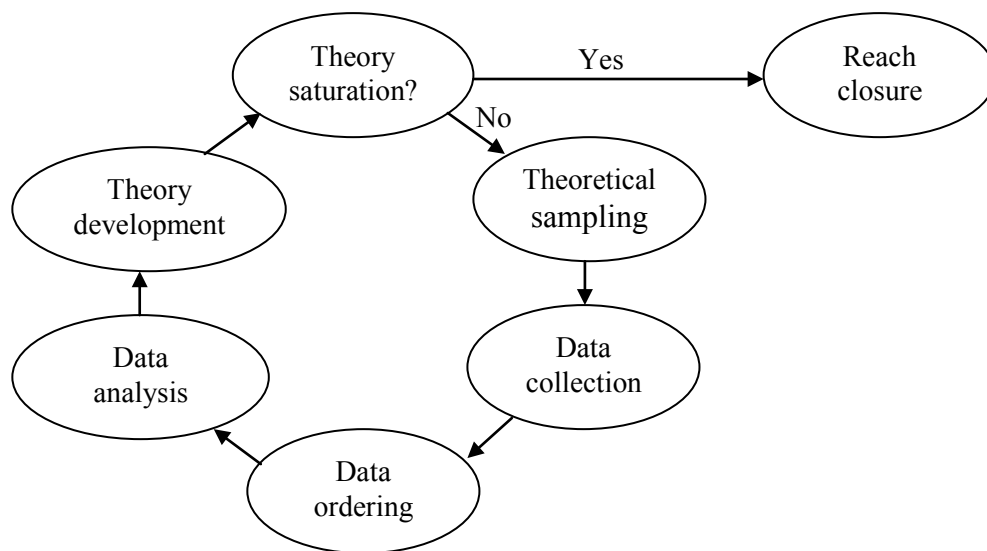
Fig. 5: The iterative process of Grounded Theory

3.4 Theoretical sampling

The selection of sites for research followed Glaser and Strauss' technique of theoretical sampling. In Grounded Theory a site for research can be e.g. a situation, an event or a group. Theoretical sampling is described as "[the] process of data collection for… generating theory

whereby the analyst jointly collects, codes, and analyses his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges" (Glaser & Strauss, 1967). Strauss and Corbin (1998) describes the concept of theoretical sampling as "data gathering driven by concepts derived from the evolving theory and based on the concept of 'making comparisons', whose purpose is to go to places, people, or events that will maximize opportunities to discover variations among concepts and to densify categories in terms of their properties and dimensions".

Denscombe (2003) describes the selection of fieldwork sites as 'a trail of discovery – like a detective follows a lead'. The nature of Grounded Theory is iterative, and the researcher cannot plan the site selection and data sources in detail ahead of the empirical work. "The selection of people, instances etc. to be included in the research reflects the developing nature of the theory and cannot be predicted at the start" (Denscombe, 2003).

The 8 sites for data collection of this thesis where selected because of their relevance to the topic and emerging categories and concepts, and because of their relevance to allow comparisons and contrast with previous research sites. Table 2 is an overview of the theoretical sampling in this thesis.

Site 1	Expert group of international researcher / system developers.
Site 2	Focus group of students at a department of teacher education.
Site 3	Focus group of faculty at a department of computer science of a college.
Site 4	Interviews with international teachers and researchers within the e-learning field and computer science students.
Site 5	Focus group of international teachers and researchers.
Site 6	Expert group of Norwegian system developers.
Site 7	Interviews with teachers, developers and one student.
Site 8	Expert groups of Norwegian researchers / system developers.

Table 2: The 8 sites for data collection

There are four main features of theoretical sampling (Strauss & Corbin, 1998). First, theoretical sampling is *cumulative*, which means that each sample builds from and adds to previous data collection and analysis. The papers of this thesis are published throughout several years and documents how theoretical sampling in this study was cumulative. Early concepts and categories are refined and further developed throughout the years of the study and the iterative process of data collection and analysis. Second, theoretical sampling involves an *increased depth of focus*. Initially the researcher aims for a large number of categories and later the researcher concentrates on smaller number of codes and categories. This has also been a natural development of this study and is further described in chapter 3.6. Third, theoretical sampling calls for *consistency*, which involves that comparisons are made systematically on each category, ensuring that each is fully developed, also described in chapter 3.6. Although the previous features of theoretical sampling emphasize focus, relevance and system, the fourth feature is that theoretical sampling needs to retain some element of *flexibility* in order to take advantage of fortuitous incidents that occur while out in the field. The expert groups, in particular, required some element of flexibility, because the problem solving activities were impossible to plan ahead.

3.5 Data collection

The empirical data, upon which this thesis is based, were collected through three methods; interviews, focus groups and expert groups. "There is no particular method of data collection that is claimed to be unique to grounded research, but Strauss has indicated that very diverse materials (interviews, transcripts of meetings, court proceedings, field observations, diaries and letters… provide indispensable data for …research" (Denscombe, 2003).

Interviews

Data collection through interviews was performed throughout the whole study, in early phases as well as late phases of the study. The study consists of 21 face-to-face interviews with 23 interviewees. The interviewees were three students and 16 teachers in higher education, in addition to two e-learning system developers and two researchers within the e-learning field. Most of the interviews were individual interviews, but two of the interviews were group interviews (two students in one group interview and two e-learning system developers in the other group interview). The interviewees come from three different nationalities.

The interviews were carried out in the following time periods:
Individual interviews with two researchers: 2006
Group interview with two students: 2006
Group interview with two system developers: 2007
Individual interviews with 16 teachers: 2007
Individual interview with one student: 2007

The individual interviews and the student group interview lasted between 60 and 90 minutes. The group interview with the system developers were divided in two parts; the first part lasted 90 minutes and was semi-structured. The second part lasted 60 minutes and was a structured interview as the interviewees discussed the emerging E-learning Circle (Kolås & Staupe, 2010). The interviews were all recorded and fully transcribed afterwards.

The interviews were semi-structured, which means flexible, but based on a framework of themes to be explored. I prepared pre-planned questions ahead, in order to find themes and open-ended questions and to prepare for flexibility during the interview, allowing new questions to be brought up based on what the interviewee was saying. Open-ended questions and flexibility during the interview situation were important in order to allow new ideas and questions to emerge. The choice of semi-structured interviews was made because of the exploratory focus of the research questions. Semi-structured interviews are also valuable in the Grounded Theory idea of theoretical sampling, which means that the pre-planned questions of late interviews were based on the earlier collected data and analysis of these data.

The 18 teacher interviews were conducted in the offices of the interviewees at the university. The student interviews were situated in meeting rooms at the university, while the group interview with the e-learning system developers took place in a meeting room in the system development company's building. The interviews with researchers were conducted in rooms at international conference venues.

The selection criteria of interviewees were designed to cover the perspectives of all user groups of an e-learning system, including students, teachers, researchers and system developers. It was also preferable to include interviewees of different nationalities.

The main challenge using interviews for data collection was to find interviewees. I planned several group interviews with students, but experienced that the students did not show up. It was also challenging to find teachers from different subject areas with a minimum use of e-learning tools in their courses. The LIKT project required teachers from a wide range of subject areas in higher education as interviewees. This explains the large number of teachers compared to students, researchers and system developers.

Focus groups
The second method of data collection was the use of focus groups. The definition of a focus group is "a small group of people assembled by a researcher to identify through informal discussion the key issues and / or themes related to a research topic" (Reitz, 2004). The use of focus groups in this study were arranged to collect data at an early stage of the study. The focus groups consisted of persons who represented the target audience (students and teachers in higher education in addition to researchers within the e-learning field).

Three focus groups were used to collect data in this study. The first focus group consisted of 10 teachers and researchers from 4 different nationalities, where some had a pedagogical and others a technological background. Then a focus group of 8 Norwegian teachers in higher education was run, and finally a focus group of 8 Norwegian students at a department of teacher education was conducted. The selection of participants was based on finding the target users of e-learning systems. The mix of students and teachers in the same focus group was avoided because they have different interests and levels of 'expertise', in addition to different user needs of an e-learning system.

The first part of the focus group session was conducted as a brainstorming session, where the focus groups got one clue; 'next generation e-learning'. The participants got 'post it' notes, and during the brainstorming session the participants wrote one idea pr note. The participants were standing up during the first part of the focus group session. The experience was that an idea from one person was likely to generate several new ideas among the other participants. Wibeck (2000) argues that brainstorming is a technique which does not belong within the definition of focus groups, because the brainstorming technique does not allow the participants to criticize each other's ideas. In this exploratory research, I argue however that brainstorming provided valuable data about some of the research questions, and was particularly useful in an initial stage of the focus group interviews as the data from the brainstorming session was used as basis of the group discussion afterwards.

The second part of the focus group sessions was a group discussion based on the ideas from the brainstorming session. In this part of the focus group sessions it was possible for the researcher to stay in the background. It was not necessary to moderate the group discussion, as the ideas from the brainstorming session kept the discussion 'on trail'. Dividing the focus group session in two parts was useful in order to first create new ideas and encourage creativity, then continue with a discussion based on the ideas.

Data collection through focus groups was chosen because focus groups provide multiple user perspectives, and because the group interaction between the different informants allows creative ideas to thrive. The use of focus groups also makes it possible for the researcher to be more passive than in a one-to-one interview setting, because as some members of the focus group share insights and ideas, other focus group members will respond, interact and continue the sharing process / dialog. An advantage using focus groups was that the researcher cannot fully control the discussion, and in an exploratory study this is useful in order to move ahead.

"Focus groups often produce data that are seldom produced through individual interviewing and observation and that result in especially powerful interpretive insights" (Kamberelis & Dimitriadis, 2005). The focus groups were useful because the interaction between the group members made the production of ideas and in-depth thoughts and considerations even more fruitful than in individual interviews.

Expert groups

As part of an explorative design, expert groups in a problem solving process were used as a data source in this study. According to the ideas of Grounded Theory the data collection was based on the need for data in the iterative process of data collection and data analysis. "Grounded Theory methods consist of simultaneous data collection and analysis, with each informing and focusing the other throughout the research process. As grounded theorists, we begin our analyses early to help us focus further data collection. In turn, we use these focused data to refine our emerging analyses" (Charmaz, 2005).There was a need for data other than those retrieved in the individual and focus group interviews. Therefore expert groups were used in both early and late stages throughout the study.

Three expert groups were consulted. The expert groups were all working on specific problems related to the emerging categories. The expert groups consisted of system developers, and my role as a researcher was an active participant in the teamwork of the problem solving activities. The expert groups contributed to the development of prototypes; two paper prototypes and one working prototype.

The first expert group consisted of international researchers / system developers. The problem solving activity was concerning how to implement best practice using design patterns. The first prototype was exemplifying how best practice can be implemented by developing wizards based on pedagogical design patterns (Kolås & Staupe, 2004; Saatz & Kolås, 2005). The second expert group consisted of three Norwegian system developers. Based on emerging categories and the E-learning ontology (Kolås, 2006), the second expert group developed the PLExus prototype (Kolås & Staupe, 2007), a running prototype of a personal learning environment where pedagogical principles as variation and individualization were implemented in the semantic technology of topic maps. In the late stages of the project, the third expert group of four Norwegian system developers / researchers developed a paper prototype of stereotype modeling of ambient learners (Kofod-Petersen et al, 2008), based on parts of the emerging E-learning Circle (Kolås & Staupe, 2010).

The use of expert groups working in teams in problem solving activities is not commonly used as a data collection method. In an exploratory research project like this, however, expert groups proved to be valuable, because the data could be collected studying the process of designing software applications. Expert groups as data collection method was valuable because the expert groups helped focus further data collection in the process of answering the research questions, clearly showing where more data was needed and was therefore an important part in the theoretical sampling of this thesis.

Expert groups were chosen as a data collection method within the Grounded Theory approach because of the exploratory research questions and in order to remain close to empirical field. Charmaz (2005) explains the importance of closeness to the studied world; "A Grounded Theory approach encourages researchers to remain close to their studied worlds and to develop an integrated set of theoretical concepts from their empirical materials that not only synthesize and interpret them but also show processual relationships." In this study, where

focus is on how to improve the development process of e-learning applications, expert groups of software developers and the problem solving activities were valuable in order to stay close to the studied world and to provide data, which cover the intersection between pedagogy and technology. The aim of the study was to bridge pedagogy and software development, and prototyping was useful in order to bring pedagogical ideas into the situation of a software development process. This process quality assured the emerging results in order to focus on pedagogy and software development, not either pedagogy or software development. "If the researcher needs to invent, or piece together, new tools or techniques, he or she will do so. Choices regarding which interpretive practices to employ are not necessarily made in advance" (Denzin & Lincoln 2005). The iterative nature of prototyping and the iterative process of Grounded Theory also were useful to combine. Expert groups provided valuable data about the inclusion of pedagogical principles into the design process, and through this secured the quality of the results.

A conclusion in retrospect is that all the data sources were equally important in the data collection of the project.

3.6 Data analysis

Strauss and Corbin (1998) describe analysis as "the interplay between researchers and data. It is both science and art" and they also emphasize being systematic and creative simultaneously during the analysis. Grounded Theory provides the researcher with analytical tools when analyzing the data in the iterative research process. "As grounded theorists, we begin our analyses early to help us focus further data collection. In turn, we use these focused data to refine our emerging analyses" (Charmaz, 2005).

From data to categories
The first stage of analyzing the data involves the coding and categorization of the data. Strauss and Corbin (1998) describe open coding, axial coding and selective coding as processes in the analytical work.

During open coding, concepts are identified and their properties and dimensions are discovered in data, then the concepts are categorized. There are three different ways to perform open coding; first, a word-by-word or line-by-line analysis. A second way of open coding is analysis of a sentence or paragraph and a third way is analysis of a document, observation or interview as a whole (Postholm, 2005; Strauss & Corbin, 1998). In the process of analyzing the interviews I performed open coding mainly by analysis of sentences and paragraphs. The open coding of the interview transcripts created a large number of concepts. Examples of concepts are: 'Picking pedagogy', 'Choosing media type', 'Freedom of relationships' and 'Documenting reflections' (see table Table 3).

The categorization of concepts also belongs to open coding, and the categorization was important for my research in order to reduce the number of data units to work with. There are two types of categories; categories named by the respondents (in vivo categories) and categories named by the researcher based on the data (in vitro categories) (Alvesson and Schiöldberg, 2008). Example of an in vivo category in this study is 'me-learning' and an example of an in vitro category is 'meta-learning'. In the introductory brainstorming sessions of the focus group interviews the participants together initialized the categorization of ideas / concepts, and during the discussion afterwards the categories and concepts were discussed.

Categories	Concepts	Empirical data
Choice of ped. methods	Picking pedagogy	"…the (students') freedom to pick pedagogy…" (Interview, researcher).
	Flexible instructional strategies	"Flexibility regarding instructional strategies" (Focus group – teachers).
	Choosing how to learn	"Interactive tools on the computer, where you can work more interactively with the content than just listening to a lecture" (Interview, student).
	Learning in different ways	"…starting to use different ways to learn" (Interview, students).
Choice of media	Choosing media type	"… (the students) choose media that they study in or with" (Interview, researcher).
	Integrated media solutions	"Integrated solutions covering audio, images, video, animations" (Focus groups – teachers).
me-learning	Learning differently	"Variation is important because students, because students learn in different ways." (Interview, students).
	Individualized learning	"…not necessarily have the same organization for all students." (Interview, students).
	me-learning	"Let's add one more letter in front and call it me-learning…people will understand what I am talking about, which is personalization." (Interview, researcher).
	Individualization	"We can't get enough of it [individualization]" (Interview, researcher).
Collaboration	Freedom of relationships	"…I call it the freedom of relationships, so that you get to have the kind of social relationships with other learners like you choose" (Interview, researcher).
	Consideration for each other	"…it is very nice to see how [students] develop consideration for each other in such groups" (Interview, student).
	Types of collaboration	"Collaboration (student-student, student-teacher, teacher-teacher)" (Focus group – teachers).
Meta-learning/ self assessment	Documenting reflections	"…the ways that the net can be used to document one's experiences and document one's reflections on that and learning…are very useful for meta analysis for one self and one's own experiences." (Interview, researcher).
	Goal building	"Student model – build goals and motivations" (Interview, teacher).

Table 3: Examples of some concepts and major categories, and some incidents from the empirical data pointing to these categories.

Strauss and Corbin (1998) recommend coding by microanalysis, defined as "detailed line-by-line analysis necessary at the beginning of a study to generate initial categories (with their properties and dimensions) and to suggest relationships among categories; a combination of open and axial coding" (Strauss & Corbin, 1998). Allan (2003) criticizes the micro-analysis

coding because it is very time-consuming, leads to confusion and focus is lost. Allan also refers to Glaser, who condemned the micro-approach as producing an "over-conceptualization". Allan (2003) also argues that following Glaser's approach of identifying key points and allowing concepts to emerge, is in line with qualitative coding analysis as a protection against data overload.

Axial coding is the process of relating categories to their subcategories, termed axial because coding occurs around the axis of a category, linking categories at the level of properties and dimensions (Strauss & Corbin, 1998). Diagrams proved to be effective aids in the axial coding of this study, because the diagrams are helpful in the process of relating categories to each other and to subcategories. The visualizations provided by diagrams were also useful to find subcategories in the collection of main categories. "Subcategories answer questions about the phenomenon such as when, where, why, who, how, and with what consequences" (Strauss & Corbin, 1998). The process of questioning, in combination with diagrams, was productive in the analyzing work to order to move the productive and creative work further. "The purpose of axial coding is to begin the process of reassembling data that were fractured during open coding... Although axial coding differs in purpose from open coding, these are not necessarily sequential analytical steps…axial coding does require that the analyst have some categories, but often a sense of how categories relate begins to emerge during open coding" (Strauss & Corbin, 1998).

The constant comparative method of Grounded Theory, where new codes, categories and concepts are compared and contrasted as they emerge, highlights similarities and differences and improves the categorization.

Interpretation challenges
Some of the respondents spoke English, and some spoke Norwegian. This involved that when coding and analyzing the Norwegian data I had to use codes, categories and concepts in English. Constantly changing language makes especially the coding process harder, because it was difficult to find the proper English codes of Norwegian text. This was of course not optimal, but a pragmatic solution, as it would be more problematic to force Norwegian-speaking respondents to speak English in interviews.

Another challenge of the study is that I as the researcher speak fluent Norwegian, while English is my second language. I might not have understood the English-speaking respondents completely, but the use of audio records and transcribed interviews minimizes the risk. This might however be regarded as a limitation of the study.

Qualitative data analysis software
The data was analyzed using NVIVO, a qualitative data analysis software package, to aid the process of Grounded Theory building. NVIVO is user-friendly, when you learn the terms used in the software package (nodes, free nodes, tree nodes, cases, relationships etc). The main advantages of using NVIVO are that the (initial) coding and categorization are simplified and this makes the analytical work potentially more thorough. The experience of NVIVO in this project was of limited usefulness. In some phases of the analysis I ended up printing the transcribed interviews and with the use of color markers and different symbols did some of the analyses on paper and later transfer the results to the digital version.

This study has different research sites and data collection methods and thereby several of the software package's features, like creating models and auto coding were not useful. The

features that were useful in this project were the collection and ordering of the transcribed interviews, creating cases and attributes, simple coding, tree nodes etc. The overall use of the qualitative data analysis software package in this project was limited; the experience is however that I would use the software package also in a later project if e.g. it contained a larger number of similar data sources (e.g. interviews).

3.7 Theory development

The aim of the Grounded Theory approach is to develop theory, based on the empirical data and the research activity itself.

From categories to theory
"Selective coding is the process of integrating and refining categories" (Strauss & Corbin, 1998). In this stage of the analysis the attention is focused on just the key components, with the goal of reaching theoretical saturation and moving from categories to theory.

Strauss and Corbin's (1998) definition of 'theory' is "a set of well-developed concepts related through statements of relationship, which together constitute an integrated framework that can be used to explain or predict phenomena". There are two types of Grounded Theory, substantive and formal theory. The difference is that substantive theory "is developed for an empirical area" (e.g. patient care, professional education etc), while formal theory "is developed for a formal / conceptual area" (e.g. stigma, socialization etc) (Alvesson & Schiöldberg, 2008). The description and explanation of the two theory types, however, are questioned by Alvesson and Schiöldberg, who claim that the difference is not totally clear.

Alvesson and Schiöldberg (2008) describe three tactics on how to create theory from a number of categories. The first tactic is to write memos about theoretical ideas emerging during the coding. "The writing of theoretical memos is strongly recommended by Strauss, Strauss and Corbin, and Glaser as part of the process of developing Grounded Theory. The idea is that, whenever a researcher is struck by an idea during coding, they should break off at that point and write a memo to develop the ideas" (Urquhart, 2001). This has been a useful tool in this project. Codes and their relationships are not obvious in the coding phases, and it has been useful to go back to my "research diary" to find old ideas that appear in a new way later in the research process. There are still unpublished works among the ideas of the theoretical memos.

The second tactic is to find the core category among which the other categories are related to. The core category is related to as many other categories as possible, and occurs frequently in the empirical data. In this project the core category for a long time was 'the student' and the initial E-learning Circle (Kolås & Staupe, 2010) presented the student in the centre of the circle. It was however obvious after a while that 'the subject' as core category was more fruitful in order to cover the pedagogical principles of variation and individualization. 'The subject' as core category was hidden in the empirical data, as several of the interviewees claimed 'the student' to be the main focus. The 'student' category was also important (which also the E-learning circle shows – as one of the main subcategory), but the subject's characteristics were mentioned over and over again during the interviews. The importance of the subject's characteristics was not said directly, but appeared during the analysis, and the 'subject' became to be considered the core category as a result of the selective coding.

Examples from the empirical data illustrate how the subject and its characteristics turned to be a core category: "I really believe lab is *very* good. The students should learn *much* more practical work" (Interview teacher). This was important for this specific subject, while other subjects focus on other qualities e.g. teacher education, where the students are trained in local schools in periods of the study "It is a lot of organization, as the mentors in the (local) schools also are regarded as part of the teacher education" (Interview teacher). The subjects' diverse characteristics should be considered in the design of e-learning applications.

The third tactic is to draw diagrams or models of how the categories are related to each other. "Strauss recommends the use of integrative diagrams, as a way of integrating threads of the emergent theory (Urquhart, 2001). One of the results of this thesis; the E-learning Circle (Kolås & Staupe, 2010), is a visual presentation that also illustrates how the use of integrative diagrams was useful in this study. Diagrams were helpful in the analyzing process to visualize the relationships between categories, and like Urquhart experienced, I found that the diagrams are useful communicative tools. I have chosen to use some well-known pedagogical theories in e.g. the E-learning Circle, connected to emerging categories from the data collection. This can be questioned in the development of empirically grounded theory, but the use of diagrams illustrated relations between the emerging categories and made the well-known pedagogical theories visible in the empirical data. The emerging categories and their relations were compared to pedagogical theories in the literature of the field, and in cases where their coverage was similar; I had the choice of using my 'home-made' names of the emerging categories or to use the well-known concepts from already existing theories. I chose the latter, as the strength of the E-learning Circle is not the parts, but the parts seen together as a whole. The illustrative circle, which also includes the relations between the categories, is as such useful as a communicative tool.

In this thesis all these tactics have been useful in order to answer the research questions of this thesis.

The concept of teaching style was changed during selective coding, and is now indirectly covered by proficiency stages, multiple intelligences and culture in the student sector of the E-learning Circle. The selective coding provided new knowledge about problem statement of the project, with a growing focus on the interdependent relationship between students and teachers.

The choice of writing papers during the doctoral project has been useful also as part of the analyzing process. Charmaz's (2005) experience is that "writing leads to further discoveries and deeper insights; it furthers inquiry". This is also the experience of this research process; the writing of papers throughout the process definitely provided the researcher with deeper insights and further discoveries as well as moving the theoretical sampling forward. This entails, however, that the papers present the gradual development of the doctoral project, and that early papers have not reached the point of theoretical saturation.

Saturation
How much data is enough in order to answer the research questions? The researcher is expected to continue theoretical sampling to test and validate the developing codes, categories and concepts until reaching the point of theoretical saturation. "Theoretical saturation is the point in category development at which no new properties, dimensions, or relationships emerge during analysis" (Strauss & Corbin, 1998). After analyzing data collected from the

eight research sites, the improvement of the theory was small and the decision to conclude the research was taken.

3.8 Researcher's role and ethics

The thesis is written in the first person, as my view of scientific research is that it is a socially constructed reality (Sohlberg & Sohlberg, 2004). Due to this, writing the thesis in the third person or passive voice would not reflect an active researcher but make the researcher almost "invisible".

The choice of closeness instead of distance in the research situation entails the danger of "going native", which means that the researcher may be "caught" by the research situation and involves that the researcher looses the ability of an analytical attitude to the research. It was especially important to be aware of this when collecting data through the expert groups. The active role as a participant in the teamwork of the problem solving activities endangered a too close integration with the other participants. This was avoided in the expert groups working with the PLExus and stereotype modeling prototypes, because the expert groups all used the emerging theory of this study as a starting point and the data collected from these expert groups where mainly the connection between pedagogy and technology.

The interviewees of this study voluntarily agreed upon joining the study based on full and open information about the study. The study protects people's identities and research locations and all personal data is ensured anonymity.

The study uses standard techniques to make references to authors of books, articles, papers, websites and projects.

Accuracy is ensured as far as possible through the thorough description of the research process. The trustworthiness of the study is discussed in chapter 5.

3.9 Reflections on method

As the earlier sections of chapter 3 (Research method) focus on describing the research process, this section offers some reflections on the use of Grounded Theory approach, including strengths and weaknesses of the method experienced in this project. It should be recognized that I have touched upon several of the issues in the previous sections of this thesis, and I will revisit some of them in the following paragraphs, this time reflecting upon own experiences in the research process. The section also includes reflections based on the criticism of Grounded Theory and finally some reflections about the use of Grounded Theory in the IS field.

Expert groups in the Grounded Theory approach
The choice of using expert groups in the process of theoretical sampling, was as earlier mentioned made because expert groups ensured closeness to the empirical field and focused the data collection on the development of components in the design process of software applications. An alternative approach would have been to interview persons who worked with the problem solving activities, and use this as a data collection method. It was however important for me to call attention to the contributions, which the prototyping process itself,

provide in a Grounded Theory approach used in IS research. This was provided by the use of expert groups, and would not have been as easy to retrieve through e.g. interviews.

A second alternative was to use 'grounded action research', a concept introduced by Baskerville & Pries-Heje (1999). "This refinement of the action research method involves integrating certain Grounded Theory activities in the phases of action research primarily in two ways. First, Grounded Theory notation (e.g., memos and diagrams) is used to represent the theory-data during the action research cycle. Second, Grounded Theory coding becomes the essence of the evaluating, learning and diagnosis phases of action research" (Baskerville & Pries-Heje, 1999). Grounded action research was for some time considered to be interesting also in this project, but was rejected because action research was not considered interesting as the overall research method, and because 'grounded action research' is not a well-established research method.

"We would argue that the adoption and diffusion of the method should be welcomed since it represents its usefulness as a pragmatic tool for qualitative research" (Hughes & Howcroft, 2000). The pragmatic view of the Grounded Theory approach, together with the exploratory research design and the traditions of the IS field allowed the idea of expert groups within the Grounded Theory approach to develop.

Strengths and weaknesses of the Grounded Theory approach
There are in the literature reflections about the use of Grounded Theory and the Grounded Theory techniques. Pandit (1996) describes some of the problems he encountered in his project: First, the Grounded Theory research is extremely time-consuming; second, the Grounded Theory research involves long periods of uncertainty. Third, Grounded Theory research requires certain qualities of the researcher. In particular, confidence, creativity and experience are of great benefit. Accordingly, the approach does not favor the novice researcher who may be just beginning to develop these qualities. This is not to say that novice researchers should not embark upon Grounded Theory studies; rather, I imply that (a) they are likely to find the approach more difficult than more conventional methodologies; and (b) the more experienced researcher is likely to produce better theory" (Pandit, 1996).

Also in my project the research has been time-consuming, and like Pandit (1996) describes as the second problem, I also experienced long periods of uncertainty. The different stages of the project were hard to plan and recognize in the moment, even though it is clearer when the stages are passed. I recognize the feeling Pandit (1996) describes; "the first half of the study period required a good measure of faith and hope", but on the other hand I took part in two EU-projects and was able to divide my project into smaller pieces, work with other researchers and actually finish pieces of work early.

Denscombe describes one of the disadvantages using the Grounded Theory method is that "the approach does not lend itself to precise planning" (Denscombe, 2003). This has been both an advantage and a disadvantage in this project. The project has been connected to several larger projects (E-LEN, QUIS, and LIKT) and this was not possible to plan in advance, since all them lasted only max 2 years. The research questions in this thesis have both influenced the research issues in the other projects (e.g. developing the QUIS requirement specification and the PLExus prototype), but it has also been necessary to adjust the work of the thesis to the work of the other projects (e.g. use of design patterns). Not being strictly dependent on a plan created early in the project has been interesting, and has in my opinion made the results of the project better. The Grounded Theory definitely works in

exploratory projects like this project, and instead of regarding no precise plan as a weakness of the method; it is experienced as one of the strengths of the method, allowing an exploratory and creative approach.

Also the fact that Grounded Theory allows a variety of qualitative data collection methods (e.g. interviews, observations, document analysis) is an advantage. Together with the rich tools and techniques, the method helps the novice researcher in the process of analyzing the data.

Literature review
How to deal with the literature within Grounded Theory is often discussed (Urquhart, 2001; Denscombe, 2003; Allan, 2003). Denscombe (2003) describe how the open-minded approach of Grounded Theory raises awkward questions; "should the researcher avoid undertaking a literature review in order to avoid having their minds 'contaminated' by existing concepts and theories? And, if so, does this invite the possibility of 'reinventing the wheel' or failing to learn from what has been researched in the past?" Urquhart (2001) claims that "one of the oft quoted misconceptions about Grounded Theory is that the researcher does not do any literature searching and goes into the field 'blind,' as it were". "The idea of setting aside theoretical ideas implies that the researcher does not look at existing literature. This in not in fact an accurate representation of Grounded Theory – the position of both Glaser and Strauss on this issue is far more subtle. The injunction about literature seems mainly designed to ensure that the researcher takes an inductive rather than deductive approach, and listens to the data rather than imposing preconceived ideas on the data" (Urquhart, 2001). She emphasizes however that the Grounded Theory researcher has to relate to literature in a slightly different way than a conventional researcher.

The concept of 'theoretical sensitivity' (Glaser, 1978) emphasizes that the researcher should "enter the research setting with as few predetermined views as possible, especially logically deducted, a prior hypotheses". That said, "theoretical sensitivity is increased by being steeped in the literature" (Glaser, 1978). Strauss and Corbin's (1998) opinions on this issue are that literature can be used as data or for making comparisons in the analysis, but they emphasize that the researcher should be aware that use of literature may hinder creativity. Walsham (1995) warns the Grounded Theory researcher that "it is possible to access existing knowledge of theory in a particular subject domain without being trapped in the view that it represents final truth in that area. Glaser and Strauss's warning are valuable for reflection, but they surely tend towards approaches which risk ignoring existing work".

The NTNU PhD program demands a "state of the art" report during the first year as a PhD student. This may complicate the use of the Grounded Theory method, which encourages collecting empirical data first, and then starting relevant literature search. However, the literature review and the "state of the art" report did not lead to hypothesis generation, and was mainly useful in the process of refining the problem statement. One may argue that the refinement of the problem statement after a literature review might be considered as "imposing preconceived ideas on the data", but on the other hand it was necessary to limit the field of investigation. Charmaz (2005) claims however, that "No analysis is neutral – despite research analysts' claims of neutrality. We do not come to our studies uninitiated". This is the case whether we do literature review in an early phase or not.

Criticism towards Grounded Theory

Critics of the Grounded Theory approach include the epistemological positions. "Glaser's strong foundation in mid-20th-century positivism gave Grounded Theory its original objectivist cast with its emphases in logic, analytic procedures, comparative methods, and conceptual development and assumptions of an external but discernible world, unbiased observer, and discovered theory... Like Glaser, Strauss and Corbin also advanced positivistic procedures, although different ones. They introduced new technical procedures and made verification an explicit goal, thus bringing Grounded Theory closer to positivist ideals... Since then, a growing number of scholars have aimed to move Grounded Theory in new directions away from its positivist past" (Charmaz, 2005). "Whilst Strauss and Corbin (1998) express concern about the diffusion of the method in that it is applied and adapted in other disciplines, given the above we would expect that Grounded Theory differs not simply by adaptation on a procedural level, but also due to the differing epistemological positions of the researchers. Simply put, positivists are more likely to treat the method literally, as a rational process, whereas interpretivists are more likely to treat the method in a metaphorical sense, intervening and interpreting en route" (Hughes & Howcraft, 2000).

This study would not be possible to conduct with a deductive, positivistic perspective; the researcher is not unbiased, but plays an active role, which a socio-constructivist perspective allows. "A constructivist Grounded Theory adopts Grounded Theory guidelines as tools but does not subscribe to the objectivist, positivist assumptions in its earlier formulations. A constructivist approach emphasizes the studied phenomenon rather than the methods of studying it. Constructivist grounded theorists take a reflexive stance on modes of knowing and representing studied life. That means giving close attention to empirical realities and our collected renderings of them – and locating oneself in these realities" (Charmaz, 2005).

Alvesson & Schiöldberg (2008) problematize the Grounded Theory approach at a lower level; "Two problems with Grounded Theory are primary that a spontaneous approach to data treatment involving bias from common sense-thinking pre-scientific categories is advocated, and secondly that too much energy is spent on detailed coding." I agree that it is possible to overemphasize coding using the Grounded Theory coding techniques, but a close inspection of data in the early phases of the project and a pragmatic approach to coding make the coding useful instead of too exhausting.

Grounded Theory research in IS

"Grounded Theory has been increasing in popularity in Information Systems as a research method. This is evidenced by the growing literature that is either discursive on philosophy and application or detailed about the method" (Hughes & Jones, 2003). Hughes and Howcroft (2000) point out that there are inconsistencies in the understanding and application of the Grounded Theory method in IS research and present four inconsistencies concerning the use of Grounded Theory in IS research. First, the projects range from those concerned with organizational change to those concerned with the practical use of the method to inform knowledge based systems design. Second, some use the method prescriptively, whilst others use some of its procedures to supplement other research strategies. Third, the underlying assumptions made explicit by the researchers range from qualitative-interpretive to qualitative-positivist and finally, Grounded Theory is used on its own or alongside other methods (Hughes & Howcroft, 2000).

"The development of the 'interpretive' empirical school in IS has not been free of controversy, and debate continues on the relative merits of interpretivist versus positivist

approaches to IS" (Walsham, 1995). Since Walsham claimed this in 1995 there has been a development, described by Myers (1999), who claims that "In Information Systems we have reached the stage where many different research methods and approaches (e.g., quantitative or qualitative, positivist or interpretive) are accepted as appropriate for our field". IS research using an interpretive approach and the Grounded Theory method in projects covering the development of information systems is limited, and hopefully this thesis' research approach and experiences will be regarded as a contribution to the debate of IS research.

There exist a lot of studies and articles using Grounded Theory, but most of them are studies within the field of sociology. There are some examples of Grounded Theory in IS research, but relevant literature of Grounded Theory in exploratory studies are rare, and this study will provide a contribution to the IS research field based on the use of Grounded Theory in an exploratory study. This thesis will not provide a contribution in the debate on which research method is best. I am open to the possibility of other research practices within e-learning. Hopefully this thesis will contribute to IS research because it combines Grounded Theory and an explorative perspective.

Chapter 3 has based on the exploratory research question and the underlying methodologies of pragmatism, empirical grounding, interpretivism and social constructivism described the choice and the use of the Grounded Theory approach in this thesis. The chapter describes the research process in detail, through the description of theoretical sampling (cumulative and iterative site selection), data collection (using interviews, focus groups and expert groups), data analysis (using the techniques of questioning, comparison, memos, core category and diagrams in the processes of open, axial and selective coding) and theory development (reaching theoretical saturation). The researcher's role is discussed and reflections on the method conclude the research method chapter.

4 Contributions

This chapter first introduces an overview of the main contributions of the thesis. Each contribution is briefly described and illustrated. Then an overview of the selected papers is presented. Each paper is summarized and related to the stated research questions.

4.1 Overview of contributions

The thesis includes the following four main contributions:
1. Design pattern-based wizards to implement best practice
2. The E-learning Circle
3. The E-learning ontology
4. The PLExus prototype

4.1.1 Contribution 1: Design pattern-based wizards to implement best practice

The first main contribution of the thesis is the idea of using pedagogical design patterns as a basis for the development of wizards in e-learning applications. Design patterns are archetypes on well-used solutions, and will build best practice and the expertise of experienced online teachers into the application. The wizard provides an interface, which presents pedagogical opportunities, hints and comments to novice online teachers. The use of pedagogical design patterns will ensure that the online learning environment is based on pedagogical motives.
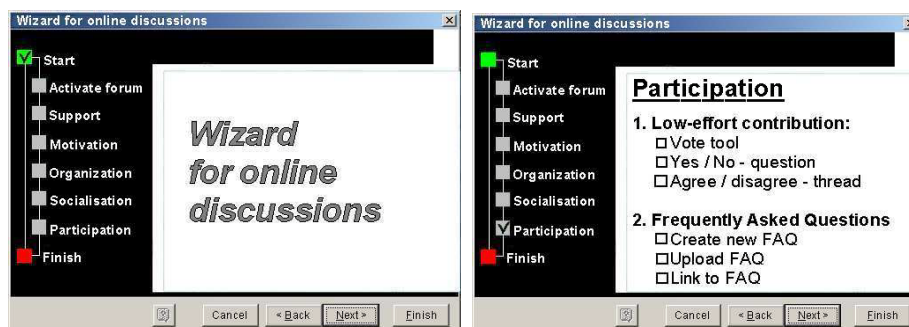
Fig. 6: Paper prototypes of wizards based on pedagogical patterns

The design pattern-based wizards mainly cover research question 4 (How to implement the pedagogical principle of ***best practice*** into the design process of e-learning applications?), but through the design pattern-based wizard in the PLExus prototype, which contributes to ensure variation and individualization, research questions 1 and 2 are to a certain extent also covered.

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4.1.2 Contribution 2: The E-learning Circle

The E-learning Circle is a tool, which assures the quality of the design process of e-learning applications, ensuring individualization and variation in an online learning environment. The E-learning Circle consists of a number of concentric circles, which are divided into three sectors; student, teacher and learning objectives. The content of the inner circles covers pedagogical considerations, while the outer circles specify how the pedagogical theories may be implemented with technology.

The strengths of the E-learning Circle are the compact presentation combined with the overview it provides, as well as the usefulness of a design tool dealing with complexity, providing a common language and embedding best practice. The E-learning Circle is not a prescriptive method, but is useful in several design models and processes. The E-learning Circle is a holistic approach to the design of e-learning applications and contributes to avoid the overexposure of few parts of an e-learning system such as learning objects or assessment.

The E-learning Circle contributes to answer research questions 1, 2 and 3 (How to implement the pedagogical principles of *variation, individualization* and *meta-learning* into the design process of e-learning applications?).
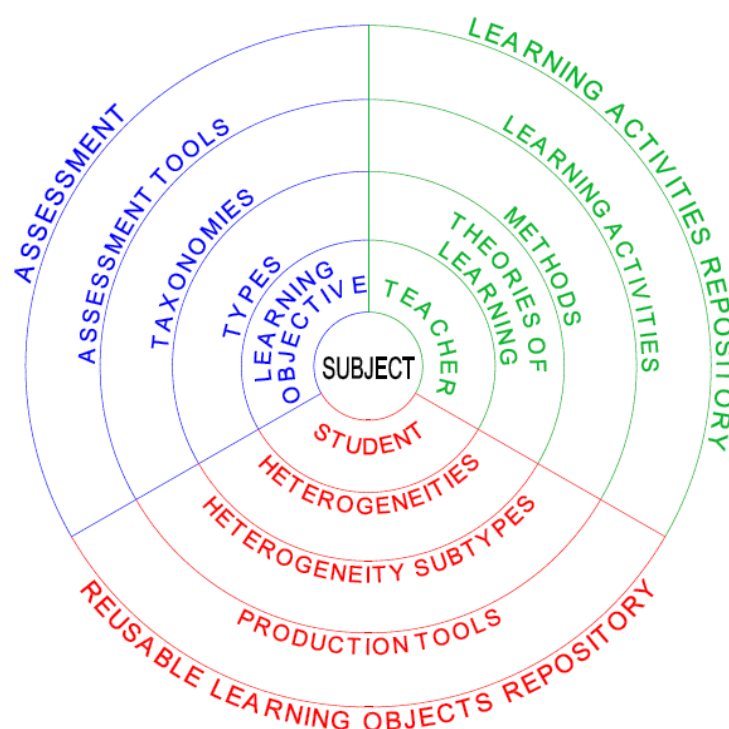
Fig. 7: An overview of the main parts of the E-learning Circle
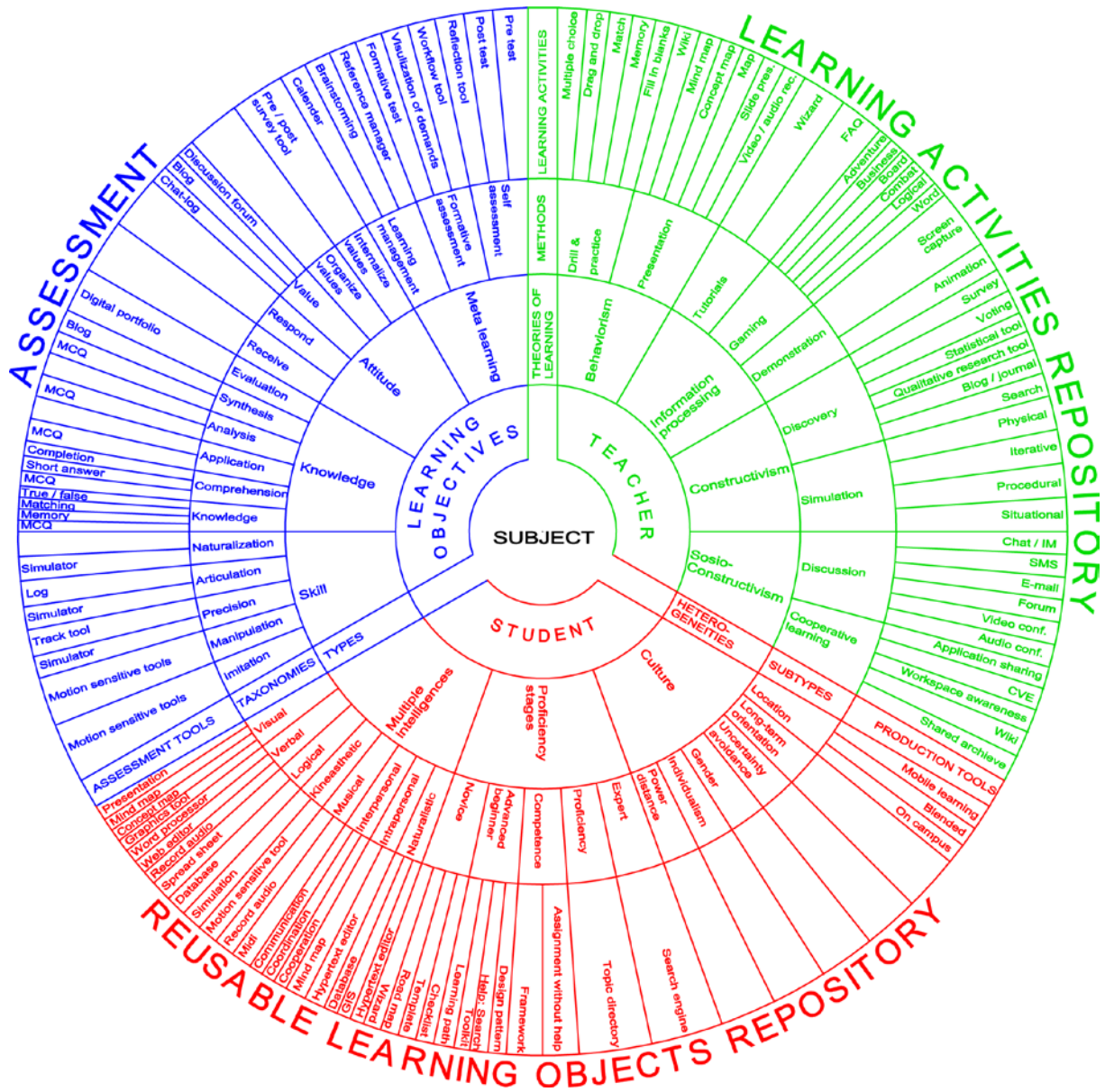
Fig. 8: The complete E-learning Circle
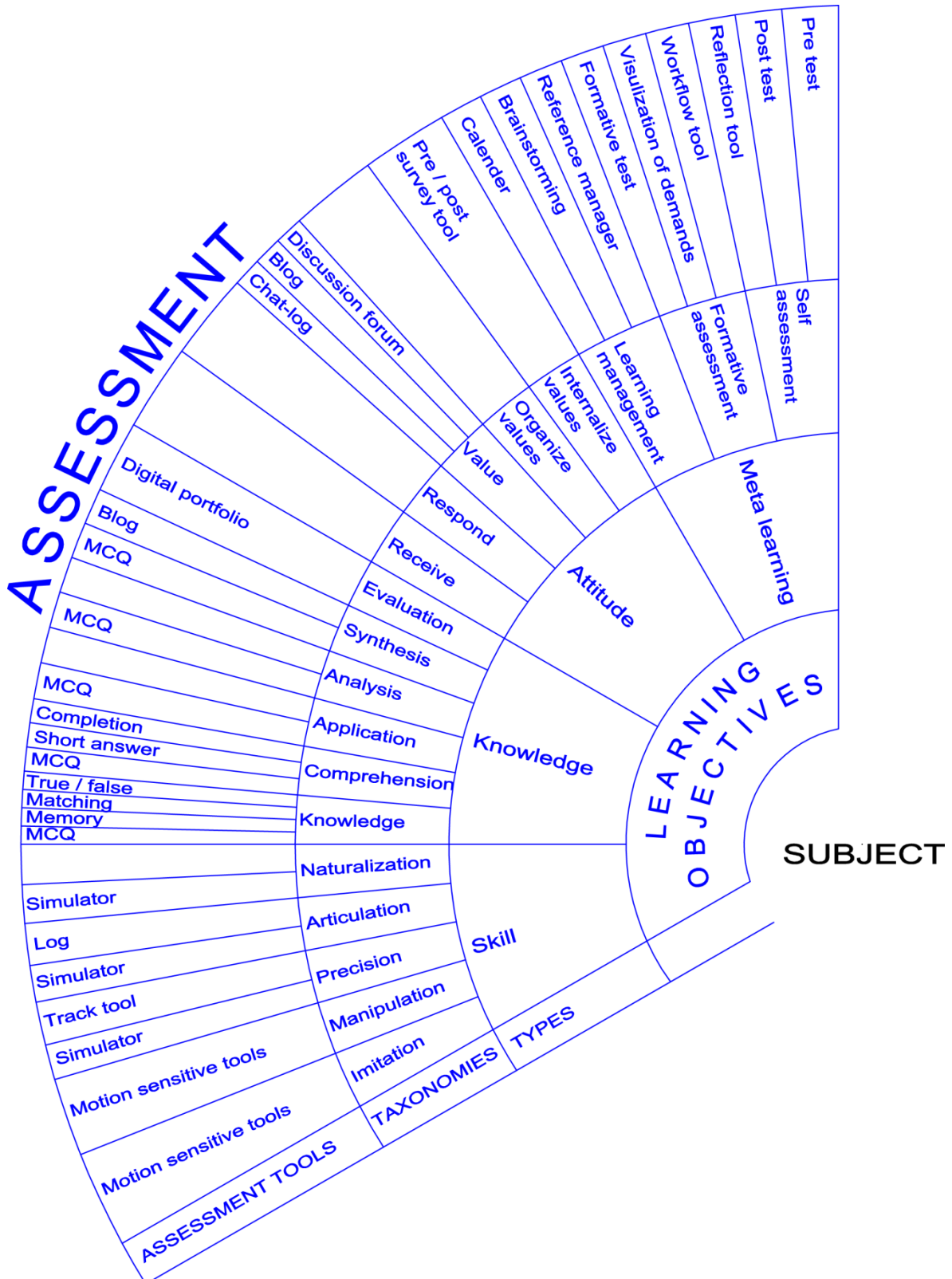
Fig. 9: The learning objective - assessment sector
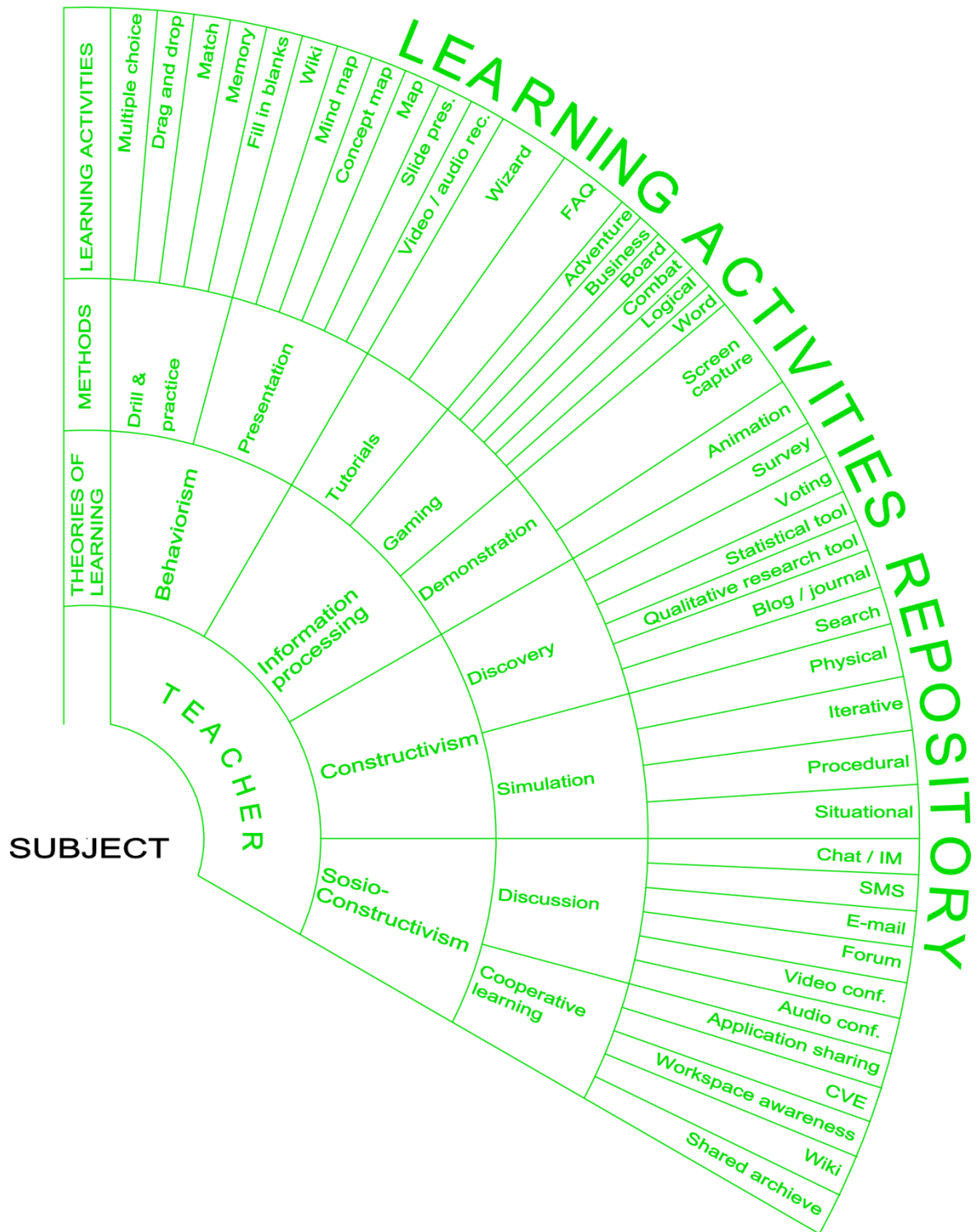
Fig. 10: The teacher – learning activities sector
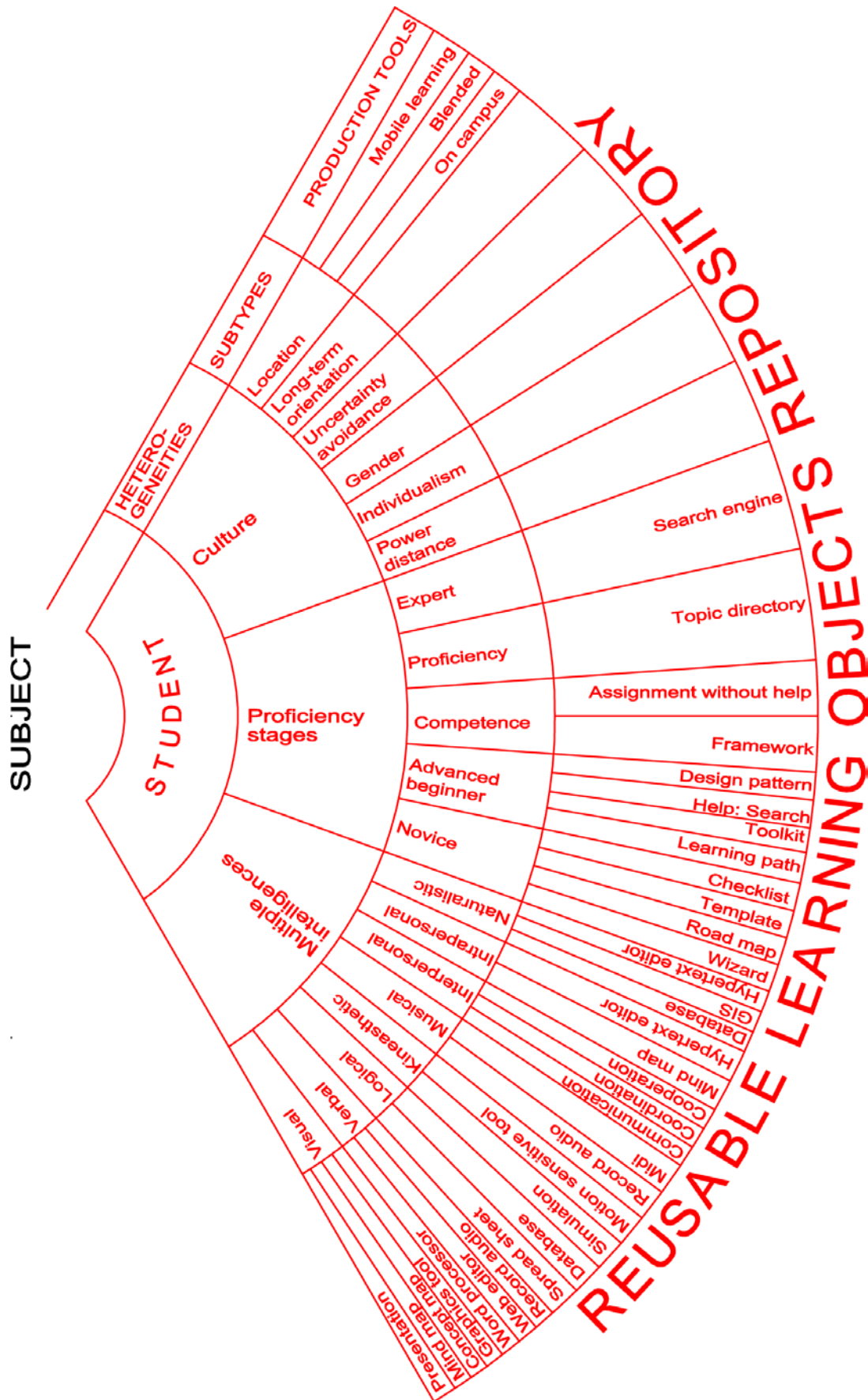
Fig. 11: The student – learning objects sector

4.1.3 Contribution 3: The E-learning ontology

The E-learning ontology is the answer to the need of an ontology, which is necessary when planning to use topic maps as a HCI-solution within e-learning. Topic maps are an ISO-standard, and the topic map architecture allows the online information to be published in several views based on the choice of the user.

The E-learning ontology presents key topics, topic types, associations and occurrences, in order to ensure that important pedagogical principles are considered in the development of a HCI-solution based on the semantic architecture of topic maps.

Key topics:	Topic types:	Associations	Occurrences
Learning objectives	Knowledge	Is assessed through	MCQ, memory, matching, true/false, short answer, completion, blog, portfolio,
	Attitude		Chat log, discussion forum, pre/post survey tool
	Skill		Motion sensitive tool, simulator, track tool, log
	Meta-learning		Pre-test, post-test, reflection tool
Pedagogical methods	Drill	Is taught through	Multiple choice, drag and drop, match, memory, fill in blanks
	Presentation		Wiki, mind map, concept map, map, slide presentation, video / audio recordings
	Tutorials		Wizards, FAQs
	Gaming		Adventure games, business games, board games, combat games, logical games, word games (Alessi & Trollip 2001)
	Demonstration		Screen capture, animation
	Discovery		Survey, voting, blog / journal, search
	Simulation		Physical, iterative, procedural and situational simulations (Alessi & Trollip 2001)
	Discussion		Chat / IM, SMS, e-mail, forum, video conference, audio conference
	Cooperative learning		Application sharing, CVE, workspace awareness, shared archive
Learning objects	*(Multiple intelligences)* Visual intelligence	Is produced through	Presentation tool, mind map, concept map, graphics tool
	Verbal intelligence		Word processor, web editor, record audio
	Logical intelligence		Spread sheet, database
	Kinaesthetic intelligence		Simulation, motion sensitive tool
	Musical intelligence		Record audio, midi

Fig. 12: Parts of the e-learning ontology

The E-learning ontology answers research question 1, 2 and 3 (How to implement the pedagogical principles of *variation*, *individualization* and *meta-learning* into the design process of e-learning applications?).

4.1.4 Contribution 4: The PLExus prototype

The PLExus prototype is a working prototype of a personal learning environment based on the semantic technology of topic maps. PLExus provides a student interface allowing customized views of learning objects and learning activities based on pedagogical methods, learning objective types, proficiency stages etc. and is addressing the needs of a heterogeneous student group.

PLExus provides a wizard to the teacher in the process of adding and structuring the learning objects in the topic map.
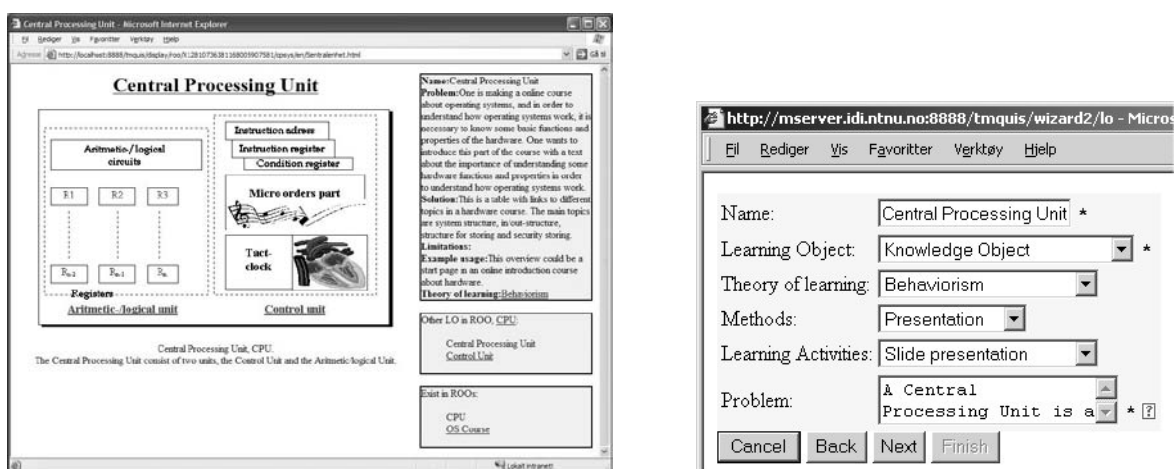
Fig. 13: Screen shots from the PLExus prototype

The PLExus prototype covers the research questions 1, 2 and 4 (How to implement the pedagogical principles of *variation, individualization* and ***best practice*** into the design process of e-learning applications?).

4.2 The papers

The papers have been selected to serve two purposes; primarily to portray my learning process, and secondly to show how the contributions have evolved over time. Therefore the papers are presented chronologically and because of this, the contributions of the project are more evident in the later papers than in the earlier ones.

The thesis includes the following 9 papers.

1. Kolås, L. and Staupe, A. (2004). "Implementing pedagogical methods by using pedagogical design patterns", Proceedings of the World Conference on Educational Multimedia, Hypermedia & Telecommunications (Ed-Media 2004), p. 5304-5309, AACE, ISBN 1-880094-53-3.

2. Saatz, I. and Kolås, L. (2005). "Support for the instructor - from technical to pedagogical point of view", Proceedings of the IASTED International Conference on Internet and Multimedia Systems and Applications (EuroIMSA 2005), ISBN 0-88986-484-5.

3. Kolås, L. (2005). "Variation and reusability in e-learning: not compatible?" Proceedings of the World Conference on E-learning in Corporate, Government, Healthcare & Higher Education (E-learn 2005) p. 1368-1375, AACE, ISBN 1-880094-57-6.

4. Kolås, L. (2006). "Topic maps in e-learning: An ontology ensuring an active student role as producer", Proceedings of the World Conference on E-learning in Corporate, Government, Healthcare & Higher Education (E-learn 2006), p. 2107-2113, AACE, ISBN 1-880094-60-6.

5. Kolås, L. and Staupe, A. (2007). "The PLExus Prototype: A PLE realized as Topic Maps", Proceedings of the 7th IEEE International Conference on Advanced Learning Technologies (ICALT 2007), IEEE Computer Society Press. *This paper was submitted as a long paper to the ICALT conference, but was accepted and published as a short paper. The long version is presented here.*

6. Kolås, L. and Staupe, A. (2007): "A Personalized E-learning Interface". The Proceedings of the international IEEE Conference on Computer as a tool (EuroCon 2007). Poland: IEEE Computer Society 2007. ISBN 1-4244-0813-X

7. Kolås, L., Staupe, A. Temperini, M. and Sterbini, A. (2007). "The QUIS Requirement Specification of a Next generation E-learning System", IADIS International conference proceedings E-learning 2007 Volume II (IADIS E-learning 2007). Lisbon: IADIS Press 2007. ISBN 9789728924423. p.188-193.

8. Kofod-Petersen, A.; Petersen, S.A.; Bye, G.G.; Kolås, L.; Staupe, A. (2008). "Learning in an Ambient Intelligent Environment - Towards Modelling Learners through Stereotypes". Revue d'intelligence artificielle: Revue des Sciences et Technologies de l'Information, 2008; Volum 22. (5) p. 569-588.

9.   Kolås, L. and Staupe, A. (2010). "The E-learning Circle – A holistic software design tool for e-learning". E-learning and Education, 2010. ISSN 1860-7470.

Paper 3 was first presented at, and included in the proceedings of the internal NTNU Computer Science Graduate Students Conference (CSGSC 2005). Paper 7 was presented and included in the proceedings of ICALT 2007 as a short paper, but is in this thesis presented as a full paper. An early version of paper 9 was orally presented at the Nordic conference Netlearning 2006 in Sweden.

	Paper 1	Paper 2	Paper 3	Paper 4	Paper 5	Paper 6	Paper 7	Paper 8	Paper 9
RQ 1: How implement the concept of variation into the design of e-learning applications?	X		X	X	X		X		X
RQ 2: How implement the concept of individualization into the design of e-learning applications?				X	X	X	X	X	X
RQ 3: How implement the concept of meta-learning into the design of e-learning applications?				X			X		X
RQ 4: How implement the concept of best practice into the design of e-learning applications?	X	X			X				X

Table 4: Overview of the papers' contributions to the research questions

Some of the papers should be seen in connection to each other. Paper 1 and paper 2 both consider RQ 4 (How implement best practice into the design of e-learning applications) and the use of design patterns as a basis to implement pedagogical wizards.

Paper 4, 5, 6 and 7 should also be seen together as the topic map of the PLExus prototype (paper 5) is based on the E-learning ontology (paper 4), and paper 6 elaborates the personalized e-learning interface provided in a topic map. Paper 7 (QUIS requirement specification) was also work contributing to the e-learning ontology and the PLExus prototype.

Paper 9 (The E-learning Circle) is presenting work, which must be seen together with all the previous papers, as it provides an overview of work conducted to answer research question 1, 2, 3 and 4.

Some of the content of the papers are repeated in several papers. This was necessary because the conference papers' page restrictions entail that there is not room to focus on more than one small topic pro paper and background information of several topics / papers was necessary to repeat. The overview of the contributions and the relations between papers and contributions are provided by the thesis.

4.2.1 Paper 1: Implementing pedagogical methods by using pedagogical design patterns

This paper focuses mainly on the pedagogical principle of best practice (research question 4) but also include ideas concerning variation and individualization (research questions 1 and 2). The background of the paper is that the goal of e-learning technology should be to develop systems with a wide range of variation and many opportunities for both teachers and students when it comes to pedagogical methods and learning styles. The paper argues that the focus of e-learning design has been administration, content and media, and that pedagogical methods have not been prioritized.

The principle of 'best practice' (research question 4) is in the paper represented as design patterns. Design patterns are 'archetypes of well-used solutions', defined by Alexander (1977) as following; "a design pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem in such a way that you can use this solution a million times over, without ever doing it the same way twice". The teacher uses his experience and expertise from pedagogy to create a pedagogical design pattern using a pattern language where he needs to state a name (e.g. E-moderation) and a category (e.g. Discussion). He then describes the problem (e.g. a discussion forum can be difficult to get to work in an online learning environment. How can we ensure that discussion forums work well and are instructive to the students?). The teacher follows up by describing best-practice solutions (e.g. organizational moderating activities like setting the agenda, social moderation activities like sending welcoming messages and intellectual moderating activities like provide low-effort contributions).

The paper presents ideas about how to implement pedagogical methods by systematizing them into pedagogical design patterns that are implemented as pedagogical wizards. A wizard is a computer user interface that makes software easier to operate by guiding the user through a process, step by step. The design pattern-based wizard enables not only a technical, but also a pedagogical configuration of the e-learning applications.

The pedagogical design patterns will provide a common language for educators and technologists and in such way bridge the gap between pedagogy and technology. Furthermore the pedagogical design patterns are useful tools for the system developers when creating wizards, which embed best practice into the e-learning systems.

The same content should be made available to learners through different methods and the students should be able to choose the combination of methods best suited for their preferences. The focus on pedagogical methods while designing e-learning systems will ensure variation for students. An e-learning system with wizards based on pedagogical design patterns is one solution to provide this.

4.2.2 Paper 2: Support for the instructor -from technical to pedagogical point of view

Paper 2 pursues the ideas from paper 1 about the use of design patterns as a basis for developing pedagogical wizards to support the online teacher.

To perform e-learning courses the instructor needs support: on one side best practice solutions and on the other side software support to bring the pedagogical ideas into action, covering all phases of planning and performing online courses. It is also important that the support provided to the teacher has a pedagogical, not technical point of view. The paper proposes to capture best practice solutions by e-learning design patterns. Design patterns are however abstract and to apply them within in course, they must be adapted to the specific course context and linked to the internet tools and services provided by the learning management system. To assist the instructor we propose a process-based software wizard, guiding the instructor by selecting appropriate educational interaction patterns for the educational scenario as well as supporting the selection and adaptation of internet tools from a pedagogical point of view. This will bridge the gap between the educational environments and the provided technical support by the learning management system.

The paper is based on three levels of abstraction; Level 1 is the educational scenarios, level 2 is the design patterns and level 3 is the software tools. The expert online teacher knows best practice (level 1), and uses a pattern language to describe his experiences as pedagogical design patterns (level 2). The e-learning patterns are implemented by software developers as process-based wizards (level 3).

The paper demonstrates how the linkage between the educational design patterns and the underlying learning management system could be provided. An adaptable course assistant, which provides adaptable course templates, is coupled with the wizard, e.g. in the "activate tool" step of the wizard the building blocks needed are added to the course template and configured within the "tool configuration" step of the wizard.

The wizard is based on a process-oriented system. The general idea of such systems is to describe the adaptation and configuration activities by means of a process description language, based on which run-time support is provided.

The proposed wizard shows, how the shift from a merely technical driven to a pedagogical-driven support for the instructor can be reached.

This paper focuses on research question 4: How to implement the pedagogical principle of best practice into the software design process?

4.2.3 Paper 3: Variation and reusability in e-learning: not compatible?

One way to improve e-learning systems for higher education is to look at the weaknesses of today's system and do something about these weaknesses. Obvious weaknesses of today's systems are lack of opportunities for variation and reusability.

This paper mainly focuses on variation (research question 1), and present an understanding of the concept 'variation' in an e-learning setting, covering eight aspects and how two and two of these aspects are closely connected; varied pedagogical methods & varied teaching styles, varied learning styles & varied levels of intellectual behavior, varied content & varied media, and varied goals & varied assessment. The paper further discusses the problems and opportunities appearing when variation and reusability are combined.

A lot of research covers the combination of reusability and varied content / media, and standards are developed to ensure the reusability of learning objects (e.g. SCORM, IMS, IEEE LOM, Dublin Core). The reusability of a learning object depend upon the granularity of the learning object, as some consider an entire curriculum as a learning object while others consider a picture to be a learning object. The decision regarding learning object granularity can be viewed as a trade-off between the possible benefits of reuse and the expense of cataloging.

Pedagogical methods are traditionally possible to reuse in different subjects. IMS Learning Design is a contribution to the standardization of pedagogical methods. A problem of Learning Design is the inclusions of learning objects, as inclusion of context is problematic for reuse. Also concerning pedagogical methods the granularity of the learning activities is important. The LAMS system, which is based on IMS Learning Design, provides an example of low level granularity where the teacher can choose from a list of pre-defined learning activities e.g. brainstorming a concept. Learning activities like these are reusable, but standing alone like they do in LAMS the danger is that 'best practice' connected to pedagogical methods disappear.

The work done on learning styles can make it easier to reuse "individualized" material, because it defines subgroups of students with the same needs. The paper illustrates however that by combining eight intelligences (visual, verbal, interpersonal etc) and five levels of intellectual behavior (e.g. novice, competence, expert) the number of student subgroups with similar needs is growing fast. Adding even more dimensions, like age or culture, this illustrates a growing problem when preparing for reuse in e-learning.

The assessment ought to fit all types of students, and work needs to be done to develop technological assessment tools that give students with different needs the same opportunity when assessing learning outcome.

Key findings of the paper is that the work done so far to improve reuse within e-learning, has not been considering all the factors that are important to achieve high quality in e-learning. Learning objects and learning activities are not the only important aspects if the goal is both quality and reuse.

The paper is an early contribution to the work of producing tools to assure the quality of e-learning systems, focusing on variation.

4.2.4 Paper 4: Topic maps in e-learning: An ontology ensuring an active student role as producer

Topic maps have been introduced as a HCI-solution within e-learning. The topic map architecture allows the online information to be published in several views based on the choice of the user, e.g. themes, time, pedagogical methods, media type, proficiency stage and ranking scores. Topic maps are an ISO standard, but in order to use topic maps in an e-learning setting it is necessary to design an ontology.

The paper proposes a topic map ontology, focusing on both students and teachers as active producers of learning resources. The e-learning topic map ontology includes key topics, topic types, associations and occurrences.

An example of the e-learning ontology:

Key topics	Topic types	Associations	Occurrences
Learning objectives	Knowledge	Is assessed through	MCQ, memory, matching, true/false, short answer, completion, blog, portfolio
	Attitude		Chat log, discussion forum, pre/post survey tool
	Skill		Motion-sensitive tool, simulator, track tool, log
	Meta-learning		Pre-test, post-test, reflection tool

Fig. 14: Example of the e-learning ontology

The paper also discusses how small-scale and large-scale sharing of student-made learning resources can be achieved. Topic maps customize the interface, and the interface should also provide possibilities for online students to share learning resources like "on campus" students do. Small-scale sharing is exemplified by a ranking system, where students rank a learning object and the system can show the ranking results for other students. Large scale sharing includes the sharing of lecture notes, slide presentations, mind maps etc.

One problem when using topic maps is that the student is left in a passive consumer role. An e-learning ontology should systematically organize student productions and make them retrievable, allowing the student to have a active role as producer. The role of the teacher is to be the editor and to have a bird eye's perspective of the entire learning environment.

The e-learning ontology ensures an individualized online learning environment (research question 2), but also ensures variation in e-learning (research question 1). The paper also includes research question 3 (meta-learning) as one of the key topics is 'learning objectives', where meta-learning is a topic type of this key topic.

4.2.5 Paper 5: The PLExus Prototype: A PLE realized as Topic Maps

The paper presents the PLExus prototype, a Personal Learning Environment based on the semantic technology of topic maps. Semantic-based navigation in e-learning will enable variation and individualization (research questions 1 and 2), which are important pedagogical factors in the development of a personal learning environment. PLExus provides a student interface allowing customized views of learning objects and learning activities based on pedagogical method, learning objective type, proficiency stage etc.

The paper describes the important primary constructions in topic maps applicable in a PLE and presents the PLE prototype with screenshots and a system description.

Topic maps proved through the PLExus prototype to be suitable as the core of a powerful PLE with information administration, search and navigation as important components.

The PLExus prototype enables the student to customize the learning environment. This requires that learning objects and learning activities are saved and retrieved in such a manner that one student can reach the learning objective through a presentation, while other students reach the same learning objective through e.g. discovery, demonstration or collaboration. Instead of presenting the learning objects and learning activities in one standard online interface for all the students, PLExus presents 'many roads to Rome', addressing the needs of a heterogeneous student group.

In the process of transforming subjects into LOs (topics), it will be necessary to add metadata and PSI (Published Subject Identifier). The PLExus editor builds the topics with the necessary elements (base names, possible variant names, occurrence(s), scope(s) and subject indicator).

The teacher prepares a topic map-based personal learning environment for the student by structuring the learning objects using a pedagogical wizard. After adding the metadata, partly by choosing from a list and partly writing free text, the teacher saves the learning objects (with metadata) to the topic map. The student will then be able to retrieve a learning object and have access to semantic-based navigation between learning objects.

The PLExus prototype is based on the E-learning ontology, presented in paper 4.

4.2.6 Paper 6: A Personalized E-learning Interface

The student group is heterogeneous, and to reach the goals of individualization (research question 2) it is necessary to fit e-learning to the different needs of the students. The paper first defines the heterogeneity factors of the student group, and then describes how an e-learning system must have a personalized interface enabling different student views / access to learning objects and learning activities. The paper should be seen together with the paper 4 "Topic maps in e-learning. An ontology ensuring an active student role as producer", as this paper elaborates on the personalization of interfaces.

Many LMS (Learning Management Systems) of today only allow one view to the users, e.g. a theme structure of the content, or a chronologically structure of the course content. This is not sufficient to provide individualization in a learning environment. A PLE must provide a student interface allowing customized views of the learning objects and learning activities. Examples of the students' views of the learning objects/ learning activities could be based on:
- Themes: This requires a user interface where learning objects / learning activities are accessible through a topic directory, with hierarchical structure of themes e.g. a folder structure based on themes.
- Time: The system may present learning objects / activities chronologically, where the student sees the newest learning objects / activities first. A student view based on time is useful when the student wants to find the learning objects according to the course run. A chronological folder structure in a LMS, is problematic when e.g. a student wants to find a specific learning object, but is not sure when it is placed in the course.
- Pedagogical methods: A student working with a learning activity e.g. based on the pedagogical method "gaming" should be able to choose other game-based learning activities.
- Media type / intelligence: The e-learning system should present learning objects based on the media type, e.g. audio learning objects (LO), video LOs, text-based LOs etc. because the visual intelligence has other needs (presentations, mind maps, concept maps and graphics) than the kinesthetic intelligence (simulations, motion sensitive tools etc).
- Proficiency stages: the system also must present learning objects / activities based on proficiency stage. One student should be able to access the learning objects covering the novice stage if this is wanted, while another student should be able to access learning objects covering e.g. the proficiency stage.
- Learning objective: Different types of learning objectives are knowledge (cognitive learning objectives), skill (psychomotor learning objectives) and attitude (affective learning objectives). In addition, meta-learning can be regarded as a learning objective category.
- Student productions of learning objects / learning activities: The students often produce texts, web sites, mind maps etc. that also could be useful for other students. In an on campus learning environment the students share lecture notes etc. and the e-learning environment should also allow sharing of student productions.
- Ranking score: If the e-learning system allows the students to rank the learning objects / learning activities, it may also be possible to present the learning objects based on the ranking score, e.g. the learning objects with a high ranking score is presented before the learning objects with a low ranking score.
- List of learning object recommended by the system based on behavior of previous students.
- Guided learning paths: In some cases it will be useful for the student to get access to a workflow of learning objects/activities presented as teacher-made guided learning paths.
- (Free text) search: An additional way of access to the learning object / activities should also be the possibility of free text search.

4.2.7 Paper 7: The QUIS Requirement Specification of a Next generation E-learning System

The QUIS requirement specification of a next generation e-learning system was one of the main outcomes of the EU project QUIS (2005-06). The paper summarizes the requirement specification and provides examples of functional requirements and use cases. The paper also describes the experiences and the conclusions from the work of the requirement specification, with the aim of providing advice to system developers, content providers and researchers within the field of e-learning.

The QUIS requirement specification of a next generation e-learning system is a report divided into six main parts: 1) project drivers and user description, 2) project and design constraints, definitions, relevant facts and assumptions, 3) functional requirements and use cases, the current situation and the methodology, 4) non-functional requirements with a main focus on how topic maps may realize a personalized learning environment, 5) conclusions, 6) appendix, which includes all the use cases and requirements, together with the prototyping experiments and descriptions of the pilot projects.

The methodology used for the requirement specification is based on the Grounded Theory approach, with interviews among the user groups (students, teachers and researchers), prototyping with expert groups in addition to literature review in the pedagogy and educational technology fields.

The specification includes about 70 functional requirements divided into six categories: assessment; content; collaboration; teaching; student / learning environment; and quality assurance at the course level. The specification contains about 30 use cases, where the scenarios are described, from both a student and a teacher perspective.

The main focus of the QUIS requirement specification is the pedagogical and the technological parts of a next generation e-learning system, not the administrative part. There is a holistic pedagogical approach, covering several theories of learning and a variety of pedagogical methods. The holistic pedagogical approach also covers different types of learning objectives, taxonomies and assessment tools, and defines the heterogeneous student group through multiple intelligences, proficiency stages and cultural dimensions. This approach also entails that a truly "user-centered" focus should be considered when building a system, rather than either a student-centered, or a teacher-centered one.

The requirement specification concludes that, to cope with the heterogeneity of the student group, a next generation e-learning system must be based on an eclectic learning view, without focusing on a single learning view e.g. behaviourism, cognitive constructivism or socio-constructivism, but drawing upon multiple learning theories, where a behaviourist as well as a socio-constructive learning perspective is accepted and considered necessary in a learning situation in order to ensure variation and differentiation. The QUIS project also suggests that a semantic technology like topic maps could achieve a personalized user interface, and presents a system description of PLExus, a prototype of a pedagogical-based PLE.

The paper covers the research questions 1 (variation), 2 (individualization) and 3 (meta-learning).

4.2.8 Paper 8: Learning in an Ambient Intelligent Environment - Towards Modelling Learners through Stereotypes

Ambient learning is an area that combines mobile learning, situated learning and context awareness, where the learners wish to learn anytime, anywhere and anyhow. The context of ambient learners is dynamic and they tend to engage in short bursts of learning, where the learning content must be adapted to the dynamic nature of their learning needs. One of the challenges of supporting such learners is the development of learner models that could be used to define the learning resources at any point in time. In this paper, we consider stereotype modelling as a means of modelling ambient learners so that the learning resources could be quickly and efficiently adapted to the learner.

User modeling is done in learning systems to provide personalized learning resources to the learner. Canonical user models are likely to be the best options for systems that require user models to adapt its services when the user group is highly homogeneous. In domains with highly heterogeneous user groups, specific user models are likely to be the preferred option. Learning in an ambient intelligent environment needs to consider a large diversity among the users.

The work presented here use the emerging E-learning Circle, and utilizes Bloom's (1956) taxonomy of cognitive domains, Gardner's (1985) theory of multiple intelligences, Dreyfus' (1998) stages of proficiency and Hofstede's (2001) framework for assessing cultures to construct stereotypes in the tradition of Rich (1983), in the ambient learning domain. Each of the stereotypes contains a set of *facets* with a *value* and a *rating*. Following Rich, each of the facets' values are in a linear scale ranging from -5 to 5, where a positive value indicates that the stereotype is positive to the facets, and a negative value indicates that the stereotype is negative to the facet. The ratings range from 0 to 1000 indicating the degree of certainty in the facet-value pair.

The paper presents the constructed facets, e.g. based on Gardner's multiple intelligences the facets of a spatial intelligence stereotype are *images*, *shapes* and *3D-spaces*, and based on Hofstede's cultural dimensions the facets of the power distance stereotype is *respect*, *discipline* and *teacher dependent*.

One advantage of stereotypes is that they are easy to build, which is important in a ubiquitous environment since the users change over time. If the user model generation is slow, there is a risk that the user will not use the system.

The work presented in this paper is build upon an existing framework for ambient intelligent applications. The implementation of the user models based on the stereotypes will primarily use online questionnaires as a means of acquiring knowledge of a student. Some information may be acquired e.g. from the student's teacher or through methods employed in intelligent tutoring systems. An initial user model needs the user to fill in the forms. Then the system is left with the responsibility of updating the user model continuously, depending on the user's activity.

4.2.9 Paper 9: The E-learning Circle – A holistic software design tool for e-learning

The paper presents the E-learning Circle, a tool developed to quality assure the design process of e-learning applications by implementing the pedagogical principles into the system design process. The E-learning Circle is a design tool, which ensures the early focus of variation, individualization and meta-learning in a software design process.

The E-learning Circle consists of a number of concentric circles which are divided into three sectors. The content of the inner circles is based on pedagogical principles, while the outer circle specifies how the pedagogical principles may be implemented with technology. The centre of the E-learning Circle is dedicated to the subject taught, ensuring focus on the specific subject's properties. The three sectors represent the student, the teacher and the learning objectives.

The student sector contains elements that describe the heterogeneity of the student group, focusing on 'multiple intelligences' (e.g. visual, verbal, interpersonal), proficiency stages' (e.g. novice, competence, expert) and 'cultural differences' (e.g. individualism, power distance). The needs of the heterogeneous student group demand a variety of learning objects.

The teacher sector includes nine pedagogical methods (e.g. presentation, gaming, discussion, cooperative learning) connected to different theories of learning (e.g. behaviorism, cognitive constructivism). The nine pedagogical methods are elaborated on by the definition of production tools to create learning activities.

The learning objectives sector illustrates how assessment and technological tools for assessment must be seen in connection to learning objectives. The learning objectives are divided into four types; skills, knowledge, attitudes and meta-learning. These types are then elaborated on by taxonomies and technological assessment tools.

The strengths of the E-learning Circle are the compact presentation combined with the overview it provides, as well as the usefulness of a design tool dealing with complexity, providing a common language and embedding best practice. The E-learning Circle illustrates in concrete terms the connection between pedagogical principles and technological tools.

The E-learning Circle is not a prescriptive method, but is useful in several design models and processes. The paper presents two projects where the E-learning Circle was used as a design tool. First, it was used in a prototyping project developing the PLExus prototype, a running prototype of a personalized learning environment based on the semantic technology of topic maps. Then the E-learning Circle was used in a project focusing on stereotype modelling of ambient learners.

The exploratory development of the E-learning Circle is grounded in empirical data, collected through interviews, focus groups and expert groups, and was developed as a result of the iterative analysis using Grounded Theory.

Papers / reports outside the scope of this thesis

The following papers / reports were written as parts of the E-LEN, QUIS and LIKT projects in the same period of time as the papers described above, but were regarded to be outside the scope of this thesis. I therefore will not go into details of their contribution and relevance. The abstracts of the papers / reports are included in appendix B.

Kolås, L. and Staupe, A. (2006). "QUIS Requirement Specification for a next generation e-learning system", report, ISBN 978-82-8055-028-6, (http://www2.tisip.no/quis/public_files.php).

Staupe, A. and Kolås, L. (2007): "Online interactive learning arena over the internet" in: Proceedings of the 6th IASTED International Conference on Web-based Education, ISBN 978-0-88986-651-5.

Staupe, A. and Kolås, L. (2007): "Online Tutoring – distributed interactive learning arena with synchronous video and audio" in: Proceedings of SITE 2007 (Society for Information Technology & Teacher Education), AACE.

Kolås, L., Edvardsen, L.F.H. and Hokstad, L.M. (2008). "Bruk av It's learning ved NTNU", NTNU report (in Norwegian).

Kolås, L. (2010). "Multiple pedagogical methods in an LMS – a qualitative study" in: Guerrero, J. (ed), Proceedings of the 2nd IADIS international conference on mobile, hybrid and on-line learning (eL&mL 2010). IEEE Computer society. ISBN 978-0-7695-3955-3.

5 Evaluation and discussion of results

This chapter first evaluates the research questions, before moving on to the evaluation of the main contributions. Here each contribution is discussed and linked to the theories and the state of the art. Finally the trustworthiness of the study is evaluated and some reflections on interdisciplinary research are provided.

5.1 Evaluation of research questions

Four research questions were formulated to be the conceptual frame of this project:
1. How to implement the pedagogical principle of *variation* into the design process of e-learning applications?
2. How to implement the pedagogical principle of *individualization* into the design process of e-learning applications?
3. How to implement the pedagogical principle of *meta-learning* (learning to learn) into the design process of e-learning applications?
4. How to implement the pedagogical principle of *best practice* into the design process of e-learning applications?

The research questions require an exploratory approach to the e-learning field, and this had to be taken into account when searching for a proper research methodology. Instead of a research approach describing or evaluating the existing e-learning field, the exploratory research questions focus on the future. By the use of the Grounded Theory approach, the exploratory research emphasizes how further work in the e-learning field can be based on empirical work. However, one should be careful drawing definitive conclusions from exploratory research. The aim of the exploratory research questions was to discover new ideas, gain a deeper understanding and provide insights into the studied field.

The research questions are interdisciplinary. It is necessary to combine the fields of pedagogy and computer science in order to address the research questions. Further reflections of the interdisciplinary research are provided in chapter 5.4.

As this thesis is based on work from three research projects, the research questions relation to the projects should be clarified. The first research project – the E-LEN project focused on e-learning design patterns and provided a foundation for this thesis' work on research question 4 (best-practice) and the contribution of the use of design patterns to implement pedagogical wizards. My contribution in the E-LEN project was to consider how to implement design patterns in software design processes. Research questions 1-4 are all covered in the second research project – the QUIS project. One of the main contributions of the QUIS project was the QUIS requirement specification of a next generation e-learning system. The work of the QUIS project provided a basis for several of the contributions of this thesis, e.g. the e-learning ontology, the PLExus prototype and the E-learning Circle. My main contributions in the

QUIS project were to administrate the development of the requirement specification, to develop requirements, use cases and the E-learning ontology and to contribute to the implementation of the PLExus prototype. The third project, - the LIKT project, consisted of both a quantitative and qualitative study of the use of the LMS "It's learning" at the Norwegian University of Science and Technology. Interviews from the qualitative study contributed to the theoretical saturation of research question 1, 2 and 3 (variation, individualization and meta-learning).

During the research project it was evident that research question 4 (best practice) differed from the other research questions. The results (contributions and papers) also show that the research questions concerning variation, individualization and meta-learning were possible to merge in the papers and contributions, but the research question about best practice mainly had to be considered on its own. One may consider well-known teaching methods as best practice, and it is therefore mentioned in several papers considering variation. The main focus on research question 4 (best practice) was however in the use of design patterns.

5.2 Evaluation of contributions

The four main contributions of the thesis are discussed and evaluated in the following sections. The first contribution (use of design pattern-based wizards to implement best practice) is presented in paper 1 and 2, and partly in paper 5 (see fig. 15). The second contribution (the E-learning Circle) is presented in paper 9, but early findings connected to the emerging E-learning Circle are presented in paper 3 and 7 and use of the emerging E-learning Circle is described in paper 5 and 8. The third contribution (the E-learning ontology) is introduced in paper 4 and 6, while the fourth main contribution of this thesis (the PLExus prototype) is described in paper 5 and 9. There must be noticed that the contributions are related to each other, and that all the papers present the contributions of this thesis.
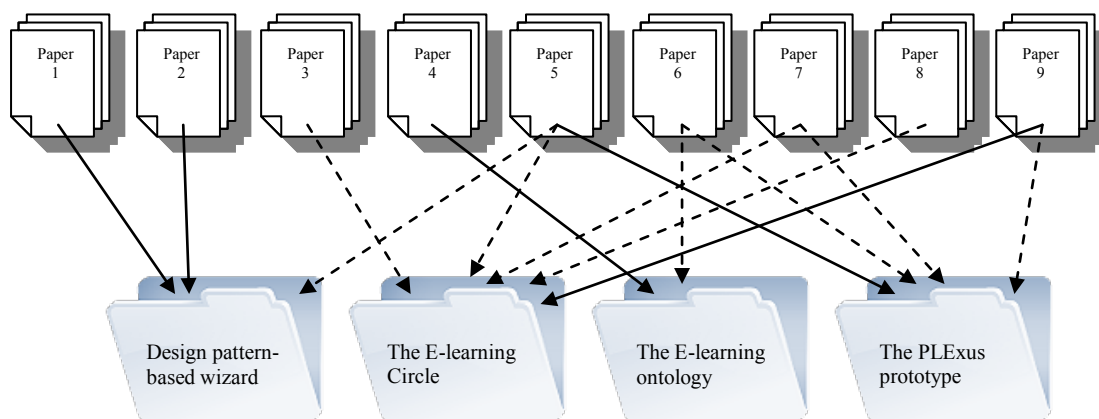
Fig. 15: The relations between papers and the main contributions of the thesis

5.2.1 Evaluation of design pattern-based wizards to implement best practice

Design patterns are used within the fields of architecture (Alexander, 1977), computer science (Gamma et al, 1994) and pedagogies (Bergin et al, 2009). The work of this thesis contributes to the merging of software development and pedagogies, e.g. by describing how to use pedagogical design patterns in software-based pedagogical wizards.

Wizards were originally made to ease the technical configuration of software application. Through the contribution of this thesis this idea is taken one step further, as the design pattern-based wizard now merges the pedagogical and technical configuration of e-learning systems.

The use of wizards for technical configurations of applications has made the users familiar to a "just in time" culture, compared to the culture of reading the manual of instructions (Conole & Fill, 2005). The requirements of a pedagogical configuration of applications must take this into consideration. Including pedagogical configurations into wizards is one step further compared to applications where much of the pedagogical configurations are done in advance of the use. The VICE-project (Acquaviva & Benini, 2005) also suggests the use of a pedagogical wizard in a semantic-based learning environment. By the means of a pedagogical taxonomy, the VICE pedagogical wizard classifies learning objects according to their style, level of difficulty and their relative importance in a specific learning process. This thesis suggests through paper 1, 2, 4 and 5 the pedagogical wizard's use of a wider range of metadata, such as e.g. pedagogical method, learning objective type and level, students' learning style and proficiency level.

Pedagogical wizards may be considered as limiting. Conole and Fill (2005) claim that wizards are "software tools that make decisions on behalf of the user, based on solicited information and drawing on pre-defined templates. In most cases, the way in which the outputs from a wizard are generated is hidden from the user. As a result, they are easy to use, but restrictive in terms of the type and variety of potential outputs from user interactions with the tool". Future work should consider how to develop wizards, which create pedagogical wizards, in addition to how to develop dynamic pedagogical wizards. In the future it should also be possible for the end-user to personalize wizards, and even create their own wizards in their work of pedagogical configuration of an e-learning application.

Wizards are valuable tools, in particular for novice users. Experienced users may consider technical wizards as time-consuming strait-jackets. By widening the wizards' area of use, from purely technical configuration to both a technical and pedagogical configuration, the usefulness of the wizards may be considered differently. This thesis has not been analyzing such user behavior, but this might be interesting for further research. Future work should consider how to develop advanced wizards for advanced users. Experienced users should however be able to choose other solutions than wizards. This, however, is difficult in e.g. wizards used to build topic maps (like presented in the PLExus prototype) as the wizards harvest important metadata used during the development of the topic map.

The introduction of pedagogical design patterns to design software-based wizards can provide a systematic approach to e-learning design, where the educators do the work of collecting the design patterns and the software engineers design the technology solutions. For software

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designers without pedagogical background the pedagogical design patterns will be useful and the design patterns will provide a common language for technologists and educators.

Design patterns are textual descriptions and since software designers often are used to graphical illustrations (e.g. diagrams, flow charts) future research should consider if text-based design patterns possibly could be created visually, by the use of e.g. diagrams or flow charts, and if this will benefit software designers, educators or both groups.

In order for the design patterns to work as design tools for software developers the design patterns must be produced. The Pedagogical pattern project (Bergin et al, 2009) and the E-LEN project (E-LEN, 2003) have started this work, and the E-LEN project has also developed a pattern language for e-learning. The value of this thesis' contribution on how to use design pattern-based wizards to implement best practice into e-learning applications is dependent on the further work on producing e-learning design patterns, since they are necessary prerequisites to implement the design pattern-based wizards.

Koper (2005) describes pedagogical design patterns as one way to capture learning design knowledge, together with prescriptions from instructional design theory and the identification of best practice in teaching and learning, and emphasizes that a teacher is influenced by one or more of these sources. This means that when a sole focus on pedagogical design patterns is made, like this work does, one should be aware of other possibilities of capturing learning design knowledge as well.

The literature of the e-learning field has during the last years had a new focus on personalization, but it is a new topic with several interpretations of the concept of 'personalization' (Johnson et al, 2006). The contribution of design pattern-based wizards provides a possibility to personalize the system also to the teacher in her process of designing learning environments to the students. Novice online teachers have different needs than expert online teachers. Design pattern-based wizards also allow a pedagogical configuration of the learning environment. The harvesting of metadata through design pattern-based wizards (Kolås & Staupe, 2006) also provides personalization of systems to fit each student, as the system can use the metadata to provide different views of the student interface, which is shown in the PLExus prototype.

In the process of developing a software-based wizard, it is important that the language and the choices are understandable to the user. A software-based wizard, which implements pedagogical choices, may be in danger of using pedagogical concepts that are not necessarily understandable to all users. This problem can be minimized or avoided by the use of tags, which explains the concepts, and by conscious planning when determining what terms to use, in combination with user tests after developing the wizard.

5.2.2 Evaluation of the E-learning Circle

Many of the components of the E-learning Circle exist as individual parts, but the strength of the E-learning Circle is that the components are elevated to another level by combining them into the same model.

The E-learning Circle is a design tool that is sufficiently general to be applicable in different development projects. This is presented in the thesis by the descriptions of the design processes of the PLExus prototype and the stereotype modeling project. The E-learning Circle is made to provide guidance, but is not a prescriptive design tool. It is possible to make use of only the parts of the circle, which are useful in the specific projects. The use of only parts of the E-learning Circle, however, does not consider the holistic approach to e-learning, which is one of the main strengths of the design tool.

The E-learning Circle is independent of software architecture. Through the stereotype modelling project, the E-learning Circle touches upon adaptive systems, while through the PLExus prototype the circle is used in the semantic architecture of topic maps.

The use of the E-learning Circle is not connected to one specific software design model, but it supports different software design models in several phases. In agile methods, the E-learning Circle can be a useful tool in costumer collaboration, which is valued in the Agile manifesto (Beck et al, 2001). Using the Unified Process (Booch et al, 1999) the E-learning Circle is useful from the perspectives of use case and design views, and specifically within the workflows of Requirements and Analysis and design. The 'Grimstad model' (Crossley & Green, 1985) was an early software design model, with a focus on teachers as developers mainly creating smaller applications (called lessonware), and in this model the E-learning Circle may be useful in phases of idea generation, goal formulation as well as in the phases of metaphor and market design. In prototyping, the E-learning Circle is useful for e.g. requirements analysis, user modelling, choice of architecture and interaction.

Learning is a complex process and the E-learning Circle is an attempt to provide a structure of the complex situation of learning. A design tool must be simple enough in order to be useful and to be considered as a useful tool. The E-learning Circle is comprehensive, but based on well-known pedagogical theories, and therefore it will not be totally new to the users and the prospect of finding supplementary information of the different parts of the model is good. The headings of each sector are also useful in order to understand the structure.

The E-learning Circle is presented as a holistic approach to e-learning. In this thesis the term 'holistic' indicates that the different parts of the E-learning Circle should not be considered alone, but should be seen together as a 'whole', and that the 'whole' is more important than the parts alone. An example is that a pure focus on learning objects or assessment should be avoided, but these part must be seen together with the heterogeneous student group and learning objectives. The term 'holistic' is in this work not synonymous to entire or total, and does not indicate that every aspect concerning learning are covered in the E-learning Circle, e.g. motivation is important within learning, but is not included into the E-learning Circle. The term 'holistic' is also used to emphasize that the E-learning Circle does not cover only pedagogical issues like the learning design toolkit (Conole & Fill, 2005) nor a technological specification made for software engineers like the IMS Learning Design specification (IMS, 2003), but it covers both pedagogy and technology.

The E-learning Circle presents the subject as the centre of the circle. The danger of this choice is that the E-learning Circle may be regarded as course-centric. Several of today's learning management systems are institution-centric or course-centric. The learning views of the last decades have been student-centric, which causes many to ask for student-centric systems. The use of the E-learning Circle developing the PLExus prototype shows by the personalization of the user interface that the E-learning Circle as a design tool is useful when developing student-centric systems.

The E-learning Circle is based on pedagogical theories. This might be problematic according to the "grounding" of the theory, with a possible argument that the content of the model is not based on e.g. the interviews, but on literature review. Grounded Theory emphasizes that coding should be performed with an open mind without preconceived ideas. The E-learning Circle uses several existing theories, e.g. Bloom's (1956) taxonomy, Koschmann's (1996) paradigms, Hofstede's (2001) cultural dimensions and Gardner's (1985) multiple intelligences. The design tool is based on the empirical data, but is refined by the already developed theories. This was a result after trying to define concepts based on the empirical data. One example; during an interview the concept of variation is reflected upon, and the interviewees are talking about different pedagogical methods. The level of a pedagogical method is however hard to categorize. One interviewee is talking about simulation as a high-level concept, while another is talking about a technique within simulation, e.g. guided communication development. In the process of comparing the ideas with existing data, the importance moved from single parts (e.g. development of a single learning object and summative tests) to the holistic overview and how the parts could be seen as a whole. I have experienced an 'internal struggle' to justify my conduct. Glaser and Strauss insisted that preconceived ideas should not be forced on the data by looking for evidence to support established ideas (Allan, 2003). The E-learning Circle must be looked upon as a compound product, where the whole is more important than the smaller parts it consists of.

The E-learning Circle includes Gardner's (1985) multiple intelligence theory, a debated and within some environments also a controversial theory. The use of this theory in this project was based on a pragmatic view of pedagogical theories. As an example, Coffield et al. (2004) identified 71 models of learning styles. Trying to connect pedagogy and information technology it is sometimes necessary to categorize, structure and simplify. This is also necessary when developing tools for software developers without a pedagogical background. As such the theories of Gardner, Bloom etc are useful, even though the educationalists have a hard time agreeing upon the theories. There might however be a problem concerning 'horseless carriage' when well-known pedagogical theories are included, implying that we are only thinking in terms of what it was before.

The relations between technology and cultural dimensions in the E-learning Circle were hard to specify based on the empirical data, and this is illustrated by empty cells in the E-learning Circle. There should be mentioned that even though interviewees of this study were international, they were all from western countries, and as such they are not representing a total view of cultural dimensions. There is presently an increasing focus on cultural design in e-learning (Masoumi & Lindstrom, 2009; Mohammed & Mohan, 2010). A focus on this will increase awareness of the topic, and future empirical studies will maybe reflect this as well.

IMS-LD is claimed to be neutral with respect to pedagogy (IMS, 2003). This is a statement, which is debatable. In the process of developing the E-learning Circle, there was no such goal as pedagogical neutrality, and the final version must be considered to have an eclectic

learning view. The focus of an eclectic learning view, instead of a focus on one learning theory and the rejection of other learning theories, allows a new starting point in the development process of e-learning systems. The focus on one learning theory, rejecting other learning theories, has since the 1960s resulted in the development of limited learning applications (Koschmann, 1996).

In the design of e-learning systems, IMS-LD (IMS, 2003) has been important over the last few years. IMS-LD is a method for modelling learning processes. Critics of the IMS-LD specifically concerns reusability and the teachers' difficulties in using the specification (Downes, 2003; Griffiths & Blat, 2005). Another problem with IMS-LD is that it is not bridging the gap between teachers and software developers, as it is based on specifications from the software engineering field. "UML is a powerful and relatively easy to understand graphical language, but it is intended for use by software developers and requires a degree of familiarity with its vocabulary and grammar to properly interpret the diagram" (Griffiths & Blat, 2005). "The IMS Learning Design specification brings many pedagogic benefits when compared with earlier open specifications for eLearning. It is not, however, easy for teachers to understand and work with… it is clear that new tools and representations are needed if teachers are to intervene in editing and creating units of learning" (Griffiths & Blat, 2005). The E-learning Circle is an attempt to provide a tool, which can work as a common language between the instructional designer / teacher and the software developer, which in turn also will be helpful towards succeeding with participatory design. The E-learning Circle also aims to provide a specific and concrete tool for the e-learning field, as UML models often are abstract and generic, and mainly known within computer science. The E-learning Circle might however be combined with IMS Learning Design and EML. This should be further investigated in future work.

The E-learning Circle also has a more specific focus on variation than IMS Learning Design. IMS Learning Design does not ensure variation of methods, and one can end up with learning system focusing only on e.g. collaboration, like several applications over the past decades have been doing. Koper (2005) specifies that a "learning design notation must be sufficiently flexible to describe learning designs based on all kinds of theories; it must avoid biasing designs towards any specific pedagogical approach". It is possible to use e.g. different pedagogical methods within IMS Learning Design, but as a design tool IMS Learning Design is not specifically focusing on variation.

IMS Learning Design focuses more on reusability than customization / personalization of e-learning. The E-learning Circle provides a framework of attributes, which should be taken into account when personalizing the user interface of an application.

The learning design toolkit (Conole & Fill, 2005) is created to provide help to educators and is as such not a tool for software developers in the software design process. The toolkit is strongly connected to 'learning design' and the heart of the toolkit is the learning activity. The learning activities are important, - but not the heart of the E-learning Circle. The E-learning Circle's centre focuses on the 'subject', as the empirical data showed the importance of subjects' different characteristics and needs. Learning objects, learning activities and assessment belong to the subjects as equally important parts in the E-learning Circle.

In chapter 2 (State of the art) five trends within e-learning are described; activity-based learning, personalization, mobile learning, ambient learning and immersive learning. The E-learning Circle can be useful in the further development of all this trends. Activity-based

learning can be supported by the E-learning Circle through a combination of IMS learning design and the E-learning Circle. The PLExus prototype (Kolås & Staupe, 2007) has shown how personalization is supported by the E-learning Circle and the stereotype modelling (Kofod-Petersen et al, 2008) shows how ambient learning is supported. The trend of mobile learning is based on technology change, but pedagogical principles like variation and individualization are equally important in e-learning supported by mobile technology, and therefore the E-learning Circle is a constructive tool also for mobile learning. The trend of immersive learning provides a new user interface, but the pedagogical considerations to ensure variation, individualization, meta-learning and best practice still are valuable in these user environments, and the E-learning Circle will be able to contribute to this trend as well.

The model of didactic relationships (Bjørndal & Lieberg, 1978) has six interrelated factors; learners, structures / resources, objectives, contents, ways of working and assessment (see Fig. 16). This model assumes that different elements are related to each other, and that there is a reciprocal influence between the factors. The model of didactic relationships is well-known among educators in Norway, and in retrospect it is possible to see that several of the interviewees were influenced by the model.
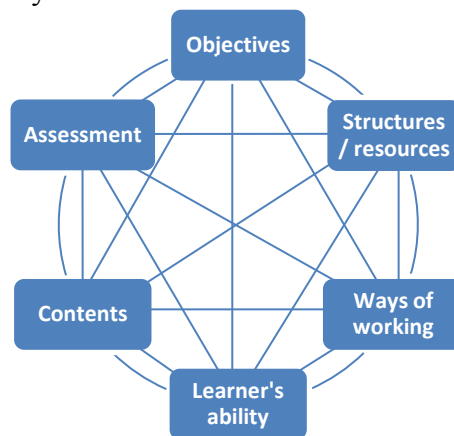
Fig. 16: The model of didactic relationships

The recognition of a socio-technical perspective (see chapter 3.2) carries with it implications not only for IS research methods, but also IS research topics. "If the technological and the behavioral are not separable, by implication they should not be researched separately from each other" (Trauth, 2001). The E-learning Circle is a result based on research combining technology and people in pedagogical settings.

The E-learning Circle is one of the results of the exploratory research using Grounded Theory. By the use of Grounded Theory, the focus is on theory development based on empirical data. The Grounded Theory approach produces theory that later can be regarded as hypotheses, which are necessary to test. User tests and usability tests of the E-learning Circle are considered to be important in the further work of the design tool.

To elaborate and verify the E-learning Circle, more empirical work is necessary, but the empirical work of this thesis provides a useful starting point. The design tool is so far used only in two development projects (the development of the PLExus prototype and the stereotype modeling project). Empirical validation and elaboration of the E-learning Circle in larger development projects would be useful. More empirical grounding and comparisons will strengthen the content and usefulness of the design tool.

5.2.3 Evaluation of the E-learning ontology

Finding a definition of the term 'ontology' is a challenge. One problem is that the term 'ontology' is used within several different fields, e.g. philosophy, meta-physics, geo-politics, and information science. The definitions of the concept 'ontology' used in semantic web literature vary from general descriptions e.g. an ontology is "an explicit specification of a conceptualization" (Gruber in Snae & Brueckner, 2007) to definitions with using concepts from topic map development, e.g. "a topic map ontology is the set of privileged topics and their characteristics, including the associations between them" (Grønmo, 2006). In this thesis the concept 'ontology' is used in the following meaning; An ontology is a formal representation of a set of concepts within a domain and the relationships between those concepts.

It is necessary to develop an ontology before developing a topic map system. Olsevicova (2006) claims that three kinds of ontologies are needed for the description of a university environment; a general ontology describing the reality of the educational institution, a course ontology that defines the structure of the course and domain ontologies that conceptualize individual disciplines. The E-learning ontology presented in this thesis belongs to the course ontologies, and presents concepts that describe important e-learning features to cover the needs of a heterogeneous student group and the relations between these concepts.

If one compares the use of ontologies and design patterns, it is clear that both techniques systematize pedagogical considerations. However, ontologies focus more on the relationships between the pedagogical considerations. A pattern language for design patterns often requires a statement describing related design patterns, but does not require a description of how they are related. An ontology on the other hand describes the relationships through the use of associations. Design patterns are problem-oriented, while ontologies are oriented towards categorizations and semantics.

The E-learning ontology is a contribution to the work of developing an ontology for the description of an e-learning reality. Venkatesh (2008) points to several peer-reviewed journal papers, which call for work to be done in implementing, evaluating and furthering the use of topic maps in educational contexts. Olsevicova (2006) calls for efforts to develop ontologies, which can be reused at different educational institutions, and the E-learning ontology presented in this thesis is such an effort and contributes to a reusable educational ontology. It is necessary to further develop the E-learning ontology, as an ontology should be based on a broad understanding of the topics and their relations among the users of a particular ontology. The publication of the E-learning ontology was a starting point in order to contribute to an educational ontology, which can be widely agreed upon in the field.

One of the trends within e-learning is personalization (see chapter 2.2), and topic maps may provide personalization of the user interface of applications. In order to create a topic map system, it is necessary to have an ontology. If the goal of the ontology development is personalization, the focus must be turned towards pedagogical issues considering the heterogeneous student group. The E-learning ontology has such an orientation.

The e-learning ontology provides semantic information for the machine, which in turn provides information about the content to the user and this explains why it is important to make pedagogical considerations early in the software design process.

One example of ontology driven E-learning systems is O-DEST (Snae & Brueckner, 2007). The ontology of O-DEST is not presented, but here they are modeling and representing the relevant aspects and domains of knowledge about students, domains, learning facilities, processes and communication. Venkatesh (2008) describes an experiment developing a topic map based on the student generated artifacts, where the ontology focuses on subject, grade, learning log, and author as topic types. Venkatesh uses grades as a topic type, with the grades A, A+, A-, B, B+ etc as topics of this topic type, which is another example of how intellectual level of students can be presented in a topic map ontology. The ontology presented in this thesis, presents a similar topic type by the use of Dreyfus' (1998) proficiency stages: novice, advanced beginner, competence, proficiency, and expert. Comparing the E-learning ontology of this thesis to the ontology presented by Venkatesh shows how topic types are similar, but still quite different. This is a good example of the necessity to agree upon an ontology within the educational field.

Venkatesh et al. (2007) recommend that the ontology should be developed manually, as it increases validity and robustness. Some experiments have been conducted to combine machine technology and manual methods to develop ontologies (Venkatesh et al, 2007). This development will be interesting to follow in the future, as there is no doubt that manually created ontologies are time-consuming and large ontologies will also be very complex to handle without technological support.

There are obvious similarities between the E-learning Circle and the E-learning ontology. The idea of the E-learning Circle is that it is a design tool, which can be used more generally in e-learning application design, while the E-learning ontology is mainly a tool in the process of topic map development.

5.2.4 Evaluation of the Plexus prototype

The PLExus prototype is based on the semantic technology of topic maps. The choice to use the semantic technology of topic maps, instead of e.g. the semantic web (RDF) was made because topic maps have a higher level of abstraction and the focus on findability. The choice was also influenced by accessible open source software (e.g. tm4j) and possibilities to move from topic maps to RDF on a later stage.

It is important to clarify that PLExus is a prototype, not a complete application. The goal of the design and development of PLExus was to gain experience on how topic maps could provide personalization of an e-learning environment as the personalization of e-learning still is immature (Johnson et al, 2006).

The concept of personalization may include personalization of content and information, as well as personalization of tools and services (Weller, 2007). The PLExus prototype is mainly personalizing the content, but is also personalizing the services through the personalized presentation of the content. According to Weller (2007) a personal learning environment (PLE) is based on personalization of the tools and services, which means that the PLExus prototype belongs within his definition of a PLE.

Other aims of the PLExus prototype were to concretize ideas and to experiment with pedagogical metadata, but also to contribute to the theoretical saturation of the research project. The PLExus prototype is a contribution to the field because pros and cons with a topic map system within e-learning are concretized, and because experience of educational topic maps is gained.

Advantages of a topic map system within e-learning are the possibilities to personalize the learning environment, and to create a student-centric system. Information overload is an increasing problem in online learning environments and the menu structures provided in an LMS often only allow a chronological or thematic structure (Kolås et al, 2008). The use of a topic map architecture allows multiple views of the content, not only restricted to chronological or thematic menues. This contributes to avoid information overload for the students.

One problem developing a topic map system within higher education today, is that there is no overreaching ontology, which is widely agreed upon in this field. The PLExus prototype is based on the E-learning ontology (Kolås, 2006), a contribution to the work of developing an educational ontology. There exist a few contributions to this work, e.g. the O-Dest (Snae & Brueckner, 2007) and the contribution of Venkatesh et al. (2007).

Another problem we encountered was that the open source software we used to build topic maps, was not as error-free as we expected. Efforts to make the open source software error-free ought to be emphasized. There are however possible to buy software, which probably are less error-prone.

The use of the wizard in PLExus assumes that the user understands the different choices of the wizard, and if the language of the wizard is too pedagogical this may cause problems. This will also entail that the metadata is not correct, and in a semantic technology this is of major importance. In a worst case scenario, users may add wrong metadata on purpose (which was

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experienced when metatags were misused to give certain web sites good ranking by fooling the AltaVista ranking algorithm).

A disadvantage of PLExus is that it only provides services concerning learning activities and learning objects, not learning management e.g. administration of student hand-ins. Learning activities, learning objects and learning management aspects should be combined in an e-learning application. The goal of PLExus was however not to develop a complete e-learning application, but to gain experience on how the user interface of a topic map would work in an educational application.

The VICE platform uses the semantic web technology and artificial intelligence techniques in order to cope with the adaptive aspects of the education contents fruition (Acquaviva & Benini, 2005). It also has a pedagogical wizard implemented, which classify LOs according to their style, level of difficulty and to their relative importance in a specific learning process. The goals of PLExus and the VICE platform are similar (personalization of e-learning), and the solutions are somewhat similar (semantic-based architecture and the use pedagogical wizards). The main differences are that PLExus is based on a topic map architecture and that the VICE platform use AI techniques to ensure an adaptive web-based learning environment.

Other adaptive semantic-based learning environments are ELENA; AHA! & MOT; Dynamic Assembly Engine (Acquaviva & Benini, 2005); and WELSA (Popescu et al, 2009). These systems are however not topic map-based. A topic map architecture in an e-learning setting is found in the pilot applications of Venkatesh et al. (2007) and Olsevicova (2006).

As PLExus is a prototype, some of the functionality is not tried yet, e.g. the large-scale exchange of subjects from the internet. Also the PSI presented in this work, must be considered immature. A PSI is necessary to ensure that the same topics are assigned the same topic names, and must be standardized in the educational field. The E-learning ontology, which was made in order to develop the PLExus prototype, is a contribution to this work.

Further work could include a comparison of information retrieval in a topic map like PLExus and e.g. a search engine or a traditional LMS with chronological or thematic menu structures. An evaluation of the user performance by user observation would also be interesting in a process of improving the prototype.

5.3 Evaluation of trustworthiness

Validating qualitative research is not as clear cut a matter as it is with quantitative research. In the discussion of validity it is also argued that the term 'validity' should not be applied to qualitative research (Thagaard, 1998; Salomon & Vavik, 2008). I prefer to use the term 'trustworthiness'. "The trustworthiness of qualitative research generally is often questioned by positivists, perhaps because their concept of validity and reliability cannot be addressed in the same way in naturalistic work…Many naturalistic investigators have, however, preferred to use different terminology to distance themselves from the positivist paradigm" (Shenton, 2004). "Terms such as credibility, transferability, dependability, and confirmability replace the usual positivist criteria of internal and external validity, reliability and objectivity" (Denzin & Lincoln, 2005).

There are several sets of criteria for evaluating the validity of qualitative studies (Shenton, 2004; Charmaz, 2005; Charmaz, 2006; Strauss & Corbin, 1998; Klein & Myers, 1999). Klein & Myers (1999) and Shenton (2004) cover all types of qualitative research, and some of the criteria are not relevant when using Grounded Theory e.g. random sampling of individuals to serve as informants. Strauss and Corbin (1998) and Charmaz (2005) focus on criteria for the evaluation of Grounded Theory. Strauss and Corbin's (1998) evaluation criteria to ensure the research quality concern the need of providing enough information about the study and the necessity of ensuring the empirical grounding of the study. These criteria are covered in the methodology chapter of the thesis. Examples are 'Are concepts generated?' and 'What major categories emerged?' This thesis mainly uses Charmaz' criteria to evaluate the trustworthiness of the study, by focusing on credibility, originality, resonance and usefulness.

Credibility
To ensure the credibility, the study has used well established research methods (Shenton, 2004). The research method used in this project is Grounded Theory, which is well established within IS research, and Grounded Theory approaches are common in IS research literature, e.g. Orlikowski (1993), Pandit (1996), Urquhart (2001) and Smit (1999). There is however no such thing as a perfect method, and as described in the methodological chapter Grounded Theory has developed in several directions. The thorough description of the research process (data collection, data analysis etc) is therefore an important attempt to ensure the credibility of the project.

Triangulation is another provision to ensure credibility (Shenton, 2004). This study makes use of triangulation by data sources (Patton, 2002). Data in this project were collected from different sources; focus groups, interviews and expert groups. This triangulation across various techniques of data collection is particularly advantageous in theory generation, as it provides multiple perspectives on an issue, supplies more information on emerging concepts, allows for cross-checking, and yields stronger substantiation of constructs (Orlikowski, 1993). The interviews and focus groups provided different perspectives and experiences through the different roles of the interviewees; students, teachers and developers of e-learning systems. This prepared the ground for the Grounded Theory technique of contrasting. It is important to collect thoughts and ideas from the different users, since learning is a complex situation where many factors play important roles. Even though the different roles are included, it is hard (if not impossible) to find data sources that cover every aspect that is important in complex situations like learning situations. The multiple roles, however, do provide a breadth which was considered necessary in this project.

Another provision mentioned by Shenton (2004) is peer scrutiny of the research project. Parts of this project have been presented at a number of national and international conferences. In addition, the result of the QUIS project was thoroughly evaluated, both by external evaluators during the project and by evaluators in the EU commission after the completion of the project. The final evaluation report from EU comments that "The QUIS project has developed some interesting activities for the continuation of the project. This concerns the maintenance of the website, the online evaluation tool, the further work on PLEXUS and the ongoing research work in the field of user requirements" (E-learning programme, 2007).

Shenton (2004) also mentions frequent debriefing sessions as means to ensure credibility. This PhD-project has not been performed as a "one man show", on the contrary, the EU-projects have provided collaboration on different parts of the project (E-LEN with a focus on design patterns, QUIS with a focus on next generation e-learning systems, and LIKT with a

focus on Learning management systems). Through discussions in project meetings the PhD project has been improved, by widening the vision and developing ideas and interpretations.

Originality

The thesis contributes to challenge the view of learning theories within e-learning, but also points out the importance of variation. The work also contributes to the personalization of e-learning environments, which is an immature research topic in the field (Johnson et al, 2006). Through the analysis of data, the importance of each subject's characteristics was evident, and this should be considered in further e-learning research and development.

The thesis also contributes with tools in the software design process, which quality assure an early implementation of the pedagogical principles of variation, individualization, meta-learning and best practice. The tools include the use of design pattern-based wizards, the E-learning Circle, and the E-learning ontology and the use of topic maps to develop semantic-based personalized e-learning environments.

Other original contributions are the combination of an exploratory perspective and Grounded theory in IS research, and the use of an interpretive approach and Grounded Theory in a project covering the development of information systems.

Resonance

Resonance is covered for example by categories portraying the fullness of the studied experience and by links between larger collectivities and individual lives drawn by the researcher. Resonance is increased by a strong combination of originality and credibility (Charmaz, 2005). The large number of codes and categories generated during the analysis are reflected in e.g. the E-learning Circle and the E-learning ontology.

Charmaz (2005) focuses on the researcher's achieved familiarity with the topic. The thesis' interdisciplinary approach to the topic makes it harder for the researcher to cover both the pedagogy and the computer science field completely. Learning is a complex situation and it will always be hard to claim that a study covers the complete learning situation. The specification of the problem statement, with a focus on the pedagogical principles of variation, individualization, meta-learning and best practice, narrows the research area to a manageable research topic, even though the complexity of e.g. the E-learning Circle also shows that trying to portray the fullness of the studied experience is a challenge.

Usefulness

Usefulness has been an important factor in the work, and developing tools to use in a software development process emphasizes the focus on usefulness in this project. The tools are generic and can be used in different types of software design theories, which may be regarded as a strength regarding usefulness, because they are useful to several developing projects, but may also be a weakness, as some may regard the tools as too generic and not useful enough in specific projects.

The choice of the Grounded Theory approach also emphasizes the project's focus on usefulness, as Grounded Theory has its roots in pragmatism (Alvesson & Schiöldberg, 2008), and grounded theories should be useful at a practical level and meaningful to those 'on the ground'(Denscombe, 2003).

5.4 Reflections on interdisciplinary research

The problem statement of this thesis requires interdisciplinary research, which entails both challenges and opportunities. The strong tradition of design science at the Department of Computer and Information Science, NTNU meets the research traditions of the pedagogy field. The design science paradigm has its roots in engineering, and is fundamentally problem solving. Design science creates and evaluates IT artifacts intended to solve identified organizational problems (Hevner et al, 2004).

This thesis has used Grounded Theory, which may be regarded as a method within the paradigm of design science, when applied to projects with exploratory perspectives. The seven design science research guidelines (Hevner et al, 2004) are covered by this research project as following. Guideline 1 'Design as an artifact' requires the creation of an innovative, purposeful artifact. An artifact is defined as constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (implemented and prototype systems). Grounded Theory aims for substantive or formal theory, where the artifact in guideline 1 of design science may be compared to substantive theory of Grounded Theory. The results of this thesis can in the language of design science be characterized as models (The e-learning Circle, The e-learning ontology), methods (The use of design pattern-based wizards to implement best practice) and instantiations (The PLExus prototype).

Guideline 2 'Problem relevance' is fulfilled since e-learning applications today lack the opportunity of variation, individualization, meta-learning and best practice, and guideline 3 'Design evaluation' is partly fulfilled since the QUIS requirement specification and the PLExus prototype are evaluated by the EU (E-learning programme, 2007) and by external evaluators (Haugen et al, 2007) as part of the QUIS project (QUIS, 2005). When using Grounded Theory, evaluation of the result is not the main focus. The result of a Grounded Theory study is theory, which in future studies can be tested and evaluated. Guideline 4 'Research contributions' is fulfilled by the presented tools to improve the development process of e-learning applications. Often the contribution of design-science is the artifact itself, but the contributions may also include foundations (the creative development of novel constructs, models, methods or instantiations) or methodologies (Hevner et al, 2004). The use of Grounded Theory techniques and procedures apply to guideline 5 'Research rigor' and guideline 6 'Design as a search process' is fulfilled by the iterative nature of Grounded Theory and data collection through interviews, focus groups and expert groups, where sites for data collection are included based on the relevance to the topic and emerging categories in the iterative research process. Guideline 7 'Communication of research' is fulfilled by the presentation of both the research process and the research contributions in the thesis, papers and project reports.

Design-science research guidelines	The work of this thesis
Design as an artifact	Substantive theory defined in Grounded Theory is in Design science defined as IT artifacts (constructs, models, methods, instantiations). Models: The e-learning Circle, The e-learning ontology. Methods: The use of design pattern-based wizards to implement best practice. Instantiations: The PLExus prototype
Problem relevance	E-learning applications today lack the opportunity of variation, individualization, meta-learning and best practice.
Design evaluation	By using Grounded Theory evaluation is not prioritized. The result of a Grounded Theory study is theory that in a future study can be tested and evaluated. The QUIS requirement specification and the PLExus prototype are evaluated by external evaluators as part of the QUIS project (E-learning programme, 2007).
Research contributions	Tools to improve the development process of e-learning applications.
Research rigor	The use of Grounded Theory techniques and procedures.
Design as a search process	The iterative nature of Grounded Theory and data collection through interviews, focus groups, expert groups, where data collection sites are included based on the relevance to the topic and emerging categories in the iterative research process.
Communication of research	Presentation of both the research process and the research contributions in thesis, papers and project reports.

Table 5: The design-science research guidelines connected to the work of this thesis

6 Conclusions

This chapter sums up the main contributions and addresses the research questions. The chapter also outlines possible future research.

6.1 Main findings

The thesis has shown how it is possible to implement pedagogical principles into the design process of e-learning applications. The thesis has focused on the pedagogical principles of variation, individualization, meta-learning and best practice.

The thesis contributes to the field of e-learning by four main contributions. First, the use of design pattern-based wizards to implement best practice into e-learning applications; second, the E-learning Circle, a design tool developed to assure the quality of the design process of e-learning applications by implementing pedagogical principles into the system design process. Third, the E-learning ontology, which is a topic map ontology enabling the development of an e-learning topic map. Finally, the PLExus prototype, a Personal Learning Environment based on the semantic technology of topic maps.

The contributions are grounded in empirical data collected through interviews, focus groups and expert groups, analyzed by the use of techniques from Grounded Theory.

Problem statement	Research Method	Contributions
Design of e-learning applications:	Grounded Theory	Design pattern-based wizards
How to implement the pedagogical principles below into the design process of e-learning applications? - Variation - Individualization - Meta-learning - Best practice	Data collection: - Interviews - Focus groups - Expert groups Data analysis: - Open coding - Axial coding - Selective coding	The E-learning Circle The E-learning ontology The PLExus prototype

Fig. 17: The thesis' problem statement, research method and contributions

6.2 Addressing the research questions

The research questions are evaluated in chapter 5.1, and this section concludes on how the research questions are addressed throughout the thesis and the contributions.

Research questions 1 and 2 (How to implement the pedagogical principles of *variation* and *individualization* into the design process of e-learning applications) are answered by all the contributions (the design pattern-based wizard, the E-learning Circle, the E-learning ontology and the PLExus prototype), see fig. 18. Research question 3 (How to implement the pedagogical principle of *meta-learning* into the design process of e-learning applications) is mainly replied to by the contributions of the E-learning Circle and the E-learning ontology, and research question 4 (How to implement the pedagogical principle of *best practice* into the design process of e-learning applications) is responded to by the use of wizards based on pedagogical design patterns, first as a general idea and a paper prototype, and later implemented into the PLExus prototype.

The pedagogical principle of *variation* has been of major importance in this thesis. The thesis presents the E-learning Circle, a design tool to ensure variation in e-learning applications. Variation is in the E-learning Circle ensured by a variety of pedagogical methods and learning activities, a variety of student heterogeneity factors (e.g. multiple intelligences, proficiency stages and cultural dimensions) and a variety of learning objective types and levels as well as a variety of assessment tools. Also the E-learning ontology and the PLExus prototype are examples of how focus on variation can contribute to e-learning. This is shown through the topics and the topic types of the E-learning ontology and through the wizard and the multiple customized views of the PLExus prototype.

The pedagogical principle of *individualization* has guided the work of this thesis towards personalization of e-learning applications. The personalization of the interface provided in the PLExus prototype is based on the e-learning ontology. The design pattern-based wizard in PLExus illustrates a practical solution to the research question about individualization. In order to individualize e-learning to the needs of the individual student, the E-learning Circle contributes with the heterogeneities factors of multiple intelligences, proficiency stages and cultural dimensions. The E-learning Circle also focuses on the individual needs during the learning activities and the assessment phase(s).

Meta-learning (learning to learn) is elucidated in the E-learning Circle and the E-learning ontology, where meta-learning is suggested as a learning objective together with the traditional 'trio' of knowledge, skills and attitudes. Doing this, the thesis contributes to a focus on formative assessment, in addition to summative assessment.

Best practice can be implemented into the design process of e-learning applications by the use of design patterns based on an e-learning pattern language. The thesis proposes the use of design pattern-based wizards in order to have best practice implemented in e-learning applications. The wizards, which are based on pedagogical design patterns, are called pedagogical wizards in the thesis as the result is that through pedagogical wizards it is possible to do both a technical and pedagogical configuration of the e-learning applications. The idea of pedagogical wizards is implemented into the PLExus prototype.
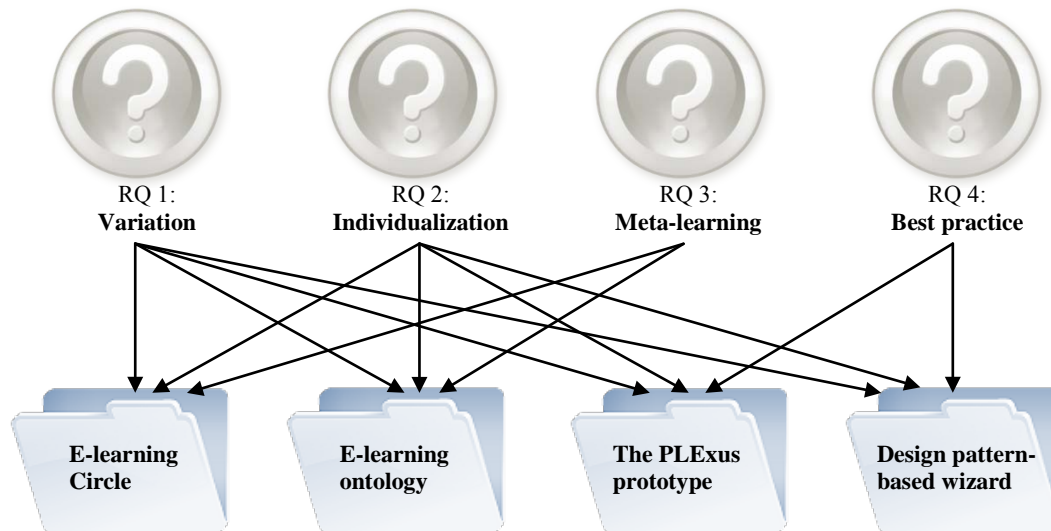
Fig. 18: The relations between research questions and the main contributions of the thesis

6.3 Further research

Grounded Theory is not about testing theory, but is a theory discovery method. "Grounded Theory is not generated a priori and then subsequently tested. Rather it is inductively derived from the study of the phenomenon it represents. That is, discovered, developed, and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon" (Pandit, 1996). The theory discovered and presented in this thesis can in further work be regarded as a hypothesis, which should be tested through new research projects. The contributions of this thesis are in an interpretive tradition not the presentation of 'best' theory, but must be regarded as contributions to the discourse in the e-learning field, where these contributions may be compared, evaluated and improved.

The QUIS project's final report and the professional project results have undergone an expert evaluation from the EU (E-learning programme, 2007) and an external evaluation (Haugen et al, 2007) in 2007. Here four of the results of the QUIS project are mentioned as interesting for further research, and among these the PLEXUS prototype and the ongoing research in the field of user requirements are mentioned.

Further research should include semantic-based e-learning, not only based on the topic map architecture, but also other technologies for semantic web.

Further research should also consider the development and analysis of personalized and / or dynamical pedagogical wizards in e-learning applications. Future research should consider if it would be functional to further develop text-based design patterns to become graphical design patterns, or if such a development would spoil the harvesting of metadata, which is important in e.g. topic map development.

The e-learning ontology is an early contribution to the work of creating an educational ontology, which can be widely agreed upon in the field. Further development of the e-learning

ontology is therefore necessary, by comparing the topics, topic types and associations of the E-learning ontology to eventually newly developed ontologies in the field.

Tools developed for the software design process should be tested, e.g. through usability tests. This concerns all the main contributions; the design pattern-based pedagogical wizard, the E-learning ontology, the PLExus prototype and the E-learning Circle. Especially interesting would an investigation of user behavior of design pattern-based wizards in the process of combining both technical and pedagogical configurations of an e-learning application be. Also an investigation of topic map use in e-learning would be an interesting project in the future.

The thesis has shown that in the process of describing the student using heterogeneity factors as multiple intelligences, proficiency stages and cultural dimensions, the cultural dimensions are the biggest challenge. There is however several researchers working on the this topic right now, and comparing and integrating future research results on this topic into the E-learning Circle and stereotype modeling will be interesting.

It would also be interesting to investigate if the E-learning Circle can act as the missing link between teachers and software developers using IMS Learning Design and EML, providing a common language and a design tool to ensure variation and individualization. Testing the E-learning Circle in other design processes, e.g. in different design models, would also be of interest.

Through the analysis of the empirical data, the importance of each subject's characteristics was evident, and this should be considered in further e-learning research and development.

6.4 Concluding remarks

The e-learning field has a lot of examples of the integration of technological tools, which first were developed for some other field. Blinco et al. (2004) claim that "rarely are technologies used in e-learning developed specifically for the learning community". Contributions to e-learning design methodologies for the software design process are therefore valuable to the future development of e-learning applications, in order to ensure both the technological and pedagogical quality.

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8 Appendices

This chapter includes the complete text of the nine selected papers in addition to the abstracts of paper I have contributed to, which fell outside the scope of the final thesis.

Appendix A: The selected papers
Appendix B: Secondary papers

Appendix A: Selected papers

Paper overview:

Paper 1   Kolås, L. and Staupe, A. 2004. "Implementing pedagogical methods by using pedagogical design patterns", Proceedings of the World Conference on Educational Multimedia, Hypermedia & Telecommunications (Ed-Media 2004), s. 5304-5309, AACE, ISBN 1-880094-53-3.

Paper 2   Saatz, I. and Kolås, L. 2005. "Support for the instructor - from technical to pedagogical point of view", Proceedings of the IASTED International Conference on Internet and Multimedia Systems and Applications (EuroIMSA 2005), ISBN 0-88986-484-5.

Paper 3   Kolås, L. 2005. "Variation and reusability in e-learning: not compatible?" Proceedings of the World Conference on E-learning in Corporate, Government, Healthcare & Higher Education (E-learn 2005) p. 1368-1375, AACE, ISBN 1-880094-57-6.

Paper 4   Kolås, L. 2006. "Topic maps in e-learning: An ontology ensuring an active student role as producer", Proceedings of the World Conference on E-learning in Corporate, Government, Healthcare & Higher Education (E-learn 2006), p. 2107-2113, AACE, ISBN 1-880094-60-6.

Paper 5   Kolås, L. and Staupe, A. 2007. "The PLExus Prototype: A PLE realized as Topic Maps", Proceedings of the 7th IEEE International Conference on Advanced Learning Technologies (ICALT 2007), IEEE Computer Society Press. *This paper was submitted as a long paper to the ICALT conference, but was accepted and published as a short paper. The long version is presented here.*

Paper 6   Kolås, L. and Staupe, A. 2007: "A Personalized E-learning Interface". The Proceedings of the international IEEE Conference on Computer as a tool (EuroCon 2007). Poland: IEEE Computer Society 2007. ISBN 1-4244-0813-X

Paper 7   Kolås, L., Staupe, A. Temperini, M. and Sterbini, A. 2007. "The QUIS Requirement Specification of a Next generation E-learning System", IADIS International conference proceedings E-learning 2007 Volume II (IADIS E-learning 2007). Lisbon: IADIS Press 2007. ISBN 9789728924423. p.188-193.

Paper 8   Kofod-Petersen, A., Petersen, S.A., Bye, G.G., Kolås, L. and Staupe, A. 2008. "Learning in an Ambient Intelligent Environment - Towards Modelling Learners through Stereotypes". Revue d'intelligence artificielle: Revue des Sciences et Technologies de l'Information, 2008 ;Volum 22.(5) p. 569-588.

Paper 9   Kolås, L. and Staupe, A. (2010). "The E-learning Circle – A holistic software design tool for e-learning". E-learning and Education, 2010. ISSN 1860-7470.

Implementing delivery methods by using pedagogical design patterns

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Abstract: The goal of e-learning technology should in our opinion be to develop systems with a wide range of variation and many opportunities for both teachers and students when it comes to delivery methods and learning styles. We argue that the focus of e-learning design has been administration, content and media, and that pedagogical methods have not been prioritized. We present our thoughts about how to implement delivery methods by systematizing them into pedagogical design patterns that are implemented as wizards. The use of pedagogical design patterns will ensure that the pedagogy, not the technology, is the main focus in the design process.

Introduction

E-learning systems are often dedicated to one or a few delivery methods. Morrison (Morrison in Helmer 2003) in contrast says that "…the ultimate goal would be to develop systems with varied pedagogical methods where the student can choose between different methods according to the learning strategy best for him / her". Morrison claims that the expense of this goal makes it utopian. We agree on the goal and think that we need to work around the expenses. Although it is too expensive to develop this kind of system today, if we give attention to developing tools for the design process and systematically learn from earlier experiments, it might be possible to achieve the goal in the near future.

Many smaller systems developed during the last decades have given us a lot of experience of what does and doesn't work, using a wide variety of pedagogical methods. We would learn a lot from these smaller experiments and experiences if we worked in a more systematic manner. There are applications based on simulation, others on CSCL, PBL or tutorials, etc. In recent years attention has been given to standardization (such as SCORM) and Learning Content Management Systems. Paulsen defines an LCMS as follows:
"A Learning Content Management System is an environment where developers can create, store, reuse, manage and deliver learning content from a central object repository, usually a database. LCMS generally work with content that is based on a learning object model" (Paulsen 2002).
The weakness of LCMS is its pure focus on learning objects. Ideally, learning objects are learning material that can be used in a wider context. SCORM is a standardization tool regarding content; we now need a standardization regarding teaching and learning methods as well.

In some communities there is now focus on "blended learning", that combines online and offline delivery methods in learning programmes (Helmer 2003). As far as we can see, "blended learning" is enforced because of the inadequacy of the technology used in e-learning so far. One solution to the problem of inadequate technology is to work with varied online methods. It should be possible to have "blended learning" in a pure online learning environment by varying delivery methods online. Many models have also been developed on how to evaluate instructional technology, e.g. Torgersen's GPK-model (Torgersen 1998), the Revised Pedagogical Framework (Britain & Liber 2004), etc. The purpose of these models is to evaluate existing applications and to make it easier for the teacher to choose the right application for his/her students. We find this too reactive, and mean that we need to be more proactive by developing methods and tools to help instructional software designers focus on pedagogy.

The special field of pedagogy consists of many pedagogical methods. Future e-learning systems need to reflect this fact. Our attention is therefore on pedagogical methods and how to implement them into e-learning systems.

Variation

Variation has been regarded as an important principle within teaching and learning for many years. This principle seems lost on the road to the online university. Many online teachers use a few delivery methods over and over again: This is convenient for inexperienced online teachers. Britain and Liber concluded in 1999 that the majority of VLEs (Virtual Learning Environments) were designed to support an education model based on information transmission (Britain & Liber 2004). However, a model based on information transfer alone does not take into consideration the pedagogical challenges facing teachers and students in online communities.

Teachers with classroom experience know that instruction needs to be varied to retain students' motivation for learning. Sometimes problem-based learning is the best delivery method, at other times collaborative learning, lectures (one to many) or drill exercises are effective. The best delivery method depends on many variables, including the age or culture of the students, their background and motivation, the subject, the theme, the teacher and learning environment.

Pedagogical Methods

Online teachers have typically adopted the delivery methods of pioneer online teachers. They have also of course been dependent on and limited by the learning system used. "Many first-time users of VLEs (Virtual Learning Environments) seek to adapt the way that they work to the way that the software needs things to be done" (Britain & Liber 2004). E-learning courses for higher education usually are based on a VLE / Learning Management System (e.g. Blackboard, WebCT, Fronter). The weakness of these systems is that they give too much attention to online administration and too little attention to pedagogical concerns (Britain & Liber 2004). The LMS forces the teacher into using only a few delivery methods. Teachers are used to finding the best methods of teaching their subject, and online teachers also should have the same opportunity. Most online teachers do, however, still need systems that help them discover the different pedagogical methods to use in a computer-based learning environment.

Systems based on pedagogy do exist, but they give attention to only one or a few delivery methods. Heinich et al., when talking about learning in classrooms, say "It would be overly simplistic to believe that there is one method that is superior to all others or that serves all learning needs equally well" (Heinich et al. 2002). This is valid for e-learning as well. Heinich et al. categorized instructional methods into the following ten categories (Heinich et al. 2002):

1. Presentation
2. Demonstration
3. Discussion
4. Drill-and-practice
5. Tutorial
6. Cooperative Learning
7. Gaming
8. Simulation
9. Discovery
10. Problem solving

Some people will argue that several of these methods are available in e-learning systems; for example, a discussion forum is the implementation of the third category "Discussion". The weakness is, however, that most systems only give the functionality of a discussion forum, while the methodical knowledge and experience of how to use it in a learning situation is lacking. The result is that experienced online teachers gather their expertise in whole books e.g. about how to moderate an online discussion. The expertise should instead be implemented into the system. Another weakness is often a lack of communication between online teachers, up until now everybody makes the same mistakes, instead of implementing the solutions into the system and so learning from each other.

Each of the above categories has many subgroups of delivery methods. As an example we mention some subgroups of the sixth category "Cooperative learning":

- Group administration
- Genuine interdependence
- Synchronous communication
- Asynchronous communication
- "Learning Together Model" (Johnson and Johnson in Heinich et al. 1993)
- Team-Assisted Individualization (Slavin in Heinich et al. 1985)

There are reasons why there are many delivery methods available in classroom learning situations. We cite Anderson and Thalheimer: "Creating a greater number of retrieval paths (multiple delivery methods) the information will strengthen the retrieval process and increase ultimate performance…"(Anderson & Thalheimer 2003) and therefore multiple delivery methods are important in the design of future e-learning systems. We argue that "the missing link" in e-learning systems of today is pedagogical methods.
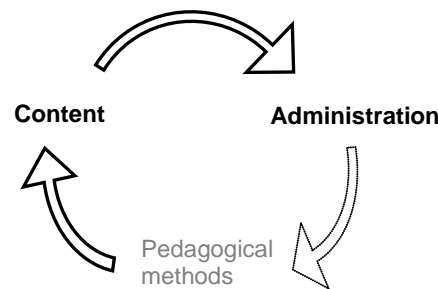
Figure 1: Illustration of "the missing link" (pedagogical methods) in e-learning systems of today

Interactive pedagogical methods

Information technology has advantages that paper cannot match. There exist "methodical guidelines" on paper available for teachers in different subjects, but integrating methods into information technology makes it possible to get interactive methods, where the system adapts to the choices made by the user.

The company "Groupsystems.com" now concentrates their work and systems around their trademark "Active methods", where they integrate methods into their systems for project management. "An ActiveMethod is a sequence of steps designed to guide a group toward an outcome. Like a software wizard, an ActiveMethod guides users through a well-defined process, automatically presenting and soliciting the information appropriate for each step in a process" (Groupsystems.com 2003). Technology has been viewed as the solution in e-learning, whereas processes / methods are usually considered solutions in classroom settings. We believe the solution for e-learning might be to integrate processes (methods) into the technology.

Design of e-learning systems

An e-learning system should consist of more than we can see in the technology solutions we find today. Different functionality such as student and course administration, content creation etc. is already implemented and in use (e.g. LMS, LCMS and Content Creation Tools). Paulsen defines content creation tools as tools that are used to develop learning material, for instance plain text, slides, graphics, pictures, animations, simulations, assessments, audio and video. Examples of content creation tools are MS Word / PowerPoint / FrontPage, Macromedia DreamWeaver / Director (Paulsen 2002). He also defines authoring tools as "a software application, used by non-programmers, that utilizes a metaphor (book, or flowchart) to create online courses" (Hall in Paulsen 2002). The functionalities mentioned above all need to be intertwined in a joint e-learning system.

Inspired by the Assure model (Heinch et al. 2002) created for classroom instruction we present a learning system triangle (Fig. 2) where we divide the design of e-learning systems according to four different aspects:
1. Media: The channel of communication.
2. Content: Systems for content building (learning objects) based on e.g. SCORM.
3. Administration: Student / Course / Learning Management Systems.
4. Methods: Pedagogical delivery methods

We argue that three of the aspects are already implemented, but that the fourth aspect "the pedagogical methods" has not been prioritized. We believe it would be right to implement the pedagogical methods as an editor program with built-in delivery methods. The teacher fills the e-learning system with learning material based on pedagogical delivery methods by using, for example, wizards available in the editor program. Pedagogical methods such as discussion, demonstration, collaborative learning, etc, are the basis of the wizards; the editor program will help the teacher make pedagogical decisions by presenting the opportunities in the application. The teacher chooses the wizards based on pedagogical judgement and when the teacher is more comfortable with different delivery methods the editor program should allow the teacher to work more freely. It also should be possible to integrate the editor program into an e-learning system, where other parts of the system take care of student and course administration, learning object creation etc.

Pedagogical methods

Editor with wizard based on methods

Media

Authoring tools

Learning Management System

Content creation

Administration

Content

Student Management System

Learning Content Management System
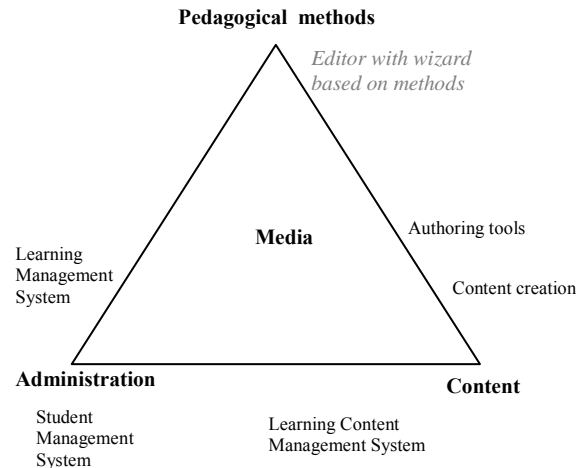
Figure 2: The focus of today's e-learning systems

Design patterns as a design tool

To make the design process more effective and of course cost-effective we need to have tools to simplify the process. The tools should make it possible to develop systems with all the features and opportunities that we want, which is to include the four aspects of figure 2. Carstensen / Schmidt see flexibility as one specific challenge for CSCW-systems design; "we have to establish basic building blocks and platforms so that the actors themselves can establish a CSCW system fulfilling their needs" (Carstensen & Schmidt 2002). Design patterns can be examples of building blocks to ensure such flexibility in e-learning systems.

Frizell and Hübscher claim that design patterns can be used to effectively support novice designers of web-based courses (Frizell & Hübscher 2002). We believe design patterns could work as one kind of e-learning design tool. Design patterns are useful tools that make it easy to share the e-learning expertise learned from past mistakes since design patterns are archetypes on well-used solutions. Design patterns will build expertise of experienced online teachers into the system, and help novice online teachers learn how to work online.

C. Alexander's definition of a design pattern is that it "describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem in such a way that you can use this solution a million times over, without ever doing it the same way twice" (Alexander 1977). The patterns are systematically described using a pattern language. In this paper we are discussing *pedagogical design patterns* and believe it is useful to categorize the pedagogical patterns according to categories of pedagogical delivery methods.

Pedagogical Patterns

Problem solving patterns

Discussion patterns

Demonstration patterns

Tutorial patterns

Drill and practice patterns
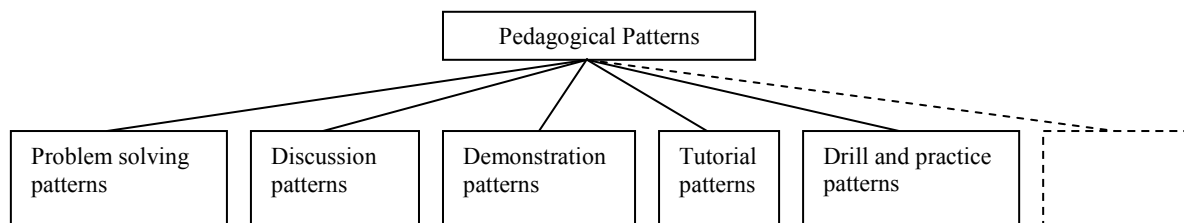
Figure 3: Systematizing pedagogical patterns according to delivery methods

The introduction of pedagogical design patterns will lead to a systematic approach to e-learning design, where the educators do the work of collecting the design patterns and the software engineers design the technological solutions. For software designers without a pedagogical background the pedagogical design patterns will be useful and it will provide a common language for technologists and educators. Design patterns are a collection of tested pedagogical methods. Some patterns will work in several categories, e.g. a pattern of e-moderation will be useful in the categories of discussion, collaborative learning and problem solving.

Pedagogical design patterns as wizards

The pedagogical design patterns can be implemented as interactive wizards, and design patterns will make it possible to develop learning systems where it is possible to adjust functionality in a program according to the learners' needs in the specific learning situations. Gilly Salmon has written a book about E-moderation, to help novice online teachers to make discussion groups be effective in online learning situations (Salmon 2000). Instead of reading whole books like Salmon's "E-moderation", the wizards can be helpful when you need them ("just in time" learning). The wizards are short versions of more experienced teachers' experiences.

Our work is based on the following procedure:

> Delivery method → Pedagogical Design pattern → Wizard

In order to avoid creating misunderstandings because of the length restrictions on this paper, we will now describe a short scenario of how the procedure works:

The teacher uses his experience and expertise from pedagogy to create a pedagogical design pattern, using a pattern language where he needs to state a name (e.g."E-moderation") and a category ("Pedagogical pattern – Discussion pattern"). Then he describes the problem ("A discussion forum can be difficult to get to work in an online learning environment. How can we ensure that discussion forums work well and are instructive to the students?"). He also does an analysis where he states why it is important to solve the problem and what makes this problem a hitch. He then describes known solutions: e.g. organizational moderating activities (setting the agenda, objectives, procedural rules, netiquette, encourage the participants to introduce themselves), social moderating activities (sending welcoming messages, thank you notes, prompt feedback, set a positive tone), intellectual moderating activities (asking questions, provide low-effort contributions, probing responses, refocusing discussion) (Vesseur 2004 / Salmon 2000). The pattern language also requires research questions, context, conditions, discussion, references and related patterns. The software designer can use this pattern as a starting point in the design process to create a wizard. In this way the expertise and experience of the teacher regarding methods is implemented into the system.
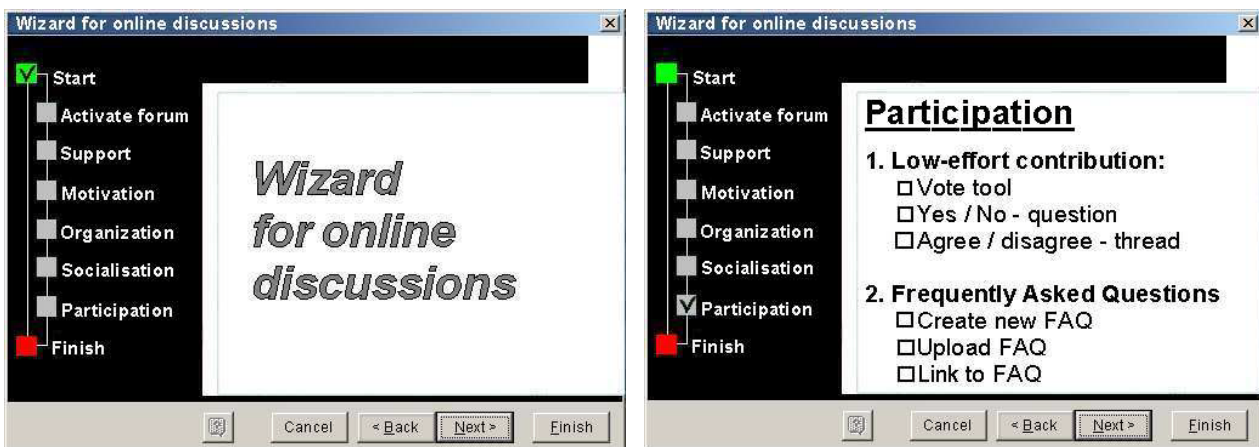
Figure 4: Two screenshots of a wizard for online discussions, based on the look of a traditional MS office wizard.

If the teacher believes that it would be effective to have a discussion to learn a specific theme, he could get the Wizard for online discussions. The first screenshot shows the first page of the wizards, with the name of the wizard, and the sequence of actions of this specific wizard. The "Cancel", "Next" and "Finish" buttons are used to navigate in the wizard. The teacher moves through the wizard's steps by clicking "Next", and reaches the 7th step "Participation" (Fig. 4). Here the teacher gets a number of choices to make. Based on the choices made, the wizard presents a discussion forum in the online learning environment, based on the teacher's pedagogical considerations.

Advantages

Skills upgrading is dependent of individuals, which make reuse difficult. The wizards described above will assure the reuse of experience and competence, also with respect to delivery methods. The editor with built-in wizards based on pedagogical patterns will help teachers by giving them access to tried-and-tested delivery

methods; novice online teachers will get to see the opportunities for online delivery methods. Students will gain access to a learning environment where variation is implemented, making it possible for them to choose learning strategies. The learning environment will also make the students more aware how they learn best and how their learning preferences change over time. For software developers the pedagogical design patterns are useful because there are few methods and tools supporting e-learning design today, especially for developing systems based on a variety of pedagogical methods.

Conclusions and future work

The time has definitely come to concentrate on pedagogical methods while designing e-learning systems to ensure variation for students. Morrison has described the concept of "content parity". The same content should be made available to learners in all delivery channels, and the students can choose the combination of channels best suited for their preferences (Morrison in Helmer 2003). Morrison also argues "channel selection should be the business of instructional designers". We therefore need learning systems that leave online teachers with the work they know best: teaching. Not administration and not technology. We believe pedagogical design patterns and wizards are the right approach to implement pedagogical methods into e-learning systems.

We will continue our work implementing delivery methods by using pedagogical design patterns and the concept of wizards, coming up with a prototype in the near future. The work will be based on patterns produced in the "E-LEN" project (a project under the Socrates Programme: http://www2.tisip.no/E-LEN/).

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SUPPORT FOR THE INSTRUCTOR:
FROM TECHNICAL TO PEDAGOGICAL VIEWPOINT

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ABSTRACT
To p erform e -Learning co urses t he i nstructor n eeds support: on on e s ide be st pr actice s olutions a nd on t he other side software support to bring the pedagogical ideas into act ion, co vering al l p hases of p lanning and performing onl ine c ourses. I t i s a lso i mportant t hat t he support p rovided t o t he t eacher h as a p edagogical, not technical poi nt of v iew. I n t his pa per we pr opose t o capture b est p ractice solutions b y e -learning d esign patterns, and to assist the instructor we propose a process-based s oftware as sistant, t o b ridge t he g ap between t he educational e nvironments a nd t he p rovided t echnical support by the learning management system.

 KEY WORDSDS.
 Distance learning, educational scenarios, e-learning, design patterns, instructor support, educational interaction patterns.

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Variation and Reusability in E-learning: not Compatible?

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Abstract: One way to improve e-learning systems for higher education is to look at the weaknesses of today's system and do something about these weaknesses. Obvious weaknesses of today's systems are lack of opportunities for variation and reusability. This paper focuses on describing the concept of "variation" and discusses the problems and opportunities appearing when variation and reusability are combined. The work done so far to improve reuse, has not been considering all the factors that are important to achieve high quality in e-learning. Learning objects and learning activities are not the only important aspects if the goal is quality *and* reuse.

Introduction

E-learning communities have been experiencing tough times after a promising introduction, but some positive experiences trigger researchers to still work on improving e-learning. The hot topics in e-learning during the last few years have been standardization and reusability.

Variation has been regarded as an important principle within teaching and learning for many years. This principle seems lost on the road to the online university. Many online teachers use a few delivery methods over and over again: This is convenient for inexperienced online teachers. Britain and Liber concluded in 1999 that the majority of VLEs (Virtual Learning Environments) were designed to support an education model based on information transmission (Britain & Liber 2004). However, a model based on information transfer alone does not take into consideration the pedagogical challenges facing teachers and students in online communities.

Teachers with classroom experience know that instruction needs to be varied to retain students' motivation for learning. Sometimes problem-based learning is the best delivery method, at other times collaborative learning, lectures (one-to-many) or drill exercises are effective. The best delivery method depends on many parameters, including the age or cultural background of the students, their background and motivation, the subject, the theme, the teacher and the learning environment.

Is it possible to combine the needs for reusability with a focus on variation in e-learning systems? Are the two concepts compatible? In this paper I will first define "variation" and "reusability" in an "educational technology" setting, giving examples and references to the literature. Then I will look at the combination of the two concepts, discussing the challenges and opportunities the combination gives. Finally I will draw some conclusions and sketch future work.

Variation

"Variation" is a concept that can have many different meanings, depending on the reader and on the context. In this paper I will use the concept of variation in a wide interpretation, as it should in educational settings.

Varied Pedagogical Methods

First of all variation can mean *varied pedagogical methods*. Koschmann wrote a position paper in 1996 that has been a common introduction to e-learning. He based the different paradigms in e-learning on different learning theories and theories of pedagogy (Tab. 1).

Paradigms	Event marking emergence of paradigm	Theory of learning	Model of instruction	Research issue
CAI	Coursewriter I	Behaviorism	Programmed instruction	Instructional efficacy
ITS	Carbonell's dissertation	Information Processing Theory	One-to-one tutorial, interactive	Instructional competence
Logo-as-latin	Publication of "Mindstorms"	Cognitive constructivism	Discovery-based learning	Instructional transfer
CSCL	NATO workshop	Socially oriented theoris of learning	Collaborative learning	Instruction as enacted practice

Table 1: Paradigms in e-learning (Koschmann 1996)

These paradigms produced different types of e-learning systems, and have lead to the fact that variation of pedagogical methods in the e-learning systems has not been prioritized. There has not been focus on inclusiveness, but more often a focus on exclusiveness when new e-learning systems have been developed. Both teachers and developers have been convinced that a specific theory of learning has been the right one, and consequently the e-learning systems have mainly been supporting one theory of learning. Some systems therefore have the main pedagogical focus on problem-based learning or simulation, others on drill/practice or collaboration.

Varied Learning Styles

Variation can also indicate *varied learning styles*. "Every human being has a learning style and every human being has strengths. No learning style is better or worse than any other style" (Dunn & Dunn 2004). The D&D model on learning styles has 21 elements grouped as five "stimuli", including environmental, emotional, sociological, physiological and psychological preferences. Some people learn best while reading (visual learning style), while others learn best while hearing (aural learning style). Some people have to move around to concentrate (kinesthetic learning style), others have to finger, note or do something with their hands (tactile learning style) (Dunn & Dunn 2004).

Howard Gardner and his theory about "multiple intelligences" provided another contribution to the discussion about who the learner is. In this theory he is defining eight different intelligences:

1. Visual / spatial intelligence:
The ability to visualize and make mental maps. Persons using mind maps are using this intelligence.

2. Verbal / linguistic intelligence:
The ability of reading, writing and communicating with words. This intelligence is well developed among writers, journalists, speakers etc.

3. Logical / mathematical intelligence:
The ability of logical thinking and performing calculations, and for abstract thinking. Mathematicians, engineers and lawyers have often developed this intelligence well.

4. Bodily / kinesthetic intelligence:
The ability of body coordination and conscious use of own body and hands, an ability typically well developed among athletes, dancers, actors and craftsman.

5. Musical / rhythmic intelligence:
The ability of singing, playing, composing and having a good musical ear, usually found among composers, conductors and musicians etc.

6. Interpersonal intelligence:
The ability of understanding people and communicating, usually well developed among competent diplomats, charismatic leaders and among "persons that people like".

7. Intrapersonal intelligence:
The ability of understanding our "self".

8. Naturalistic intelligence:
The ability to recognize and classify elements / patterns of the natural world
(Gardner 1985).

The thought is that all persons have eight intelligences, but that some intelligences are better developed than others. It is therefore possible to use the knowledge about a student's intelligences to let him/her feel mastering, but also to give adequate challenges to improve weak abilities. It will in the future be important for e-learning systems to offer a varied learning environment supporting the different learning styles and intelligences to provide individualized learning.

Varied Levels of Intellectual Behavior
In some cases "variation" also could indicate *varied levels of intellectual behavior*. Blooms taxonomy (Bloom 1956) has been an important contribution to educational literature.

Knowledge	Observation and recall of information
Comprehension	Understanding information
Application	Use information, methods, concepts, theories in new situations
Analysis	Seeing patterns, organization of parts, recognition of hidden meanings
Synthesis	Use old ideas to create new ones, generalize from given facts, relate knowledge from several areas
Evaluation	Compare and discriminate between ideas, assess value of theories.

Table 2: Blooms taxonomy

In addition, Dreyfus has another approach to the view of the heterogeneous student group. He makes a division between different stages for learners, and claims that students on different stages have different needs. The stages he uses are:
1. Novice
2. Advanced beginner
3. Competence
4. Proficiency
5. Expertise (Dreyfus 1998).
Despite different professional competences, there are some characteristics identifying a specific progress (Vavik 2005). The "novice" needs models, rules, prescriptions, while an "advanced beginner" starts to recognize based on experience. With "competence" the user chooses a plan of progress to reach the goal based on instruction and experience, while with "proficiency" the theory connected with the skill will gradually be replaced by situational discriminations accompanied by associated responses. With "expertise" the learner not only sees what needs to be done, but also sees how to achieve his goal (Dreyfus 1998).

Varied Teaching Styles
Like students and their learning styles teachers are also a heterogeneous group with *varied teaching styles*. Grasha identified five teaching styles that represented typical orientations and strategies college faculty use.
- Expert: Possesses knowledge and expertise that students need. Concerned with transmitting information and insuring that students are well prepared.
- Formal Authority: Possesses status among students because of knowledge and role as faculty member. Concerned with the correct, acceptable and standard ways to do things and with providing students with the structure they need to learn.
- Personal Model: Believes in "teaching by personal example" and encourage students to observe and then to emulate the instructor's approach.
- Facilitator: Emphasizes the personal nature of teacher-student interactions, with the goal to develop in students the capacity for independent action, initiative, and responsibility.
- Delegator: Concerned with developing students' capacity to function in an autonomous fashion, where students work independently on projects and teacher is available as one of many resources (Grasha 1996).

Varied Content
An additional meaning of variation in an e-learning setting could be *varied content*. In the e-learning field a lot of effort has been put into this area. Defining learning objects has created discussions in the field. IEEE defined a learning object as "any entity, digital or non-digital, that may be used for learning, education or training". Wiley found the definition too broad, and defined a learning object as "any digital resource that can be

reused t o support l earning."(Wiley 2 005). The co mponents o f a l earning o bject ar e t he co ntent (image, animation, text, quiz etc) and searchable metadata.

Varied Media

Varied media (multimedia) has for a long time been one of the major advantages of e-learning and it has been used as a justification for still working in the area of e-learning. Books, lectures etc. have not been able to match the added value of multimedia with it's opportunities for pictures, video and audio etc. "Interactive multimedia i s notoriously e xpensive and time-consuming to p roduce, y et there i s e vidence t hat if made a nd deployed effectively it can enhance the learning experience" (Leeder & Morales 2004).

Varied Goals

Traditional education as well as e-learning has to consider the fact that learning can have *varied goals*. Bloom has id entified th ree d omains o f e ducational a ctivities: c ognitive (mental skills), a ffective (growth in feelings of e motional a reas) a nd ps ychomotor (manual or ph ysical s kills) (Bloom 1956) . This pa per distinguishes learning goals into three types: Skills, Knowledge and Attitudes, based on Blooms identification. There ha s not b een much focus o n different types of learning goals in e-learning, but le arning a skill requires other environments, tasks and activities compared to learning attitudes or knowledge.

Varied Assessment

E-learning s ystems have f or s ome years p rovided n et-based a ssessment, lik e multiple-choice t ests, digital portfolios etc. The ideas of multiple intelligences and different learning styles also demand varied ways of assessing a s tudent. Therefore *varied assessment* should also be considered when discussing variation in e-learning.

The Concept of Variation

Focusing o n va riation i n e -learning I ha ve no w d efined t he f ollowing a spects t hat ne ed t o b e considered, some closely connected:
· Varied pedagogical methods - Varied teaching styles
· Varied learning styles - Varied levels of intellectual behavior
· Varied content - Varied media
· Varied goals - Varied assessment.

Reusability

IEEE has defined "reusability" as "The ability of a component to function and integrate outside the environment for which it was primarily designed." So far there have been many barriers to reuse; examples are copyrights, technology, economy, missing standards, language and culture of sharing.

Discussion

Reusability and Varied Content / Media

When i t c omes to the c ombination o f v ariation a nd r eusability a lo t o f work has b een d one o n especially one of the variation a spects mentioned ab ove; varied content. The reusability of a learning object depends o n t he granularity o f t he l earning o bject. S ome consider an e ntire c urriculum as a l earning o bject (Wiley 2005), while others c onsider a picture (e.g. .jpg-file) as a l earning o bject. This is of co urse a p roblem regarding reusability.

Standards e xist to en sure t he r eusability o f l earning o bjects, an d t he t erm RLO (Reusable l earning objects) is used extensively. Examples of standards for content are SCORM, IMS, IEEE LOM and DublinCore. The main problem of the standards mentioned is the a mount of metadata co nnected to each learning object. "From an "efficiency" point of view, the decision regarding learning object granularity can be viewed as a trade-off b etween t he p ossible b enefits o f r euse an d t he ex pense o f cat aloging" (Wiley 2 005). There i s software (authorware) ba sed on t hese standards, made t o pr oduce l earning obj ects pos sible t o i ntegrate i nto di fferent learning management systems. J ust t he f act t hat t here a re many s tandards c oncerning learning c ontent, t hat authorware has to adapt to, shows how difficult reusability in e-learning is.

Varied media n eeds t o b e cl osely co nnected t o co ntent. One g oal within e -learning will b e to g ive access t o l earning co ntent i n a v ariety o f media. T his i s n ecessary t o s atisfy d ifferent l earning s tyles o r intelligences o f t he students. T he e -learning s ystems must t herefore cat egorize l earning o bjects n ot o nly according to learning outcome and theme, but also to media used. The fact that interactive media is expensive and time-consuming to produce (Leeder & Morales 2004) is a good reason to work for reusability.

Reusability and Varied Pedagogical Methods / Teaching Styles

Combining reusability and varied pedagogical methods is a topic many researchers are working on right now. Teachers education consists of several parts, one important part is to learn the subject that you are going to teach, but as important is to learn how to teach the subject. Pedagogical methods are traditionally possible to reuse in different subjects, e.g. the pedagogical method "problem-based learning" is used within health care education (higher education) as well as in geography in primary schools. It should therefore be possible to reuse pedagogical methods also in an online learning environment. When Koschmann wrote his article (Koschmann 1996) about the paradigms in e-learning, he claimed that three paradigms (CAI, ITS and Logo-as-latin) were passed by and that CSCL was the *emerging* paradigm. After the article was written all paradigms have developed further and there has been acceptable to blend tools etc. from the different paradigms based on knowledge about the opportunities and limitations of the tools.

IMS Learning Design (IMS-LD 2003) is IMS' contribution to standardization of pedagogical methods and is now being tested all over the world. Downes is criticizing IMS Learning Design, claiming "In order to use a learning design with a set of objects, the learning design must specify the objects to be used and if the objects to be used are specified, then the learning design is not reusable"(Downes 2003). As Robson stated it shortly; "Context is the friend of learning and the enemy of reuse" (Robson 2004).

One of the problems of IMS Learning Design is, like with content and learning objects, the granularity of the "learning activities". The "LAMS" system can give an example of the low level granularity. According to Leeder and Morales the e-learning system "LAMS" has innovative design features that put it at the forefront of current tools for activity management (Leeder & Morales 2004). "LAMS" provides a simple interface where the user can choose from a list of pre-defined learning activities (e.g. brainstorming a concept, taking a poll etc). Learning activities like these are reusable in several pedagogical methods. Standing alone like they do in "LAMS" the danger is however that "best practice" connected to pedagogical methods disappear. The learning activities in "LAMS" do not provide any help to the teacher nor are they connected to specific pedagogical methods. As they now are presented in "LAMS" they are nothing but tools rewritten into learning activities; e.g. brainstorming tool → Brainstorming a concept, polling tool → taking a poll. Is the flexibility in LAMS and IMS Learning Design too large, and will it depreciate the quality, because of the demand for reusability?

Online teachers have typically adopted the delivery methods of pioneer online teachers. They have also been dependent on and limited by the learning system used. "Many first-time users of VLEs (Virtual Learning Environments) seek to adapt the way that they work to the way that the software needs things to be done" (Britain & Liber 2004).

E-learning courses for higher education usually are based on a VLE / Learning Management System (e.g. Blackboard, WebCT, Fronter). The weakness of these systems is that they give too much attention to online administration and too little attention to pedagogical concerns (Britain & Liber 2004). The LMS forces the teacher into using only a few delivery methods. Teachers are used to finding the best methods of teaching their subject, and online teachers also should have the same opportunity. Most online teachers do however still need systems that help them discover the different pedagogical methods to use in a computer-based learning environment. In an earlier paper we suggested the use of wizards, based on pedagogical methods, where tools like brainstorming tools, discussion forums etc. were integrated into the interface through the wizard, providing "interactive pedagogical methods" (Kolås & Staupe 2004). This example shows the granularity level of "learning activities" on a higher level than for instance "LAMS". The drawbacks can however be less flexibility.

Maybe e-learning should be used as an opportunity to change the traditional coupling "one teacher – one subject" to "several teachers – several subjects". If systems are built with opportunities to make teachers aware of their strengths and weaknesses in teaching, the teacher could specialize on one teaching style, and additional teachers provide additional teaching styles in one subject. Awareness about teaching styles might lead to more reuse.

Reusability and Varied Learning Styles / Levels of Intellectual Behavior

The work done on learning styles (e.g. Dunn & Dunn, 2004) can make it easier to reuse "individualized" material, because they divide the student group into several subgroups with the same needs. The "individualized" material needs to be connected to the learning objects, but adding even more metadata to the learning objects is however not the perfect solution. The dilemma using learning styles is whether to capitalize or compensate, that is should a student with a visual learning style get all learning material visualized, or is it better to try to improve his/her weaker sides, and instead focus on other learning styles? This is a dilemma experts disagree upon in the ATI-field (Aptitude Treatment Interaction).

To be able to individualize learning, one needs to consider both varied learning styles and varied levels of intellectual behavior. Combining H. Gardner's "Multiple intelligences" and Dreyfus' five stages will give a two-dimensional illustration (Tab. 3) of how many different users one need to take into account developing an

e-learning system allowing differentiation and individualization. There could also be added a third dimension to this problem, e.g. age, culture etc.

Dreyfus' stages: Gardner's intelligences:	Novice	Advanced beginner	Competence	Proficiency	Expert
Visual / spatial					
Verbal / linguistic					
Logical / mathematical					
Bodily / kinesthetic					
Musical / rhythmic					
Interpersonal					
Intrapersonal					
Naturalistic					

Table 3: Combining Gardner (1985) and Dreyfus (1998).

This illustration allows a critical view of tools like personas, usability tests etc. commonly used in system development. Personas are difficult to use because it is hard to find the general types of users. Usability tests are difficult to use because a system that works for a student on a novice level with a strong visual intelligence might not work for a student on the competence level with a strong logical intelligence. The problem of the heterogeneous student group needs to be considered well if we are going to succeed with both reuse and individualization. IMS-LD and the toolkit of Conole (2004) focus on "roles" of the participants (both students and teacher), e.g. individual learner, group participant, presenter. These roles are very general, and they are more connected to the pedagogical method in use, than to the individual needs of a heterogeneous student group. By focusing on the heterogeneity of the student (and teacher) group more aspects are brought into the discussion (varied learning styles, varied levels of intellectual behavior etc). To succeed with individualization and differentiation in e-learning we need to know the different types of users.

Reusability and Varied Goals / Assessments

Conole connects "learning outcome" to a learning activity. Learning outcome is what learners should know, or be able to do, after completing the learning activities e.g. understand, demonstrate, and design (Conole 2004). These learning outcomes are on a lower level compared to the learning goals previously defined in this paper, but fit into the three categories (skills, knowledge and attitudes), and are therefore reusable in the different categories.

The assessment ought to fit all types of students, and work needs to be done to develop digital assessment tools that give students with different individual needs the same opportunity for good results. The work on digital portfolios is maybe the best contribution so far, where students get individual feedback throughout the course. The portfolios are also reusable, with reference to the demand of variation described in this paper.

Conclusions

One problem succeeding with the combination of reuse and variation, is that the demand of reuse is based on need for saving money, while the need for variation is based on the need for quality. Reuse may also give better quality, and is therefore an important goal within e-learning, but it needs to be seen in connection with other aspects, e.g. variation.

Wiley stated that "Learning objects must participate in a principled partnership with instructional design theory if they are to succeed in facilitating learning" (Wiley 2005), but this paper has suggested aspects additional to content and pedagogies. The work done so far to improve reuse, has not been considering all the factors that are important to achieve high quality in e-learning. Learning objects and learning activities are not the only important aspects if the goal is quality *and* reuse.

This paper is a contribution to the work of producing a framework for evaluating e-learning systems, with the focus on the concept of variation and reusability. It represents also background work in the EU-project QUIS (2005), where it will be used in the work of developing a requirement specification for a future e-learning system.

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Topic Maps in E-learning:

An Ontology Ensuring an Active Student Role as Producer

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Abstract: Topic maps have been introduced as a HCI-solution within e-learning. One problem when using topic maps is that the student is left in a passive consumer role. The article proposes a topic map ontology, focusing on both students and teachers as active producers of learning resources. The article also discusses how small-scale and large-scale sharing of student-made learning resources can be achieved. Topic maps customize the interface, and the interface should also provide possibilities for online students to share learning resources like "on campus" students do. The article also discusses implications for the online teacher's role and how students could be encouraged to share in an online learning environment.

Introduction

During a semester students produce a lot of written material in the form of notes from lectures, books and articles, mind maps, illustrations, diagrams, checklists, templates, questions and answers etc in addition to e.g. oral presentations. Taking "on campus" courses it is common that the students share notes, experiences and explanations, while this exchange is harder to achieve in an online learning environment.

Topic maps and the semantic web are suggested as HCI (human computer interaction) solutions within e-learning (Dichev et al. 2003). There is, however, the problem when using topic maps that mainly teacher-productions will be available. This article suggests a systematic student production of learning resources and systematically sharing of student-made learning objects within e-learning, also in topic map environments. The article also discusses implications for the online teacher's role and how students could be encouraged to share, in addition to discussing the HCI implications that the reuse of student-made learning objects introduces in an online learning environment. The article introduces an e-learning ontology for the systematic production and reuse of student-made learning objects.

The method used in this study is a qualitative approach, more specifically the Grounded Theory (Glaser & Strauss 1967, Strauss & Corbin 1990) with data collection from brainstorming sessions and depth interviews among the user groups, in addition to requirement specification development and literature review from the fields of pedagogy and educational technology.

Student productions

Most students are eager to share in "on campus" learning situations. They share lecture notes when one student was not able to attend the lecture, they exchange notes from the curriculum, they distribute URLs to interesting websites, they share mind maps and assignment answers. A student typically does this because there is "something in it for me" as well. They know that if they share their lecture notes this time, they will get something back from the receiving student later, so it will be useful for both the giver and the receiver.

In an online learning environment, however, the sharing is not as easy, because you do not necessarily know your fellow students very well and the answer of the question "What's in it for me?" is not clear to neither students nor teachers. Today, sharing among online students is done through e.g. discussion forums. If online

sharing is going to be successful, it must be obvious for the student that "giving now" will mean "receiving later". If online students are going to share, it should not only be sacrifices and waste of time and energy, but the online students must know that the sharing will be useful for them later.

Being an active producer of learning objects and learning activities the student not only prepares learning objects and learning activities for his fellow students, but the process of making the learning objects is also a valuable learning experience for the producer.

Within e-learning there has been a lot of research on reusable learning objects by making standards like SCORM, IMS, IEEE-LOM etc (Marsico et al. 2005) to ease the reuse of learning objects, but the focus has been on the reuse of teacher-made, not student-made learning objects. This article emphasizes that time and energy for both teacher and students could be saved if sharing was systematically performed among online students.

What to share in an online environment?

In an online environment it is possible to share in both a small and large scale. In a small scale sharing could be performed through a ranking system (where students e.g. rank a learning object, and the system could show the ranking results for other students). The ranking would be interesting feedback to the teacher as well, in the process of reviewing and improving the learning objects. The system could also use the ranking results to give suggestions of other learning objects to the student based on the behaviour of the fellow students, similar to Amazon.com, which has a suggestion list of other books that might be interesting to the buyer ("Costumers who bought this item also bought: … "). An e-learning example could be that the student ranks one learning object high, and the system provides a list of learning objects ranked high by fellow students who also had high ranking score on the same learning object.

In a larger scale we can imagine the online students sharing multiple choice questionnaires, mind maps, screen capture recordings, slide presentations and lecture notes. An incentive to get access to the student-produced learning object repository could be that you need to submit one learning object before you get access to the learning objects produced by fellow students.

The teacher role

McGhee and Kozma defined the new teacher roles in technology supported classrooms to be instructional designer, trainer, collaborator, team coordinator, advisor and monitoring and assessment specialist (McGhee & Komza 2003). This article suggests an additional role as "editor". Student-made learning objects / learning activities should be quality assured before it is published to the fellow students, and this should be done by the teacher.

There could also be a problem with a large amount of learning objects that will put the student in a consumer role, which can make him / her passive. Getting access to a large amount of finished notes, mind maps etc may leave the student in a passive consumer role. An ontology of an e-learning topic map is therefore needed for the teacher to systematically organize the student production of learning objects and make them retrievable, in addition to avoiding that the students keep making similar learning objects to already existing ones. The ontology presented in this article will be useful for the teacher in the editor role finding what themes, methods, media types etc are already covered and what topics are still not produced.

The process of producing the learning objects should be as useful as getting access to the produced learning objects. This will mean that the student production of learning objects is not extra work, but part of the learning process. The teacher is not replaceable even if students make many of the learning objects and learning activities. It is important to have one person who knows the subject field and has a pedagogical background. It is also important that the teacher has a bird eye's perspective of the entire learning environment.

An e-learning topic map

An HCI solution within e-learning could be to use the concept of topic maps, where the information can be shown in several views based on the choice of the user. Topic maps are an ISO standard - ISO/IEC

13250:2003. "A topic map is a technology for knowledge integration, describing concepts and their relations" (Garshol 2006). Organizing documents into a topic map, it is necessary to identify the topics, the topic types, the occurrences and the associations (Pepper 2002). To use topic maps in an e-learning setting it is necessary to design an ontology, and this article presents the initial version of an e-learning ontology.

The student interface

The student interface based on a topic map will allow customized views of the learning objects and learning activities. Examples of the students' views of the learning objects and learning activities, could be views based on:

- Themes
- Time (the newest learning objects / learning activities)
- Pedagogical methods (Heinich et al. 2002)
- Media type / intelligence (Gardner 1985)
- Proficiency stages (Dreyfus 1998)
- Learning objective (knowledge / skill / attitude / meta learning)
- Student productions of learning object/ learning activities
- Ranking score (the learning objects with the highest ranking scores)
- List of learning object recommended by the system based on behaviour of previous students (the students who liked a specific learning object also liked these learning objects).
- Guided learning paths produced by teacher
- (Free text) search.

A user-friendly, individualized and differentiated interface is an important feature of an e-learning system. Instead of presenting the learning objects and learning activities in one standard interface for all the students, an e-learning topic map could present "many roads to Rome", addressing the needs of the heterogeneous student group (Kolås 2005).

Why e-learning topic maps?

Dichev et al. (2003) mention many advantages using topic maps, e.g. efficient context-based retrieval, customized views, information visualizations and deeper understanding of the domain conceptual relations. The advantages of a topic map presenting information (e.g. learning objects) are that the user will experience a flexible learning environment and is able to make choices of his / her own on what perspective he/she wants to the learning material.

Information overload for the student is a problem which may occur when we are trying to arrange for an individualized and differentiated learning environment prepared for individual needs when it comes to methods, media, intellectual stages, cultural needs, assessment, and different intelligences in the online learning environment. If nothing else is done other than organizing many different learning objects into folders, the students will not know which learning object to start and which to continue with. "One problem with web portals is how to locate the information you are interested in" (Hjeltnes 2006). This problem also applies to the situation when the students produce learning resources, they must be easily retrievable. There is therefore a need for good HCI-solutions, and topic maps are suggested as one solution of this problem (Dichev et al. 2003).

A disadvantage with topic maps is however the passive student role. The student is able to be active in the sense of choosing the perspective of the information, but there should also be an opportunity for the students to produce information as well. Table 1 lists some of the differences between being an active producer and a passive consumer (Tab. 1). Also in e-learning environments it is necessary for the students to have the possibility of both roles; consumer and producer. Currently the topic maps only provide the consumer role.

Student as Producer (active) - producing learning activities / lessons	Student as Consumer (passive) - consuming learning activities / lessons
Write text (in a word processor, wiki, blog)	Read text (in a word processor, wiki, blog)
Make a multiple choice questionnaire	Fill in a MCQ
Make mind map	See mind map
Make concept map	See concept map
Make illustration	See illustration
Make slide presentation	See slide presentation
Make aural presentation	Hear aural presentation
Make video presentation	Watch video presentation
Make tutorial	Do tutorial
Make a screen capture sequence	Watch screen capture sequence
Make animation	Watch animation
Make survey	Answer survey
Make database	Use database
Make music	Hear music
Ask question / answer question in FAQ	Read questions and answers in FAQ
Make vote question	Vote
Search for information	Get access to information
Quality assure information	Get access to quality assured information (topic directory, teacher-made website of URLs)

Table 1: Active vs. passive student role

HCI implications

To ensure that a topic map learning environment is not leaving the student in a passive consumer role, the students must get access to the same production tools (for the production of learning objects and learning activities) as teachers do in the online learning environment. It is also necessary for the system to provide an overview for the teacher of what is produced.

One idea is to use the information from the course specification (where the name of the course, the prerequisites, the learning objectives, the course content, the teaching methods and the assessment methods are defined) to create metadata based on this information. This approach does, however, require an e-learning ontology.

The e-learning ontology

A topic map ontology is "the set of privileged topics and their characteristics, including associations between them" (Grønmo, 2006). The e-learning ontology (Tab. 2) covers the different needs of the heterogeneous student group when it comes to different pedagogical methods (Heinich et al. 2002), proficiency stages (Dreyfus 1998), multiple intelligences (Gardner 1985) and taxonomies for affective, cognitive and psychomotor domains (Kratwohl 1964; Bloom 1956; Dave 1970). The e-learning ontology is based on key topics, topic types and associations and occurrences:

Key topics:	Topic types:	Associations	Occurrences
Learning objectives	Knowledge	Is assessed through	MCQ, memory, matching, true/false, short answer, completion, blog, portfolio,
	Attitude		chat log, discussion forum, pre/post survey tool
	Skill		motion sensitive tool, simulator, track tool, log
	Meta-learning		pre-test, post-test, reflection tool
Pedagogical methods	Drill	Is taught through	Multiple choice, drag and drop, match, memory, fill in blanks
	Presentation		Wiki, mind map, concept map, map, slide presentation,

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			video / audio recordings
	Tutorials		Wizards, FAQs
	Gaming		Adventure games, business games, board games, combat games, logical games, word games (Alessi & Trollip 2001)
	Demonstration		Screen capture, animation
	Discovery		Survey, Voting, blog / journal, Search
	Simulation		Physical, Iterative, procedural and situational simulations (Alessi & Trollip 2001)
	Discussion		Chat / IM, SMS, e-mail, forum, Video conference, audio conference
	Cooperative learning		Application sharing, CVE, workspace awareness, shared archive
Learning objects	*(Multiple intelligences)* Visual intelligence	Is produced through	Presentation tool, mind map, concept map, graphics tool
	Verbal intelligence		Word processor, web editor, record audio
	Logical intelligence		Spread sheet, database
	Kinaesthetic intelligence		Simulation, motion sensitive tool
	Musical intelligence		Record audio, midi
	Interpersonal intelligence		Communication, coordination and cooperation tools
	Intrapersonal intelligence		Mind map, hypertext editor
	Naturalistic intelligence		Database, map, hypertext editor
	(Proficiency stages) Novice		Checklist, template, road map, wizard, design pattern
	Advanced beginner		Toolkit, search help
	Competence		Assignment without help, framework
	Proficiency		
	Expert		

Table 2: The e-learning ontology

Conclusions and further work

Instead of an online learning environment with too many unstructured learning resources available, the topic maps will make it possible to find the needle in the haystack, which is the right learning resource for the specific student in a specific situation, to ensure good learning. Topic maps can be a good HCI solution in e-learning, because it customizes the student interface and meet the student's needs in a consumer role. This article has, however, focused on the problem of a passive student role using topic maps. The article proposes an e-learning ontology, focusing on both the teacher and the student as active producers of learning objects and learning activities, to enable sharing among online students.

Further work should include a discussion about copyright issues of student made learning objects. The ontology should also cover cultural dimensions as a factor of the student heterogeneity, but this is not completed at the current time.

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The PLExus Prototype: A PLE realized as Topic Maps

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Abstract

The article presents the PLExus prototype, a Personal Learning Environment based on the semantic technology of topic maps. Semantic-based navigation in e-learning will enable variation, differentiation and individualization, which are important pedagogical factors in the development of a personal learning environment. PLExus provides a student interface allowing customized views of learning objects and learning activities based on pedagogical method, media type, learning objective type, proficiency stage etc.

1. Introduction

An HCI solution offering a customized interface within e-learning could be realized using the semantic technology of topic maps, where the information can be shown in several views based on the choice of the user. Topic maps are an ISO standard - ISO/IEC 13250:2003. "A topic map is a technology for knowledge integration, describing concepts and their relations" [1]. Organizing documents into a topic map, it is necessary to identify the topics, the topic types, the occurrences and the associations [2].

This article first describes topic maps within e-learning, where topic maps may be a solution to achieve a personalized learning environment. A description of important primary constructions in topic maps applicable in a PLE is presented. Finally PLExus, the PLE prototype is presented with screenshots and a system description.

Based on the development of the functional requirements [3], one of the experiences was that a next-generation e-learning system must be a personal

learning environment (PLE). Johnson et al. describes how individuals have different understandings of the concept "PLE", from "empowering users of informal learning resources away from institutions" or "an extended portfolio" to "a superfluous accessory to the technologies of the desktop operating systems and the World Wide Web" [4]. The variety of interpretation illustrates how diffuse the concept of PLE still is. This article will present our interpretation of the concept "PLE" based on the experiences developing pedagogical-based topic maps.

2. An e-learning topic map

In a pedagogical-based PLE like PLExus the student is able to customize the learning environment. This requires that Learning objects (LO) and learning activities (LA) are saved and retrieved in such a manner that one student could reach the learning objective through a presentation, while other students reach the same learning objective through e.g. discovery, demonstration or collaboration [5].

The student interface based on a topic map allows customized views of the LO and LA. The students' views will be based on e.g: themes, time (the newest LO / LA), pedagogical methods [5], media type / intelligence [6], proficiency stages [7], learning objective (knowledge/skill/attitude), student productions of LO/LA, ranking score (LO with the highest scores), list of LO recommended by the system based on behavior of previous students, guided learning paths produced by teacher and free text search.

3. Topic Maps in E-learning and Personal Learning Environments

A user-friendly, individualized and differentiated interface is an important feature of an e-learning system. Instead of presenting the LO/LA in one standard interface for all the students, an e-learning topic map presents "many roads to Rome", addressing the needs of the heterogeneous student group [8]. Dichev et al. [9] mention many advantages using topic maps, e.g. efficient context-based retrieval, customized views, information visualizations and deeper understanding of the domain conceptual relations. The advantages of a topic map presenting information (e.g. LO) are that the user will experience a flexible learning environment and is able to make his / her choices on what perspective s/he wants to the learning material.

Information overload for the student is a problem which may occur when we are trying to arrange for an individualized and differentiated learning environment prepared for individual needs when it comes to methods, media, intellectual stages, cultural needs, assessment and different intelligences [3] in the existing online learning environments. If nothing else is done other than organizing many different LOs into folders, the students will not know which LO to start with and which to continue with. With a chronological structure of the folders (week 1, week 2 …) it will be hard for the students to relocate e.g. the World War 2-lesson. A folder structure based on themes makes it hard to individualize / differentiate the lessons e.g. by using a variety of pedagogical methods (the student then will have to choose from WW2-demo, WW2-simulation, WW2-discussion etc). Adding other pedagogical factors e.g. several proficiency stages will make navigation in the online learning environment even harder.

In order to meet the requirements of a PLE, a powerful computer architecture is needed, where it is easy to locate resources based on context and needs. There should also be a powerful search- and navigation system connected to the architecture. The architecture must ensure relevant, complete and consistent information. One example of this type of architecture is Topic Maps.

For a PLE we need a system for administering a certain amount of information which is in constant change, normally growing, and which also consists of a variety of information that can be linked together in many different ways. That means administration of

complex information. In Topic Maps, metadata can be isolated and stored separately from the object, but will still be closely connected to the object. Metadata will be a central component during information search.

4. Realizing a PLE using Topic Maps

In this article we focus more on the strength of topic maps in order to create a PLE, and therefore, to some extent, we describe the qualities of parts of the primary structure in topic maps. Previously we have described the use of LOs [3]. The LOs may exist many places, in a local database, in a publisher's database, available on the Internet, etc. In the first place, LOs can be made of images, text files, animations, videos, etc. without necessarily being used / viewed as LOs. To stick to the terminology of topic maps we therefore call these "subjects".
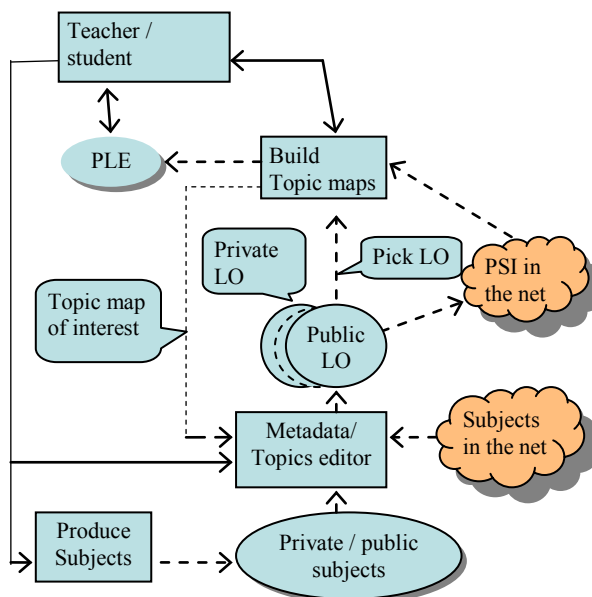
Figure 1: The conceptual model

The metadata connected to these subjects will only be those connected to ordinary files. Based on the subjects, it should be possible to create LOs containing additional metadata necessary when the object is to be used in learning situations. In turn, one might want to create new LOs around one, two, or several basic LOs. The new LO will then get its metadata and can be made available. And we could go on like this; several LOs forming parts of courses, course modules, or sometimes a complete course in a PLE.

The subjects can originate from many different sources, e.g. images, text files, web pages, videos etc. Not all subjects can be put into a computer or be directly connected to it, the alternative will then be to describe it in the form of a substitute (proxy) in the topic map architecture.

The conceptual model (fig. 1) is built around the use of topic maps, since we believe that topic maps are suitable as the core of a powerful PLE with information administration, search and navigation as important components. Topic maps are "the GPS of the information universe" [10], it tells us where we are and where to find the requested information.

4.1 Teacher

The model is based on the assumption that both teachers and students can act as consumers and producers in an online learning environment. A typical situation is when a teacher is creating a course or a course module. The teacher will then check if any LOs already exist. S/he searches and reuses LOs from his/her own library, locally published LOs or from an internet-based PSI (explained in 6.1).

If no suitable or preferred LO exists, the teacher can choose to develop his/her own. S/he may use already-existing subjects in the form of images, text, animations, videos, evaluation programs, arenas of cooperation, toolkits etc. In the process of transforming subjects into LOs (topics), it will be necessary to add metadata and PSI (see 6.1). The PLExus editor builds the topics with the necessary elements (base names, possible variant names, occurrence(s), scope(s) and subject indicator). The LO is added to a private or a public database, or in both.

The next step will be to build a topic map with the topics, as association hierarchies and class hierarchies. When the final step of the topic map construction is completed, one will have a complete PLE. However, the road there could include several steps where topic maps are expanded. Each of these steps may lead to topic maps that are interesting enough to be made public, or to be added to a private database of LOs.

4.2 Student

Students will get access to a learning environment as both producers and consumers of LO/LA. The most extreme case is that students build the content of the entire PLE. A more common example is that the students design their own electronic workbook, develop smaller course modules etc. As for the teacher, it is natural that the students work in relation to private LO bases and it will be necessary with authorization before the LO is made publicly available.

5. PLExus – a prototype of a pedagogical-based PLE

We here introduce PLExus - a prototype of a pedagogical-based PLE realized as a topic map. The student experiences a personalized user interface where s/he gets access to the LOs from different points of view, e.g. pedagogical method (e.g. game, tutorial, discussion etc), proficiency stage (e.g. novice, competence etc), or intelligence (visual, verbal etc). The PLExus prototype presented is at this point in time only covering a few views, but the basic structure is implemented. PLExus is based on our experiences with LOs and writing metadata with design patterns [3].

5.1 The wizard

The teacher prepares a personal learning environment for the student by structuring the LOs using a pedagogical topic map wizard. The prototype is operational, but a self-instructing user interface is not yet implemented. We first present the wizard where the teacher adds a new LO to the system, then presents the student view of the system.

Figure 2: The wizard - Adding initial metadata.

In fig. 2 the teacher fills in metadata, partly by choosing from a list, partly by writing free text. In the existing version of the prototype, the metadata covered in this phase include: name, LO type, theory of learning, pedagogical method, type of learning activity and problem description. The question marks provide help to the user.

The next s tep is to a dd the l earning p art b y providing a U RL. We use design p atterns to d escribe the learning parts, by introducing the idea o f creating the metadata in s everal s teps. T he making of an L O with metadata will then be one process, instead of two separate parts w here one f irst cr eate t he l earning p art and then create the metadata.
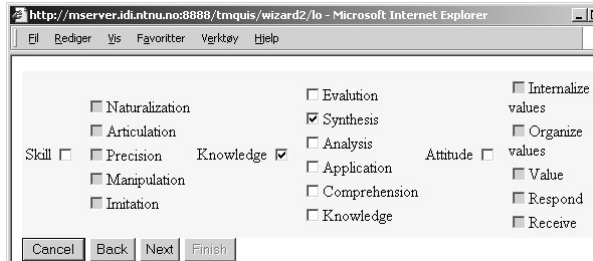

Figure 4: The wizard -defining learning objective type and taxonomy level.

The teacher must mark what learning objective type and taxonomy level(s) the LO covers (fig. 4). In fig. 5 the teacher fills in metadata covering solution, steering/ control, p articipation, c onstruction, lim itations and example usage [3]. After adding the metadata the teacher saves the LO (with metadata) to the topic map.
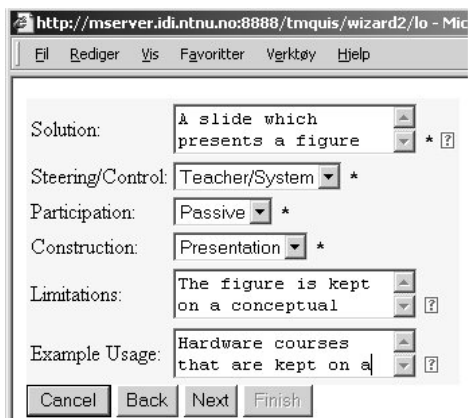

Figure 5: The wizard - Adding metadata.

Fig. 6 illu strates h ow th e s tudent currently experiences t he l earning environment; the chosen LO, which i s o f t ype " knowledge o bject" is shown o n the left side of the screen. All the links on the right side of the s creen en able s emantic-based n avigation b etween LOs. Currently, t he pr ototype pr ovides on ly a few navigation o pportunities (based o n t heory of learning and R OOs), b ut t he s tudent w ill i n t he f uture ha ve access t o LOs based o n e. g. pedagogical method, theme, media type, ranking score etc.

The second b lock o n t he r ight s ide o f t he s creen shows that t he k nowledge o bject " Central P rocessing Unit" is part of the resource organizing object (ROO) "CPU". I t a lso s hows t he o ther L Os i n the current ROO, in this case the knowledge object (KO) "Control Unit". I ts p urpose is to e nable navigation between objects in the r esource o rganizing o bject. T he t hird block s hows an d p rovides acces s t o all the ROO the KO "Central P rocessing U nit" is p art o f. T he lin ks enable the user t o c hange c ontext without leaving t he current knowledge object.

Figure 6: Example of topic map screenshot.
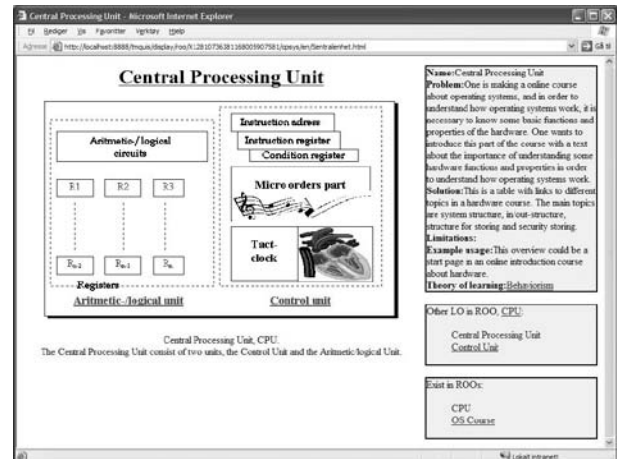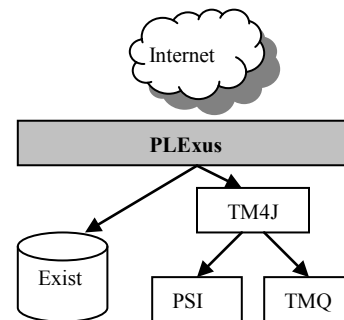
6. System overview

Figure 7: System overview

Explanation of fig. 7:
- "Exist" [11] is an X ML d atabase, which s tores r aw data without knowledge of metadata.
- TM4J [12]: T he T opic M ap en gine, i ntegrated through TM4Web [13].
- PSI: The Published Subject Identifier in topic maps.
- TMQ: The QUIS topic map with LOs and metadata.

6.1 The PSI Topic Map

A PSI (Published Subject Identifier) is necessary to ensure that the same topics are assigned the same topic names and should in the future be standardized by the educational field. An educational PSI must be made available via Internet. Such environments already exist within several subject areas. The PSI topic map is in our work of the PLExus prototype a local and temporal variant of a PSI.
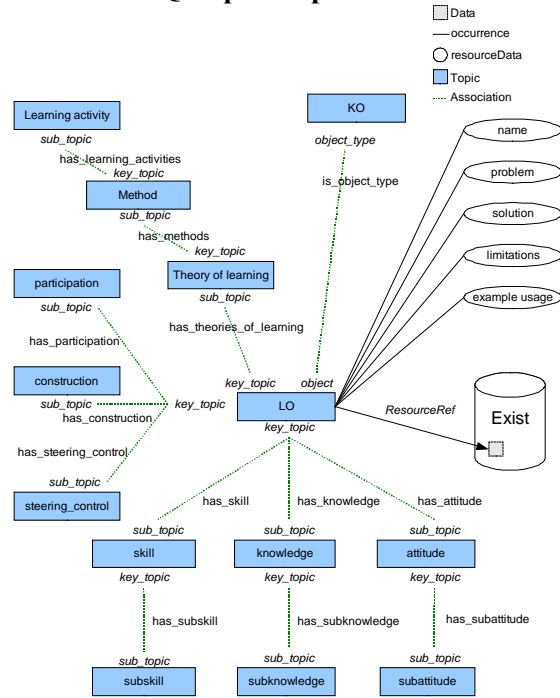
6.2 The TMQ Topic Map

Figure 8: A KO with a variety of associations.

TMQ (topic map QUIS) in fig. 7 is the topic map prototype containing the metadata for the subjects / raw data. Each LO has metadata directly connected to itself as resourceData in occurrences. The metadata (resourceData) is written and searchable in free text. The metadata will in the topic map-based user interface provide semantic navigation. There are five LO types; knowledge, monitor, test, tool and resource organizing object [3]. The first four of these will have similar constructions. The resource organizing object will in addition to similar associations also have a wrapper.
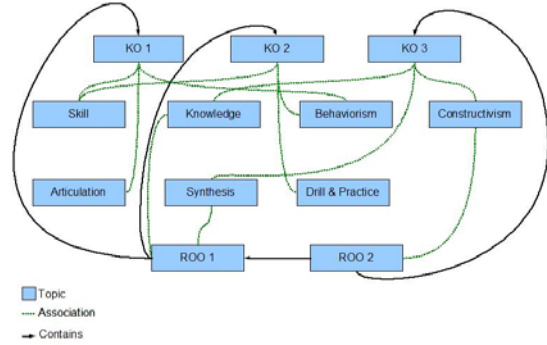
Figure 9: Example: The content of ROO2 is KO3 and ROO1 (existing of KO1 and KO2).

A Knowledge Object (KO) topic is an LO topic, pointing to the subject. It also has an association binding the topic to a common KO topic, identifying it as a KO and allowing easier access by queries. The second LO type implemented in the prototype is the resource organizing object (ROO). As the KO, the ROO is an LO associated to identifying topic. The ROO's function is to bind together several LOs, which could be other ROOs or KOs (fig. 9).

7. Conclusions

The article has presented PLExus, which is a prototype of a PLE realized with the topic map technology. The term "plexus" means "network", which very well describes a PLE based on the semantic technology of topic maps. Semantic-based navigation in e-learning will enable variation, differentiation and individualization, which are important factors developing a personal learning environment.

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A personalized E-learning Interface

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Abstract—The student g roup i s he terogeneous, and t o reach the goals of in dividualization a nd differentiation it is necessary t o f it e -learning t o t he different needs o f t he students. The article first d efines t he heterogeneity factors of the student group, and then describes how a n e-learning system must have a personalized interface enabling different student v iews / a ccess t o l earning o bjects a nd l earning activities.

Keywords—Learning s ystems, Personal L earning Environment, LMS, personalization.

I. INTRODUCTION

In a next ge neration e-learning system it must be possible t o personalize t he user i nterface. B eing ab le t o present a n online learning environment which covers the heterogeneous needs of a student group when it comes to e.g. d ifferent in telligences, d ifferent intellectual levels, different cultural background, there is n ecessary th at th e system is able to present personalized views / interfaces.

A. Definition of a PLE

PLE (Personal L earning E nvironment) is suggested as the next-generation e-learning system [1, 2]. The question so far is however; - What is really a PLE? Johnson et al. describes h ow d ifferent p ersons h ave different understandings of the concept "PLE", from "empowering users of i nformal l earning r esources aw ay f rom institutions" or "an extended portfolio" to "a superfluous accessory t o t he t echnologies o f the d esktop o perating systems a nd t he Wo rld Wi de W eb" [1]. The v ariety o f interpretation illustrates how diffuse the concept still is.

Our d efinition o f a P LE (Personal Learning Environment) is an online learning environment where the student is able to customize his / her learning environment based on pedagogical and personal choices.

II. THE HETEROGENEOUS STUDENT GROUP

The s tudent gr oup i s no t hom ogeneous, b ut i n gr eat extent heterogeneous. T o be able t o individualize a nd differentiate e -learning to a h eterogeneous s tudent g roup, it i s n ecessary t o f ind an d describe t he heterogeneity factors of the student group. We here focus on the theories of multiple in telligences [3], p roficiency s tages [4] and cultural di mensions [5] to de scribe i mportant heterogeneity factors in a he terogeneous s tudent gr oup. It is important that all these theories are considered together, not a lone. A ho listic approach i s ne cessary when describing the heterogeneous student group, avoiding that smaller p arts n ot a re v iewed as m ore i mportant t han necessary.

A. Multiple intelligences

Gardner's "Multiple intelligences" theory [3] provides a contribution to the discussion about who the learner is. In this theory he is defining eight different intelligences:

1. Visual / s patial in telligence: The ability to visualize and make mental maps. Persons using mind maps are using this intelligence.

2. Verbal / lin guistic in telligence: The a bility o f reading, writing and communicating with words. This in telligence is w ell d eveloped among writers, journalists, speakers etc.

3. Logical / m athematical in telligence: The a bility o f logical thinking, performing calculations and abstract thinking. M athematicians, e ngineers a nd l awyers often h ave a w ell-developed logical / mathematical intelligence.

4. Bodily / kinesthetic intelligence: The ability of body coordination and c onscious use o f o wn b ody a nd hands, - an a bility ty pically well d eveloped among athletes, dancers, actors and craftsman.

5. Musical / r hythmic in telligence: The a bility o f singing, p laying, c omposing and ha ving a go od musical e ar, u sually f ound a mong c omposers, conductors and musicians etc.

6. Interpersonal intelligence: T he a bility of understanding p eople a nd c ommunicating, us ually well developed am ong competent d iplomats, charismatic l eaders and among "persons that people like".

7. Intrapersonal intelligence: T he a bility o f understanding our "self".

8. Naturalistic intelligence: The ability to recognize and classify elements / patterns of the natural world [3].

The idea is that all persons have eight intelligences, but that some intelligences are better developed than others. It is t herefore possible t o us e t he kno wledge about a student's intelligences t o le t him/her f eel m astering, b ut also to give adequate challenges to improve weak abilities. It will in the future be important for e-learning systems to offer a v aried l earning e nvironment s upporting different intelligences to provide individualized learning.

B. Proficiency stages

Dreyfus ha s a nother a pproach t o t he vi ew o f t he heterogeneous s tudent g roup. He m akes a d ivision between different proficiency stages for learners, and claims t hat s tudents on d ifferent s tages h ave different needs. The proficiency stages are:

1. Novice
2. Advanced beginner
3. Competence

4. Proficiency
5. Expertise [4].

Despite d ifferent p rofessional competences, there ar e some ch aracteristics i dentifying a specific p rogress [6]. The "novice" needs models, rules and prescriptions, while an "advanced beginner" starts to recognize based on experience. With "competence" the user chooses a plan of progress t o r each the goa l b ased on i nstruction a nd experience, while with "proficiency" the theory connected with th e s kill w ill g radually b e replaced by s ituational discriminations acc ompanied b y as sociated responses. With "expertise" t he l earner not o nly s ees what ne eds to be done, but also sees how to achieve his goal.

C. Cultural dimensions

The c ultural dimension also needs t o b e c onsidered when d escribing t he s tudent gr oup. We m ay use Hofstede's f ive c ultural dimensions [5] in a n a ttempt to describe the heterogeneous student group;

1. P ower Distance I ndex: T he extent to w hich t he l ess powerful m embers of organizations and institutions (like the f amily) acce pt an d ex pect t hat p ower i s d istributed unequally.

2. Individualism v s. C ollectivism: T he d egree to w hich individuals are integrated into groups.

3. M asculinity v s. F emininity: T he d istribution o f r oles between the genders.

4. Uncertainty A voidance Index: A society's tolerance for uncertainty and ambiguity.

5. L ong-term v s. S hort-term O rientation: Thrift a nd perseverance versus respect for tradition, fulfilling social obligations, and protecting one's "face" [5].

E-learning i s often u sed as a m ean t o reach a l arger audience, and authorities often e ncourage students to study a t o ther i nstitutions / a broad, e .g. t he European Union i s i n the ongoing " Bologna process" w orking t o ease the mobility of students. This will in the future mean that w e p robably will in a l arger e xtent h ave a diverse student group also when it comes to cultural dimensions.

D. Combination of heterogeneity factors

To be able to i ndividualize and pe rsonalize learning, one ne eds to c onsider all t he h eterogeneity f actors presented a bove. I n a L earning Management System where l earning obj ects are presented i n s tatic s tructure (e.g. folder structure) this is hard. Table 1 illustrates parts of t he personalization c omplexity. Only considering Dreyfus' p roficiency s tages [4] combined w ith Gardner's "Multiple in telligences" [5] we g et a t wo-dimensional illustration of how many di fferent u sers one need to take into a ccount de veloping a n e -learning s ystem a llowing personalization, differentiation a nd i ndividualization. There c ould also be a dded a t hird d imension t o this problem, e .g. c ultural di mensions, and the complexity is then growing fast.

Dreyfus' stages:					
	Novice	Advanced beginner	Competence	Proficiency	Expert
Visual					
Verbal					
Logical					
Bodily					
Musical					
Interpersonal					
Intrapersonal					
Naturalistic					

(Gardner's intelligences:)

The described h eterogeneity f actors c an b e a h elpful framework f or t he t eacher p reparing a p ersonalized learning e nvironment, b ut i n a L MS where t he t eacher only have a static folder structure to help structuring the learning c ontent, i t is im possible t o create a l earning environment t hat a ppears a s a p ersonalized l earning environment t o t he s tudent. The c omplexity o f t he described h eterogeneity f actors w ill d emand a l arge amount o f l earning m aterial, an d there i s a danger of information o verload in a traditional L MS, b ecause the content structure is too limited.

The heterogeneity of the student group can be described by a va riety o f t heories, e .g. learning styles; media ty pe categorizations; active vs. pa ssive student roles; theories of d ifferentiation etc. Several of th ese th eories a re variations o ver a t heme. The h eterogeneity f actors described s eems in a l arge e xtent t o cover the mo st important factors in individualization.

III. PERSONALIZED VIEWS

A P LE m ust p rovide a s tudent i nterface allowing customized v iews o f th e learning obj ects a nd l earning activities. Examples of the students' views of the learning objects and learning activities could be views based on:

- Themes.
- Time.
- Pedagogical methods.
- Media type / intelligence.
- Proficiency stages.
- Learning objective.
- Student productions of learning objects / learning activities.
- Ranking score.
- List of l earning o bject recommended by t he system based on behavior of previous students.
- Guided learning paths produced by teacher.
- (Free text) search.

Many L MS (Learning M anagement S ystems) o f to day only allow one of these views, e.g. a theme structure of the content, or a ch ronologically s tructure o f t he co urse

content. This is not sufficient if the learning environment should provide individualization and differentiation.

A. Themes

One student view in the user interface may be based on themes. This requires a user interface where learning objects / learning activities are accessible through a topic directory, with hierarchical structure of themes, e.g. in an "English as a second language" course.

Example "English as a second language":
- Grammar
  - o Nouns
  - o Pronouns
  - o Verbs
- History
- Culture
- Literature

A thematic structure like this is often used in the learning management systems of today, which often allows structuring the learning objects into folders. A folder structure based on themes may be useful, but is not sufficient to cover the needs of a heterogeneous student group.

B. Time

Time should be an additional student view. The system may present learning objects / activities chronologically, where the student sees the newest learning objects / learning activities first. A student view based on time is especially useful when the student wants to find the learning objects according to the course run and the course's plan of progress throughout the semester.

Some teachers use a chronological folder structure in a LMS. This is problematic when e.g. a student wants to find a specific learning object, but is not sure when it is placed in the course.

C. Pedagogical methods

Learning objects and learning activities could also be accessible based on the pedagogical method used to reach the learning objective. This means that if a student has been working with a learning activity e.g. based on the pedagogical method "gaming", s/he should also be able to choose other game learning activities.

We choose to use Heinich et al.'s categorization of pedagogical methods [7]:

1. Presentation: "In the presentation method, a source tells, dramatizes or otherwise disseminates information to students. It is a one-way communication controlled by the source, with no immediate response from or interaction with students. The source may be a textbook, an audiotape, a videotape, a film, an instructor etc" [7]. Examples of computer-based tools possible to use for presentation are word processors, mind maps, concept maps, slide presentations, encyclopedias, maps, audio- and video-recorders.

2. Tutorials: "A tutor (in form of a person, computer, or special printed material) presents the content, poses a question or problem, requests a student's response, analyzes his / her response, supplies appropriate feedback, and provides practice until the student demonstrates a predetermined level of competency. Tutorial arrangements include instructor to student (e.g. Socratic dialog), student to student (e.g. tutoring or programmed tutoring), computer to student (e.g. computer assisted tutorial software), and print to student (e.g. branching programmed instruction). The pattern followed is that of branching programmed instruction, that is, information is presented in small units followed by a question or task. The computer analyzes the student's response (compared with responses supplied by the designer) and gives appropriate feedback. A complicated network of branches can be programmed. The more alternatives available to the computer, the more adaptive the tutorial can be to individual differences" [7].

3. Demonstration: "In the demonstration method, students view a real or lifelike example of the skill or procedure to be learned. The objective may be for the student to imitate a physical performance or to adopt the attitudes or values exemplified by someone who serves as a role model" [7]. Screen capture videos and animations are examples of how computer-based tools can be used for demonstration in an e-learning system.

4. Discussion: "As a method, discussion involves the exchange of ideas and opinions among students or among students and teacher. It can be used at any stage of the instruction / learning process, and in small or large groups" [7]. Computer-based tools for discussion can be divided into two main categories; synchronous and asynchronous tools. Examples of tools are chat, forums, sms, audio- and video conferences and e-mail.

5. Drill and Practice: "In drill and practice students are led through a series of practice exercises designed to increase fluency in a new skill or to refresh an existing one. Use of the method assumes that students previously have received some instruction on the concept, principle or procedure that is to be practiced… The drill and practice exercises should include feedback to reinforce correct responses and to remediate errors…". Drill and practice tools are e.g. multiple choice, drag and drop, match, memory and fill in blanks.

6. Cooperative learning: "Students can learn cooperatively not only by discussing texts and viewing media but also by producing media" [7]. Examples of cooperative learning tools are shared archives, application sharing and collaborative virtual environments.

7. Game-based learning: "Gaming provides a playful environment in which students follow prescribed rules as they strive to attain a challenging goal. It is a highly motivating technique, especially for tedious and repetitive content. The game may involve one student or a group of students" [7]. Alessi & Trollip categorize games into adventure games, business games, board games, combat games, logical games and word games [8].

8. Simulation: "Simulation involves students confronting a scaled-down version of a real-life situation… The simulation may involve participant dialog, manipulation of materials and equipment, or interaction with a computer" [7]. There exist different

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types o f s imulations: p hysical, it erative, p rocedural and s ituational s imulations [8] an d al l the d ifferent types can be useful in a learning situation.

9. Discovery: " The d efinition of d iscovery method: a teaching strategy that proceeds as follows: immersion in a real or contrived problem situation, development of hypothesis, te sting of h ypothesis, arrival a t conclusion. The discovery method uses an inductive, or inquiry, approach to learning; it presents problems to b e s olved th rough tr ial a nd e rror or s ystematic approaches" [7].

10. Problem s olving: "Problem solving i nvolves placing students in the active role of being confronted with a problem situated in the real world. Students start with limited kno wledge, b ut t hrough p eer c ollaboration and consultation they d evelop, e xplain, a nd defend a solution or position on t he problem. S tudents m ust examine t he d ata or i nformation presented, cl early define the problem, perhaps state hypotheses, perform experiments, ten re-examine the d ata and g enerate a solution. The c omputer m ay pr esent t he problem, process t he d ata, m aintain a d atabase, an d p rovide feedback w hen a ppropriate" [7]. Computer-based tools useful f or di scovery a nd pr oblem s olving a re survey tools, statistical tools, voting tools, qualitative research tools and search tools.

A personalized e -learning interface m ust pr ovide opportunities to vary the pedagogical methods, in order to meet the demands of the heterogeneous student group.

D. Media type / intelligence

Examples o f different m edia types ar e t ext, n umbers, audio, vi deo, i llustrations e tc. T he student should be able to choose learning objects / activities based on media type. This m eans t hat th e e-learning system should be a ble t o present all the audio learning objects, the video l earning objects, the textual learning objects and so on.

The multiple intelligences will demand different type of learning objects, e .g. the visual i ntelligence w ill d emand presentations, m ind m aps, concept m aps and g raphics, while the kinesthetic intelligence will demand simulations and motion sensitive tools.

E. Proficiency stages

Based o n Dreyfus' theory o f p roficiency s tages [4] described e arlier, t he s ystem a lso must p resent l earning objects / activities based on proficiency stage.

One student s hould be a ble t o access t he l earning objects c overing the no vice stage i f this i s w anted, while another student s hould be able to access learning o bjects covering the proficiency stage.

F. Learning objective

The s tudent s hould also be a ble t o a ccess l earning objects based on t ype o f l earning obj ective. D ifferent types o f l earning o bjectives c ould b e f ound i n t he m ain categories knowledge (cognitive learning objectives), skill (psychomotor l earning obj ectives) and attitude (affective learning objectives).

Based on well-know taxonomies there are also subtypes of learning objectives, that may b e considered when producing a personalized s tudent i nterface. Bloom's taxonomy for the cognitive do main [9] has the following subtypes; knowledge, c omprehension, a pplication,

analysis, synthesis and e valuation. K ratwohl's t axonomy of t he af fective d omain [10] has f ive s ubtypes: r eceive, response, v alue, organize v alues an d i nternalize v alues and subtypes of Dave's t axonomy o f t he ps ychomotor domain are im itation, m anipulation, precision, articulation, naturalization [11].

In addition it is possible to have one learning objective category cal led m eta-learning. Meta-learning i s t he s tate of "b eing a ware of and t aking c ontrol o f one's o wn learning" [12]. Learning management tools (e.g. calendar, learning pa ths, workflow t ools) and s elf a ssessment tools (e.g. pr e- and post-test, reflection tools etc) are tools that are helpful to reach meta-learning goals.

G. Student productions of learning object / learning activity

It is important that the student in a learning situation not only ha s the consumer role, b ut a lso may ha ve the producer role. The students often produce texts, web sites, mind maps etc. that also could be useful for other students. In an on campus l earning environment the students share lecture notes et c. and t he e -learning e nvironment s hould also a llow s haring o f s tudent pr oductions. B ecause of validation of t he l earning objects' quality, it m ust b e obvious for the students what learning objects are student-made an d w hat l earning o bjects are p roduced b y t he teacher.

H. Ranking score

If the e-learning system allows the students to rank the learning objects / le arning activities, it m ay a lso be possible to pr esent the l earning o bjects based o n t he ranking score, e.g. the learning objects with a high ranking score is presented before the l earning o bjects with a l ow ranking score.

Based on r anking scores t he e-learning system ma y recommend l earning obj ects t o a specific student, ba sed on s imilar p references o f f ellow s tudent. I f the student ranks a learning obj ect hi gh, the system presents learning objects th at s tudents w ith th e s ame r anking s core o f th e specific learning object also liked.

I. Learning object recommended by the system based on behavior of previous students

The s ystem s hould a lso r ecommend l earning obj ects based on t he be havior of t he s tudents. The s ystem may recommend a learning object to a student, based on earlier behavior and choices of fellow students.

J. Guided learning paths

In s ome cases i t w ill be useful for t he s tudents to get access to a workflow of learning objects / activities presented as guided l earning p aths produced b y t he teacher. The l earning pa th will b e c onsidered quality assured, since it is produced by the teacher.

K. Free text search

An ad ditional w ay o f a ccess t o t he l earning obj ect / activities should also be the possibility of free text search.

IV. HCI SOLUTIONS

A. Metadata

Implementing the different personalized student views described above requires a technological solution that save learning objects in such a manner that the learning object is saved one place but is retrievable in several semantic contexts. The student views described above also show that it is necessary to focus more on pedagogical metadata of learning objects.

According to a LOM survey report [13] metadata elements describing the intellectual content (Keywords, Classification [with Purpose = Discipline]) and the characteristics of the resource as media and Internet files (Technical Format, Learning Resource Type) are well-utilized. Metadata elements which attempt to describe the resource as a software "object" or to associate with it an educational context or level are much less frequently used (e.g. Life-cycle.Version, Aggregation.Level, Semantic Density, Context).

B. Manual vs automatic

There is a division between manual and automatic access to learning objects and learning activities. There has during the last years been conducted a lot of research and development within "adaptive user interfaces", with an objective to provide user interfaces that automatically adapt based on user behavior.

There are also HCI (human-computer interaction) solutions, which will make it possible to achieve personalization based on manual principles (the user make the choices based on a user interface that presents data semantically), e.g topic maps and semantic web.

C. Topic maps as HCI solution

Topic maps are an ISO standard - ISO/IEC 13250:2003. "A topic map is a technology for knowledge integration, describing concepts and their relations" [14].

A user-friendly, individualized and differentiated interface is an important feature of an e-learning system. Instead of presenting the learning objects and learning activities in one standard interface for all the students, an e-learning topic map could present "many roads to Rome", addressing the needs of the heterogeneous student group [15]. In an e-learning topic map the student is able to personalize the learning environment.

The requirements of a personal learning environment are complex, based on the different needs of a heterogeneous student group. A PLE is therefore in need of a powerful computer architecture, where it is easy to locate resources based on context and needs. There should also be a powerful search- and navigation system connected to the architecture. The architecture must ensure relevant, complete and consistent information. One example of this type of architecture is Topic Maps. Topic Maps are today acknowledged computer architecture and it is expected that it will be further developed with new functions and qualities.

For a PLE we need a system for administrating a certain amount of information which is in constant change, normally growing, and which also consists of a lot of different information that can be linked together in many different ways. That is, administration of complex information. In topic maps, metadata can be isolated and stored separately from the object, it will however still be closely connected to the object. Metadata will be central during information search.

We have developed PLExus [2], a prototype of a pedagogical-based PLE, built with the topic map technology. PLExus shows that it is possible to use the heterogeneous factors described in this article to ensure a personalized user interface based on pedagogical principles.

V. CONCLUSIONS

The article has presented how to define the heterogeneous student group, based on several pedagogical theories like multiple intelligences [3], proficiency stages [4] and cultural dimensions [5]. A personalized user interface must take all the heterogeneity factors into account, and we have presented different student views that should be implemented to create a personal learning environment that offers individualization and differentiation to every individual student.

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THE QUIS REQUIREMENT SPECIFICATION OF A NEXT GENERATION E-LEARNING SYSTEM

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ABSTRACT

The Q UIS r equirement s pecification of a ne xt ge neration e -learning s ystem was one of t he main out comes of t he European pr oject Q UIS (2005-06). T he ar ticle summarizes t he requirement s pecification a nd pr ovides e xamples o f functional requirements and use cases. The article also describes the experiences and the conclusions from the work of the requirement specification, with the aim of providing advice to system developers, content providers and researchers within the field of e-learning.

KEYWORDS

Educational software, LMS, personal learning environment (PLE), next generation e-learning, requirement specification.

1. INTRODUCTION

The main goals of work package 6 of the QUIS project [1] were to develop a requirement specification for a next generation e-learning system and to provide experience and advice to system developers, content providers an d r esearchers i n o rder t o en hance q uality within e -learning. T he r equirement s pecification attempts to clarify a nd co ncretize t he t erm "next g eneration e -learning s ystem", which la cks a c ommon understanding: The UNFOLD project claims that activity-based e-learning is the next generation e-learning [2], w hile o thers a rgue t hat mobile le arning is [3, 4]; t he P LE p roject s uggests t hat Personal L earning Environments will b e th e f uture [5]. The m ain f ocus o f t he Q UIS r equirement s pecification r eport i s t he pedagogical and technological parts of a next generation e-learning system, not the administrative part.

2. THE QUIS REQUIREMENT SPECIFICATION REPORT

The QUIS r equirement s pecification o f a ne xt ge neration e -learning s ystem [1] is a r eport divided in to s ix main parts: 1) project drivers (purpose, background and goals) and user description, 2) project and design constraints an d d efinitions, r elevant f acts an d as sumptions, 3) f unctional r equirements an d u se cas es, t he current situation and the methodology, 4) non-functional requirements with a main focus on how topic maps may r ealize a p ersonalized l earning e nvironment, 5) c onclusions, 6) a ppendix, with a ll t he us e c ases and requirements, together with the prototyping experiments and descriptions of the pilot projects.

The methodology us ed f or t he r equirement s pecification is ba sed on t he q ualitative grounded t heory approach [6,7], with br ainstorming s essions a nd i n-depth i nterviews a mong t he us er g roups (students, teachers and researchers), in addition to literature review in the pedagogy and educational technology fields.

Moreover, we have experimented with topic map prototypes and learning object metadata standards, and we have run pilot projects with online tutoring and online interactive learning arenas.

2.1 Functional Requirements

The specification includes about 70 functional requirements divided into six categories. The functional requirements are described using a template, inspired to the Volere template [8], consisting of "req. name", "req. number", "associated use cases", "description", "rationale", "sources", "fit criterion", "conflicts" and "dependencies" to other requirements. Sample requirements are shown in Fig.1 (from cat. "Quality assurance at the course level") and Fig. 2 (from "Content"). A description of the categories is reported right after Fig.1.

Requirement name: Quality assurance: Assessment phase
Requirement #: 6.3   **Use case #:** 12.1, 12.2, 13.1, 13.2
Description: Quality assuring the formative and the summative assessment of an online course.
Rationale:
1. Formative assessment (assessment for learning - is used to improve a student's learning process / learning outcome):
- Assessment of students pre-qualifications: Pre-test results diagnose the students' pre-qualifications in the subject and make possible the preparation of a differentiated learning environment, but can also be used to tell the student where pre-requirements are lacking. In the future it will be easier for the students to take courses at other institutions / countries. This may cause that the student group's pre-qualifications will differ in a larger extent than earlier. To ensure a learning environment covering the students' needs, an pre-test is helpful.
- Mutual student assessment: Feedback to / from fellow students can be valuable in a learning process.
- Self assessment: For individual self-monitoring (checking progress). Self-assessment is hard, and the system must provide help to the student in the self assessment process, e.g. provide keywords, methods etc
- Formative tests: Students uses tests as part of the learning process. The teacher does not get access to the results of the individual student, but get access to the average results.
- Visualize demands and criteria: It is important to try to describe the demands and the criteria of summative assessment. Other methods could e.g. be to hand out last year's student exam answers and ask the students to assess these results. Then the students get access to the grade the exam answers got.
- Visualize progression: It is valuable in the learning process to see your own progression. There is possible to plan for this, by keeping the first deliverable in the course, use video to film first try in professional training etc.
2. Summative assessment (assessment of learning):
- Student verification: In case of online exams, there must be a system to verify the student.
- Matching learning objectives and assessment: The assessment activities must be matched with the learning objectives, because the goal of assessment is to find if the student learned what was intended in the course.
- Guidance document to external examiner: In the case of exams, exercises, portfolios etc that are being assessed by external examiners the teacher should provide guidelines for the external examiner to follow in the assessment process.
- Transfer of assessment results to administrative systems: In the approving of exercises, group work etc the student get grades etc. These data should be easy accessible and easy to collect in order to transfer from the e-learning system to an administrative system. Some students don't finish the course in one semester, and continue the course in a later semester. Transfer of already approved work from an earlier semester to current semester is needed.
Source: Lauvås, P. (2003). *Vurdering for læring - viktigere enn eksamen (vurdering av læring).* Høgskolen i Østfold.
Fit Criterion: The system must allow the most important methods of formative and summative assessment: Assessment of students pre-qualifications, Mutual student assessment, Self assessment, Formative tests, Visualize demands and criteria, Visualize progression, Student verification, Matching learning objectives and assessment, Guidance document to external examiner, Transfer of assessment results to administrative systems.
Conflicts: None.   **Dependencies:** 1.1.1-1.3.5, 3.6, 4.2, 4.18

Figure 1: Example of a Functional Requirement "Quality Assurance: Assessment phase"

The description of the categories follows.
- **Assessment**: This category is partitioned into three sub-categories (knowledge, skill and attitude) based on learning objective types to be assessed. Each category is described by well-known taxonomies.
- **Content**: How the learning objects should cover different proficiency stages (from novice to expert).
- **Collaboration**: The collaboration requirements cover the need for awareness in a online learning environment, and describe how the "open source approach" should be utilized in collaboration. The perspective of the learner in a producer role, in addition to its more common consumer role, is covered here.

- **Teaching**: The teaching requirements describe how it is possible and necessary to vary teaching methods and media types to meet the demands of a heterogeneous student group.
- **Student / Learning environment**: Personalization of learning environment to the individual student.
- **Quality assurance at the course level**: QAS are implemented in every aspect of the academic institutions activities, from promotion of courses and enrollment of students till graduating students leave. We focus on quality assurance at a course level, on both the student and the teacher perspective. E-learning systems allow monitoring of quality and rapid adjustment of activities. The QAS should improve the course, leaving the students and teachers in control.

Requirement name: Proficiency stage - Novice

Requirement #: 2.10   **Use case #:** --

Description: The system shall satisfy the needs of the students on a novice stage.

Rationale: The student group is heterogeneous also when it comes to proficiency stages.

Dreyfus makes a division between different stages for students, and claims that students on different stages have different needs. The stages he has described are [Dreyfus 1998]: 1. Novice, 2. Advanced beginner, 3. Competence, 4. Proficiency, 5. Expertise. Despite different professional competences, there are some characteristics identifying a specific progress [Vavik]. The "novice" needs models, rules, prescriptions, while an "advanced beginner" starts to recognize based on experience. With "competence" the user chooses a plan of progress to reach the goal based on instruction and experience, while with "proficiency" the theory connected with the skill will gradually be replaced by situational discriminations accompanied by associated responses. With "expertise" the student not only sees what needs to be done, but also sees how to achieve his / her goal [Dreyfus]. There must be possible for the teacher to create learning objects and learning activities for the novice student.

Source: Dreyfus, H.L. (1998). *Intelligence without Representation*. http://www.hfac.uh.edu/cogsci/dreyfus.html
Vavik, Lars (2004). *Perspektiver på samarbeid og veiledning i nettbaserte læringsomgivelser* in: Sigmundson, Hermundur & Finn Bostad (Red.), Læring. Grunnbok i læring, teknologi og samfunn. Universitetsforlaget. Kap 6, ISBN 8215006302.

Fit Criterion: Are the following tools possible to create and use in the system: Wizards, road maps, templates, checklists, design patterns?

Conflicts: None   **Dependencies:** 2.11-2.14

Figure 2: Example of a Functional Requirement: "Proficiency Stage: Novice"

2.2 Use Cases

The requirement specification contains about 30 use cases, where scenarios are described, from both a student and a teacher perspective, covering ten categories of pedagogical methods [9].

Use case 7.2: Simulation – knowledge (teacher)

Username: Online teacher

Description: Teaching the law of dynamics (knowledge: application level) using simulation as pedagogical method.

Fit criterion: The system must provide tools to produce different types of simulations (physical, iterative, procedural and situational simulations).

Use case scenario: The teacher wants to teach the laws of dynamics and their usage to a student of first year of University. S/he opens the "learning activity wizard" and gets to choose wizards based on ten different methods (drill, presentation, tutorials, gaming, demonstration, discovery, simulation, discussion, problem solving and cooperative learning). S/he opens the "simulation wizard". S/he then chooses learning objective "knowledge" from {skill, knowledge, attitude, meta-learning}. S/he then chooses taxonomy "Bloom" from {Bloom, Anderson…}, then choosing the "application" level from {Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation}. S/he must specify what type of simulation s/he wants to use: {physical, iterative, procedural, situational simulations}. S/he chooses physical simulation and gets access to a number of physical simulations editors. S/he chooses a tool where s/he is able to create an environment of a physics experiment and where s/he can change the general physics parameters of the simulated world/experiment (gravity, air pressure, temperature …). Then s/he is able to insert 3D (or 2D) objects in the simulation (cannon, ball, target, hills ….). After saving the experiment definition s/he is able to set up a set of hidden parameters (gravity) that the student will have to find by calculating from data collected through the experiment. The teacher can also set up a set of "control variables" (e.g. cannon vertical angle) that the student can change to obtain the stated goal (e.g. hit the target). The teacher/system could insert some noise in the measures so that the student has to apply some statistics computations to fit the observed data with the physics formulas. The teacher then saves the new learning activity in a repository and activates the learning activity to the students.

Figure 3: Example of a use case with the teacher's perspective: "Simulation"

The categories of pedagogical methods mentioned above are: Drill, Presentation, Tutorial, Gaming, Demonstration, Discovery, Simulation (see Fig. 3), Discussion, Cooperative learning and Problem solving. Additional use cases are covering "collaborative annotation of tags", "assessment" and "meta-learning".

3. A HOLISTIC PEDAGOGICAL APPROACH

The main focus of the QUIS requirement specification is the pedagogical and the technological parts of a next generation e-learning system, not the administrative part. We have a holistic pedagogical approach, covering several theories of learning and (as mentioned in Sec. 2.2) a variety of pedagogical methods (ranging from "drill" to "problem solving"). The holistic pedagogical approach also covers different types of learning objectives, taxonomies and assessment tools, and defines the heterogeneous student group through multiple intelligences [10], proficiency stages [11] and cultural dimensions [12]. This approach also entails that a truly "user-centered" focus should be considered when building a system, rather than either a student-centered, or a teacher-centered one. The importance of keeping both a student and a teacher perspective was strengthened during the development of the requirement specification.

3.1 An Eclectic Learning View

Our requirement specification concludes that, to cope with the heterogeneity of the student group, a next generation e-learning system must be based on an eclectic learning view, without focusing on a single learning view e.g. behaviourism, cognitive constructivism or socio-constructivism, but drawing upon multiple learning theories, where a behaviourist as well as a socio-constructive learning perspective is accepted and considered necessary in a learning situation. The specific subject's distinctive characters allow a variety of pedagogical methods to be used to reach the learning objectives. Variation and differentiation, so important as pedagogical principles, are equally important within e-learning.

3.2 Personal Learning Environment

Such approaches require a personal learning environment. Johnson et al. [5] describes how differently the PLE concept is conceived: from "empowering users of informal learning resources away from institutions" to "an extended portfolio", to "a superfluous accessory to the technologies of the desktop operating systems and the World Wide Web". The variety of interpretation illustrates how fuzzy the concept still is. In our definition, an online PLE is an environment that the student can customize, based on pedagogical and personal choices. We concretize our definition of PLE through requirements, use cases, experiments and prototypes in the QUIS requirement specification report.

The needs of a PLE imply an e-learning architecture that must handle extensive information structures. We suggest topic maps as one way to achieve a personalized user interface. Based on the introduced e-learning ontology we have developed PLExus - a prototype of a pedagogical-based PLE based on the semantic technology of topic maps [1]. PLExus provides a wizard to add learning objects with metadata to the topic map. The topic map allows a personalized user interface where the student gets access to the learning objects from different points of view, based on e.g. pedagogical method, learning objectives, proficiency stage etc.

4. DISCUSSION

In the last years, Higher Education Institutions have increasingly been using Learning Management Systems (LMS), and our analysis of commercial and experimental e-learning systems concludes that LMSs "allow for the hand-crafted construction of courses that follow different pedagogical styles and that there are no specific automated tools available to help the teacher implementing more complex pedagogical settings" [13].

While the UNFOLD project focuses on activity-based learning [3], the learning design model [14] places the learning activity in the center. In our holistic pedagogical approach, a learning activity is just one of

several factors i mportant within e -learning. O ther factors th at are equally i mportant ar e l earning o bjects, assessment activities etc. The NKI-project suggests that mobile learning is the future [3], an argument with which we could agree if the technological solution was the main transition factor from one VLE generation to another. Focusing on pedagogy in addition to technology, mobile learning is one of several technological solutions that will find its place within the requirements of the QUIS specification. The QUIS requirement specification ag rees t hat p ersonalization i s a n i mportant factor in th e tr ansition to a new g eneration e - learning, based on different needs of the heterogeneous student group. We have, however, experienced that a pedagogical-based P LE r equires n ew ap proaches t o s tandardization o f l earning o bjects' metadata. T he pedagogical elements of the existing metadata standards are not extensively used [15]. In our experiment we use design patterns as a new metadata approach for learning objects [1], and this is interesting because it focuses on pedagogical elements, uses free-text and introduces the idea of creating the metadata in several steps. The pedagogical elements of our alternative metadata approach are:

- **Name:** a name o f t he p attern which c overs t he c ontent (problem a nd solution), meaningful a nd eas y t o remember, that should gives rise to association that are related to the described problem and solution.
- **Learning o bject t ype,** chosen a mong: knowledge o bject, t ool object, m onitor o bject, t est o bject an d resource organizing object [16].
- **Context**: The environment within the learning and use of this learning object is intended to take place.
- **Problem**: A de scription a nd ba ckground of t he pr oblem t hat t he l earning obj ect i s g oing t o s olve. T he problem is written in free-text, and should contain information about the context (additional information), the learner, the principal user(s) for which this learning object was designed, the typical age or level of the intended user, the learner's starting knowledge and the target knowledge.
- **Solution**: A description of the learning object - the solution to the problem. Solution is written in free-text, and specifies the learning object type, describes the required knowledge and learning object in detail.

A ne xt ge neration e -learning s ystem will b e a n o pen s ystem, where b oth s tudents a nd t eachers p roduce learning objects, learning activities and assessment activities that may be shared between institutions across nations. Marketing of learning objects could be done via PSI (Published Subject Indicators), available in the topic maps architecture. A PSI is necessary to ensure that the same topics are assigned the same topic names and should in the future be standardized by the educational field like it is currently happening in other fields.

There is a need for an "open source" collaborative development of learning activities, learning objects and assessment activities within e-learning. The "open source" mentality should be built into the e-learning systems to allow sharing among online teachers and online students.

A n ext ge neration q uality a ssurance s ystem (QAS) must a lso c over t he c ourse l evel, no t o nly t he administrative level of education. A course QAS must have both a student and a teacher perspective, and should be built into all parts of the e-learning system. A course QAS should be implemented for learning improvements, no t for c ontrol o f s tudents a nd t eachers. The Q UIS r equirement s pecification s uggests a course QAS based on four main phases: the planning, running, assessment (fig. 1) and evaluation phases.

5. CONCLUSION

The QUIS requirement specification provides a concretization of the vague concept of a "next generation e-learning system". The project has used the Bologna process of the European Union as a basis for the work and the QUIS requirement specification contributes with added value, by proposing new insights and input concerning the pedagogical quality within e-learning to the ongoing Bologna process and the e-learning field.

The Q UIS r equirement s pecification r eport i ndicates t hat a n ext generation e -learning s ystem m ust be based on an eclectic learning view to ensure variation and differentiation, which are important pedagogical principles within e -learning. A holistic a pproach to e -learning an d a n ecl ectic l earning view r equire a Personal Learning Environment where the online student customizes his / her learning environment based on pedagogical an d p ersonal ch oices. A next generation e -learning s ystem, l ike t he W eb 2 .0 [17], w ill b e a number o f s oftware s ervices p resented with p ersonalized v iews. T he Q UIS r equirement s pecification describes what s ervices ar e needed i n a t eaching an d l earning en vironment, b y d escribing 7 0 f unctional requirements a nd 3 0 u se cas es. Another ex perience from t he d eveloping p rocess o f t he r equirement specification is that a future e-learning system must focus on meta-learning ("the state of being aware of and

taking c ontrol o f o ne's o wn l earning" [18]). There i s also a n eed f or an " open s ource m entality" with collaborative development of learning activities, learning objects and assessment activities within e-learning. The P LE ar chitecture will handle ex tensive information s tructures. We suggest t hat a semantic t echnology like t opic maps co uld ach ieve a p ersonalized u ser i nterface, an d we p resent P LExus - a pr ototype of a pedagogical-based PLE. We have also experienced that the existing metadata standards for learning objects are not ideal in a pedagogical-based PLE. To ensure the use of the pedagogical elements we propose a n ew metadata approach for learning objects based on design patterns in the QUIS requirement specification. One of the future challenges within the development and use of topic maps within e -learning is to standardize a PSI (Published Subject Identifier) within educational technology to ensure that the same topics are assigned the same topic names.

ACKNOWLEDGEMENT

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Learning in an Ambient Intelligent Environment

Towards Modelling Learners through Stereotypes

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ABSTRACT. Ambient learning is an area that combines mobile learning, situated learning and context awareness, where the learners wish to learn anytime, anywhere and anyhow. The context of ambient learners is dynamic and they tend to engage in short bursts of learning, where the learning content must be adapted to the dynamic nature of their learning needs. One of the challenges of supporting such learners is the development of learner models that could be used to define the learning resources at any point in time. In this paper, we have considered stereotype modelling as a means of modelling ambient learners so that the learning resources could be quickly and efficiently adapted to the learner.

RÉSUMÉ. L'apprentissage diffus est un domaine qui combine l'apprentissage mobile, l'apprentissage situé et l'attention au contexte, et où les apprenants souhaitent apprendre à n'importe quel instant, n'importe où, et de n'importe quellle manière. Le contexte des apprenants diffus est dynamique et ceux-ci tendent à s'engager dans de courtes explosions d'apprentissage où le contenu de ce qui doit être appris doit être adapté à la nature dynamique de leurs besoins en apprentissage. Un des challenges pour aider de tels apprenants est le développement de modèles d'apprenants utilisables pour définir les ressources à tout instant. Dans ce papier nous considérons le stéréotype modelé comme un moyen de modeler des apprenants diffus de sorte que les ressources d'apprendre puissent être adaptées à l'apprenant.

KEYWORDS: Ambient learning, Context awareness, User modelling, Mobile learning. MOTS-CLÉS : Apprentissage diffus, Attention au contexte, Modélisation de l'utilisateur, Apprentissage mobile.

The E-learning Circle – a holistic software design tool for e-learning

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The article introduces the E-learning Circle, a tool developed to assure the quality of the software design process of e-learning systems, considering pedagogical principles as well as technology. The E-learning Circle consists of a number of concentric circles which are divided into three sectors. The content of the inner circles is based on pedagogical principles, while the outer circle specifies how the pedagogical principles may be implemented with technology. The circle's centre is dedicated to the subject taught, ensuring focus on the specific subject's properties. The three sectors represent the student, the teacher and the learning objectives. The strengths of the E-learning Circle are the compact presentation combined with the overview it provides, as well as the usefulness of a design tool dealing with complexity, providing a common language and embedding best practice. The E-learning Circle is not a prescriptive method, but is useful in several design models and processes. The article presents two projects where the E-learning Circle was used as a design tool.

Keywords: personalization; variation; e-learning; software design tool, grounded theory.

Introduction

Looking at research in the field, there are different opinions about where e-learning design will turn in the future. Some claims that activity-based e-learning is the next-generation e-learning (Griffiths 2004), while others argue that mobile learning (Dye et al 2005; Traxler 2006), personalization (Johnson et al 2006) or immersive digital games (Kickmeier-Rust et al 2007) is the next-generation e-learning.

There is a need for a holistic approach to e-learning, because the paradigms of instructional technology show how changing paradigms reduce the accepted models of instruction and instructional technology types (Koschmann 1996), which in turn reduce the opportunities for variation and individualization within e-learning. The holistic approach is also needed to avoid the overexposure of few parts of an e-learning system such as learning objects or assessment.

The study's main objective is to investigate how to assure the quality of the development process of e-learning applications by implementing pedagogical principles into the software design process, more specifically the pedagogical principles individualization, variation and meta-learning.

Quality assurance means in this study systematic and planned actions in order to ensure that the product should be suitable for the intended purpose and to eliminate mistakes. Quality assurance will improve the end user satisfaction and reduce mistakes during the software development.

The structure of the article is as follows; first the research method is presented, with focus on research design, data collection and data analysis. The E-learning Circle is then described with text and figures (sector by sector), and an explanation of the use of the E-learning Circle is provided. The article then continues with a presentation of two projects, where the E-learning Circle is used. The results and the trustworthiness of the study are discussed, and reflections upon the research method are provided. Finally the article concludes with an overview of conclusions and further work.

Research method

Research design

The problem statement of the study is exploratory and open-ended, and requires an exploratory design. The research method used to develop the E-learning Circle is Grounded Theory (Glaser & Strauss 1967, Strauss & Corbin 1998). The inductive, theory discovering approach of Grounded Theory, allowing the grounding of theory in empirical data, is appropriate for exploratory studies.

Data collection

The selection of research sites followed the technique of theoretical sampling, described as "data gathering driven by concepts derived from the evolving theory and based on the concept of 'making comparisons', whose purpose is to go to places, people, or events that will maximize opportunities to discover variations among concepts and to densify categories in terms of their properties and dimensions" (Strauss & Corbin 1998). The empirical data, upon which this article is based, were collected through interviews, focus groups, and expert groups.

Interviews

Interviewing as data collection method was performed throughout the whole study. The study consists of 21 face-to-face interviews with 23 interviewees. The selection criteria of interviewees were designed to cover the users' perspectives, including students, instructors, researchers and system developers.

The interviews were semi-structured, which means flexible, but based on a framework of themes to be explored. Questions were planned ahead, in order to find themes and open-ended questions and to prepare for flexibility during the interview. This was important in the exploratory study in order to allow new ideas and questions to emerge. The interviews lasted ca one hour and the interviews were recorded and transcribed.

Focus groups

The second method of data collection was the use of three focus groups, defined as "a small group of people assembled by a researcher to identify through informal discussion the key issues and / or themes related to a research topic" (Reitz 2004). The focus groups were arranged to collect data at an early stage of the study and each focus group consisted of 8-10 persons (students, teachers and researchers). The mix of user groups in the same focus group was avoided due to different interests, levels of 'expertise', and user needs.

The focus group sessions first consisted of a brainstorming session, where the focus groups got 'next generation e-learning' as clue, and then continued with a group discussion based on the ideas from the brainstorming.

Expert groups

The third data collection method was the use of three expert groups in a problem solving process. The expert group participants were system developers and researchers working on specific problems related to the emerging categories. The researchers were active contributors in the problem solving activities. The expert groups contributed to the development of three prototypes.

The first prototype was exemplifying how to implement best practice by developing wizards based on pedagogical design patterns (Kolås & Staupe 2004;

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Saatz & Kolås 2005). The second expert group developed the E-learning ontology (Kolås 2006) and the PLExus prototype (Kolås & Staupe 2007), which is a running prototype of a personal learning environment implemented in the semantic technology of topic maps. The third expert group developed a paper prototype using stereotype modelling to model ambient learners (Kofod-Petersen et al 2008), based on the emerging E-learning Circle.

Data analysis

Grounded Theory provides the researcher with analytical tools when analyzing the data in the iterative research process. "As grounded theorists, we begin our analyses early to help us focus further data collection. In turn, we use these focused data to refine our emerging analyses" (Charmaz 2005). In the processes of open, axial and selective coding (Strauss & Corbin 1998) tools like questioning, constant comparison, diagrams, and memos were valuable.

Open coding

During open coding concepts are identified and their properties and dimensions are discovered in data, then the concepts are categorized. There are three different ways to perform open coding; a word-by-word or line-by-line analysis, analysis of a sentence or paragraph and analysis of a document, observation or interview as a whole (Strauss & Corbin 1998). In the process of analyzing the interviews open coding was mainly performed by analysis of sentences and paragraphs. The open coding of the interview transcripts created a large number of concepts, e.g. 'Picking pedagogy', 'Choosing media type' and 'Freedom of relationships'.

The categorization of concepts also belongs to open coding, and is important in order to reduce the number of data units. We used in vivo categories (named by the respondents), e.g. 'me-learning', in addition to in vitro categories (named by the researcher) (Alvesson & Schiöldberg 2008) e.g. 'meta-learning'. The focus group participants together initialized the categorization of ideas / concepts during brainstorming, and during the discussion afterwards the categories and concepts were questioned and compared.

Axial coding

Axial coding is the process of relating categories to their subcategories (Strauss & Corbin 1998). Diagrams proved to be effective in the axial coding, relating categories to each other and to subcategories. Diagrams also provided visualizations, which were useful finding subcategories among the main categories. "Subcategories answer questions about the phenomenon such as when, where, why, who, how, and with what consequences" (Strauss & Corbin 1998). The process of questioning, in combination with diagrams, was productive in the analysis in order to move the productive and creative work further.

Selective coding

"Selective coding is the process of integrating and refining categories" (Strauss & Corbin 1998). In this analyzing stage the attention is focused on the key components, with the goal of reaching theoretical saturation and moving from categories to theory. The writing of memos was one useful tactic. Codes and their relationships are not obvious in the coding phases, and it has been useful to go back to the memos to find old ideas that appear in a new way after more research.

A second tactic was to find the core category among which as many other categories as possible are related to and which occurs frequently in the empirical data. In this project the core category for a long time was 'the student' and the initial version of the E-learning Circle presented the student in the circle's centre. After more research it was however obvious that 'the subject' as core category was more fruitful than 'the student' in order to cover the pedagogical principles of variation and individualization. 'The subject' as core category was hidden in the empirical data, as several interviewees claimed 'the student' to be the main focus. The 'student' category remains important, now as one of the circle's main subcategories, but the subject's characteristics were mentioned over and over again during the interviews. The importance of the subject's characteristics was not said directly, but came through during the analysis. The 'subject' became during the selective coding to be considered as the core category.

A third tactic was to draw diagrams or models of how the categories are related to each other. The E-learning Circle illustrates how the use of integrative diagrams was useful in this study. Diagrams were helpful in the analyzing process to visualize the relationships between categories and based on the selective coding's tactics the three sectors of the E-learning Circle emerged.

The E-learning Circle

The E-learning Circle is a contribution to the software design process of e-learning applications, more specifically a tool to ensure early focus on the pedagogical principles of variation and individualization, including learning, teaching and assessment. The tool visualizes the connection between pedagogical principles and technological solutions.

The E-learning Circle is presented with "Subject" at the centre (Figure 1), which includes both a specific subject (e.g. Object-oriented programming or English literature) and a complete subject field (e.g. Computer science or English). Then the circle is divided into three sectors (illustrated with different colours):
- Learning objectives,
- The student,
- The teacher.

Each sector has four levels, where pedagogy is the focus of the three inner circles turning to technology in the outer circle.
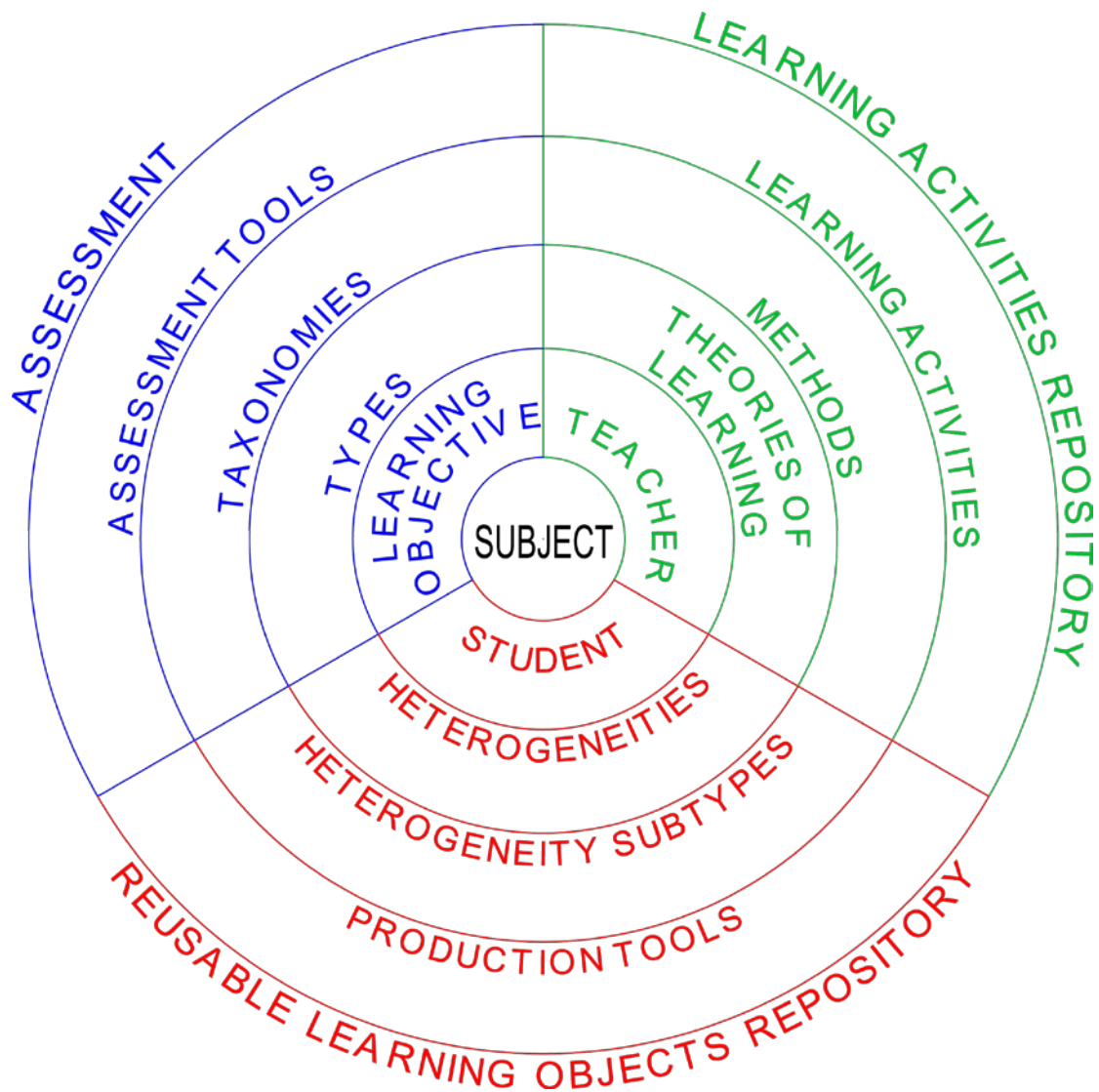
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Fig. 1: The main parts of the E-learning Circle. The centre of the circle is dedicated to the subject taught, and the E-learning Circle has three main sectors.

The "learning objectives" sector

The "learning objectives" sector illustrates the connection between learning objectives and assessment tools (Figure 2). The learning objectives are divided into four types; skills, knowledge, attitudes and meta-learning. The use of the terms skills, knowledge and attitudes are inspired by well-known taxonomies (Bloom 1956; Kratwohl 1964; Dave 1970). Meta-learning is the state of "being aware of and taking control of one's own learning" (Biggs 1985) and is added as a learning objective because also in e-learning settings it is important to focus on students' ability to 'learn to learn'.

The learning objective "Knowledge" is based on Bloom's taxonomy for the cognitive domain (1956), and has the following subcategories; Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. Several articles (Conole 2004; Conole 2005) have been formulating verbs that belong to each level in Bloom's taxonomy e.g. the verbs *reproduce*, *arrange*, and *memorise*, which belong to the knowledge level, while the verbs *categorize*, *combine*, *create* and *design* belong to

the 'synthesis' level. Similar categorization of verbs can also be found for other taxonomies, e.g. the taxonomies for the affective and the psychomotor domains.
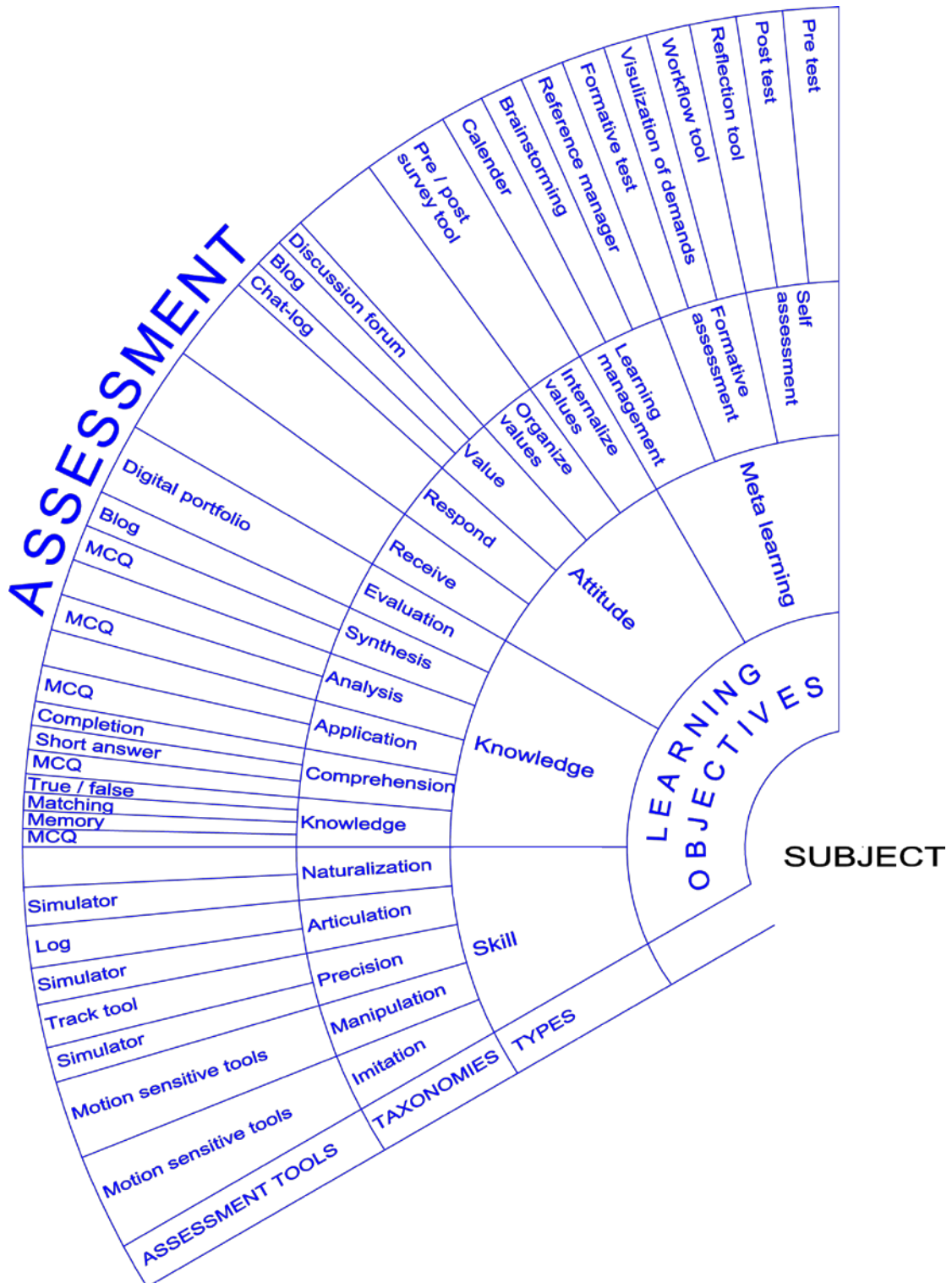

Fig. 2: The learning objective sector. The sector describes how the learning objectives via taxonomies are concretized into technological solutions.

The outer circle presents existing assessment tools to cover the assessment needs of different learning objectives on specific levels. A procedure to find existing

assessment tools covering the different learning objectives is to consider each verb mentioned at each level of the four learning objective types and then connect assessment tools to these, e.g. the verbs *reproduce*, *arrange* and *memorise* (from the Knowledge level of Bloom's taxonomy) have assessment tools like *short answer*, *match* and *memory* connected to them. This exercise is performed on each level of all the taxonomies and the results are shown in the E-learning Circle. Doing this exercise we find that it is necessary to develop more assessment tools within e-learning systems in order to assess the different learning objective levels.

The "student" sector

This sector contains elements that describe the student group's heterogeneity. The "student" sector is divided into the main categories "multiple intelligences", "proficiency stages" and "culture" (Figure 3). To be able to individualize e-learning to a heterogeneous student group we need to quality assure the production of learning objects based on all categories mentioned.
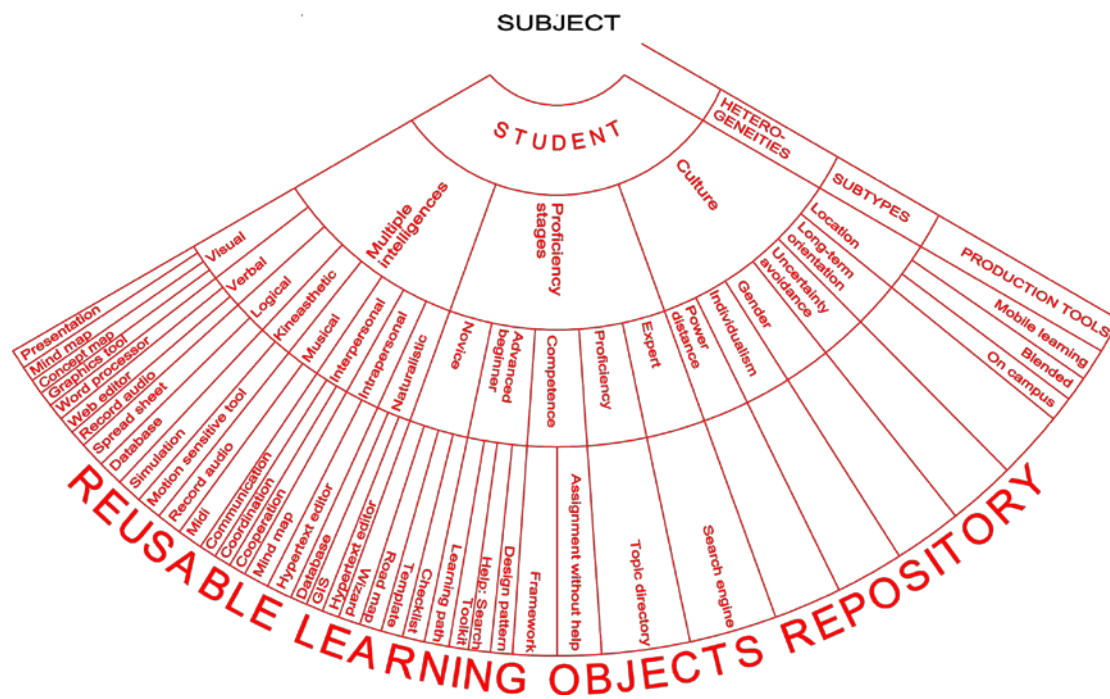

Fig. 3: The student sector. This sector describes how learning objects need to take into account the various needs of a heterogeneous student group.

The "multiple intelligences" theory (Gardner 1985) provided a contribution to the discussion about who the learner is. The theory defines eight different intelligences: the visual / spatial intelligence, the verbal / linguistic intelligence, the logical / mathematical intelligence, the bodily / kinaesthetic intelligence, the musical / rhythmic intelligence, the interpersonal intelligence, the intrapersonal intelligence and the naturalistic intelligence. The idea is that all persons have eight intelligences, where some intelligences are more developed than others. The student sector describes what production tools the different intelligences require. Producing learning objects for different intelligences requires a variety of media types and production tools. Learning objects for the visual intelligence can be produced in tools like presentation software, mind maps, graphics tool (raster and vector graphics) and

motion graphics tool (animation tool, screen capture tool, motion graphics tool and video editing tools). For the verbal intelligence we have tools like word processors, web editors, and tools to record audio. The logical intelligence needs tools like spread sheets, databases and modelling software.

The kinaesthetic intelligence has until now had few useful tools for e-learning, since simulators (e.g. a flight simulator) have been too expensive to use in e-learning settings. TV-games etc use cheap technology for kinaesthetic in-data with motion sensitive tools, where a web camera captures the user movements, which the system interprets and the user interacts with the system "waving" his hands. The e-learning systems also need to look to TV-games to satisfy the needs of the musical intelligence e.g. karaoke-systems that interprets if the singer hits the right tone. In addition there are midi tools to produce music. The interpersonal intelligence is covered by communication, coordination and cooperation tools (Studio Apertura 2006), while the intrapersonal intelligence is covered by tools like mind maps. The naturalistic intelligence is represented by tools like databases and hypertext editors.

The students also differ when it comes to proficiency stages; novice – advanced beginner – competence – proficiency – expert (Dreyfus 1998). The novice has different needs, e.g. need the help provided by a wizard, compared to a student on the advanced beginner stage, where e.g. a toolkit is useful, or the competence stage, where e.g. a framework is sufficient.

The cultural context also needs to be considered in e-learning. The E-learning Circle uses Hofstede's (2001) five cultural dimensions; Power distance index, individualism, masculinity, uncertainty avoidance index and long-term orientation. In addition, "Location" is added to the E-learning Circle because one of the main features of e-learning is the opportunity for learning "anywhere".

The "teacher" sector

The teacher facilitates e-learning, and will use a variety of pedagogical methods based on different theories of learning; Behaviourism, information processing theory, cognitive constructivism and socially oriented theories of learning (Koschmann 1996). Heinich et al. (2002) have specified ten main pedagogical methods. In this article two of them; problem solving and discovery, are merged. The teacher sector (Figure 4) illustrates the nine methods' relations to different theories of learning. Pedagogical methods are traditionally reusable, and the "teacher" sector shows how the pedagogical methods are implemented in an e-learning environment as learning activities, such as procedural simulation (Alessi & Trollip 2001), chat, animation etc.

The teacher sector illustrates that it is possible to vary the pedagogical methods also in an e-learning setting, and can make it easier to understand and accept that an e-learning system not necessarily needs to be dedicated to one learning theory (e.g. socio-constructivism) if the goal is to vary according to the different needs of the student group and the specific subject's characteristics. The teacher sector also makes it possible to detect what learning activity tools an e-learning system requires.
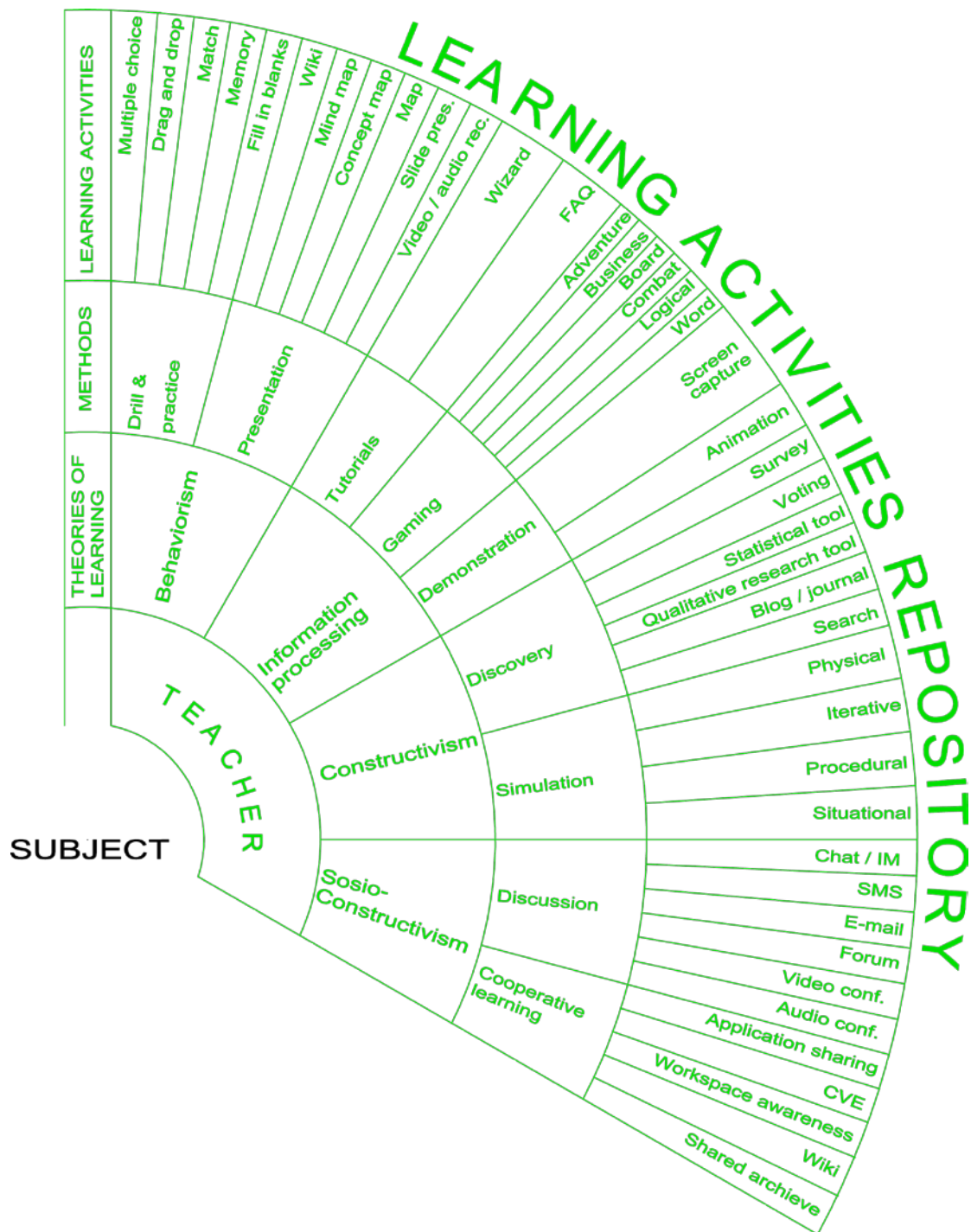
Fig. 4: The teacher sector. This sector implies an eclectic view of learning theories within e-learning, and emphasizes that different pedagogical methods must be used when designing learning activities.

Using the E-learning Circle as a design tool

The E-learning Circle's (Figure 5) main application area is to assure the quality in the design process of e-learning systems ensuring that new systems support variation and individualisation. This section describes how this can be done.
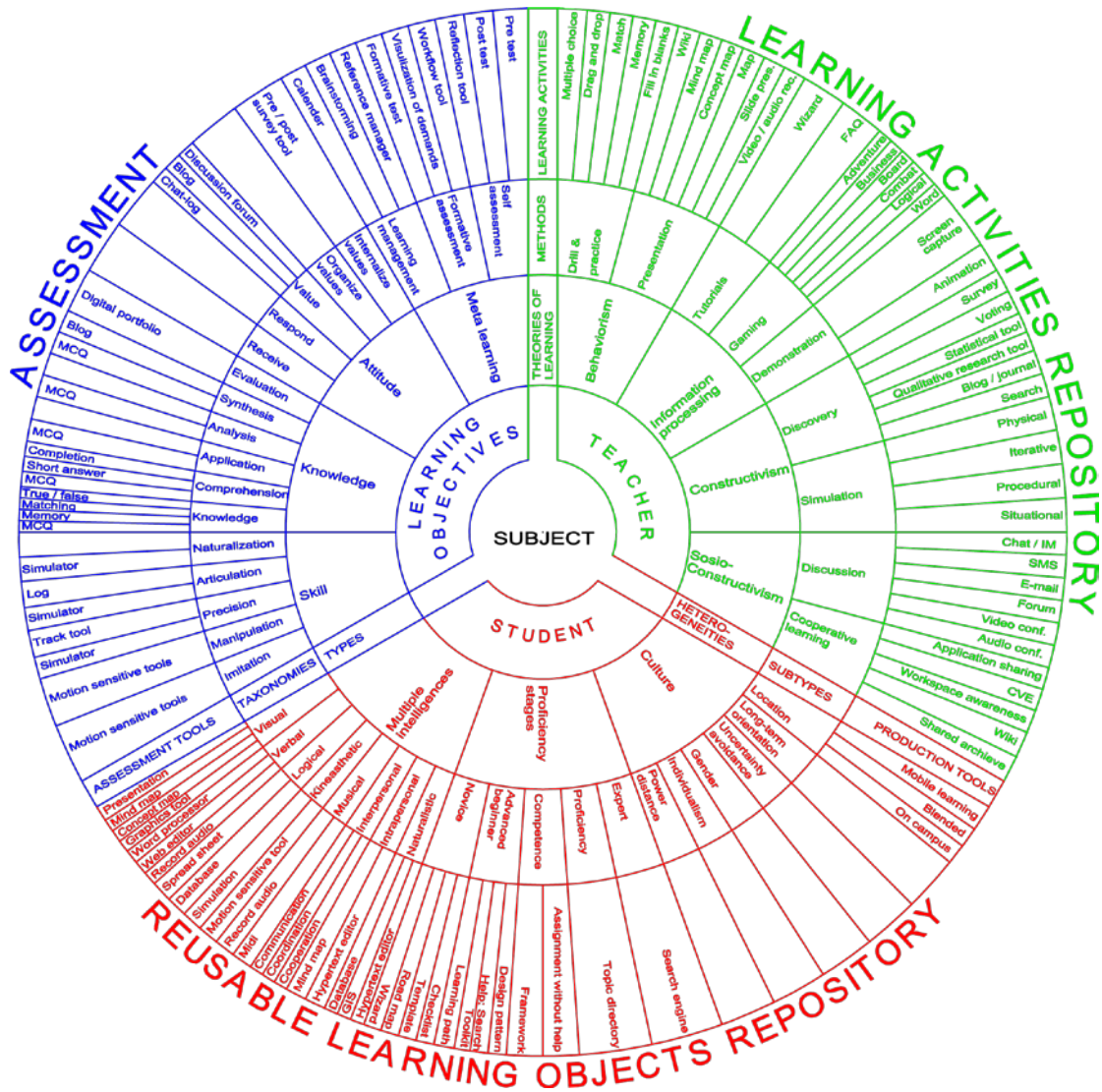
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Fig. 5: The E-learning Circle – A holistic approach to e-learning.

Dealing with complexity

The E-learning Circle is a tool dealing with complexity. Vendelhaven (2002) describes how mistakes, information loss, work duplication and misunderstandings are typical problems when the responsibility of segments is moved between persons. The E-learning Circle provides a systematic overview and merges both pedagogical principles and technological solutions, and as a design tool in the process of designing e-learning systems, this is useful dealing with complexity.

Bridging the gap – common language

In the design of e-learning systems IMS-LD (IMS 2003), a method for modelling learning processes, has been important the last years. IMS-LD critics concern reusability and the teachers' difficulties to use the specification (Downes 2003, Griffiths & Blat 2005). IMS-LD is not bridging the gap between teachers and software developers, as it is based on specifications from the software engineering field. "New tools and representations are needed if teachers are to intervene in editing

and creating units of learning" (Griffiths & Blat 2005). The E-learning Circle is an attempt to provide a tool, which can work as a common language between the teacher and the software developer, which in turn also will be helpful to succeed with participatory design.

Best practice
Best practice is a process or method that is more effective delivering a specific outcome than other processes or methods. The E-learning Circle has best practice embedded, e.g. the pedagogical methods and proficiency stages are best practice within instructional design.

Useful in several design models and processes
The E-learning Circle is not a prescriptive method, but a design tool, which may be used to support several processes, e.g. development of requirement specification, user modelling, interface design and choice of system architecture.

The use of the E-learning Circle is not connected to one specific software design model, but it supports different software design models in several phases. In agile methods, the E-learning Circle can be useful in costumer collaboration, which is valued in the Agile manifesto (Beck et al 2001). Using the Unified Process (Booch et al 1999) the E-learning Circle is useful from the perspectives of use case and design views, and specifically within the workflows of Requirements and Analysis and design. The 'Grimstad model' (Crossley and Green 1985) was an early software design model with focus on teachers as developers mainly focusing on smaller applications (lessonware), and in this model the E-learning Circle may be useful in phases of idea generation and goal formulation, as well as the phases of metaphor and market design. In prototyping the E-learning Circle is useful for e.g. requirements analysis, user modelling, choice of architecture and interaction.

Examples of use
The use of the E-learning Circle as a design tool of course depends on the software design model in use. The following sections describe the use of the E-learning Circle in two prototyping projects.

The PLExus prototype
In the process of theoretical sampling a prototype of a personal learning environment called 'PLExus' (Kolås & Staupe 2007) was developed. PLExus is based on the semantic technology of topic maps, a choice based on the emerging E-learning Circle. The semantic-based navigation of topic maps enables variation and individualization in e-learning through e.g. efficient context-based retrieval, customized views, information visualizations and deeper understanding of the domain conceptual relations (Dichev et al 2003).

To be able to develop a topic map it is necessary to build a topic map ontology, described as "the set of privileged topics and their characteristics, including associations between them" (Grønmo 2006) and a unique PSI (published subject identifier). PLExus was developed using the E-learning Circle in the requirement analysis and as a framework developing the e-learning ontology and unique PSI (Kolås 2006). PLExus provides a student interface allowing customized views of learning objects and learning activities based on pedagogical method, learning objective type, proficiency stage etc. An online wizard is provided to add metadata

and learning objects to the PLExus topic map. The choices provided by the wizard are directly connected to the E-learning Circle.

Stereotype modelling of ambient learners
The E-learning Circle is also used in the work of stereotype modelling of learners in an ambient intelligent learning environment (Kofod-Petersen et al 2008). The aim of this project was to use stereotype modelling as a mean of modelling ambient learners so that the learning resources could be quickly and efficiently adapted to the learner. The student sector of the E-learning Circle was specified by a set of facets with a value and a rating in the process of stereotype modelling, e.g. the facets of a spatial intelligent person are images, shapes and 3D-spaces, based on a person's capability of conjuring up mental images and transforming them, working with shapes and navigating in three-dimensional spaces.

The two developing projects both based the work on the E-learning Circle, despite the major differences of the systems. The PLExus prototype provides the student a user interface where learning resources are accessible in a web interface with multiple access opportunities. The ambient intelligent learning environment on the other hand will provide the student an adaptive interface. This shows that the E-learning Circle is not system dependent, but is able to contribute to the design process of a variety of e-learning systems.

Alternative application areas
Other application areas of the E-learning Circle are to evaluate existing e-learning systems and to quality assure development of e-learning courses.

Evaluation method
It is possible to use the E-learning Circle as an evaluation method, to evaluate existing e-learning systems in order to find the systems strengths and weaknesses and in order to compare e-learning systems based on pedagogical considerations. The drawback of using the E-learning Circle in evaluations is that such a process is reactive, while the use of the E-learning Circle in a design process is proactive. Advantages using the E-learning Circle as an evaluation tool are that the evaluation is independent of the evaluated system and that the evaluation will have a holistic approach.

Quality assuring instructional design
Newby et al (2006) define instructional design as "the process of translating principles of learning and instruction into plans for instructional materials and activities. The emphasis is on creating a plan for developing instructional materials and activities that increase an individual's learning". Examples of instructional design models are the ADDIE model, A.S.S.U.R.E (Heinich et al 2002) and rapid prototyping.

The E-learning Circle may also be useful for teachers, and can contribute to quality assure the course development in an online learning environment. "Many first-time users of VLEs (Virtual Learning Environments) seek to adapt the way that they work to the way that the software needs things to be done" (Britain & Liber 2004). As a tool in the course development, the E-learning Circle illustrates and provides a systematic approach to the teacher how it is possible to vary the learning based on the different needs of the heterogeneous student group when it comes to e.g. teaching methods / learning activities, multiple intelligences, proficiency stages and cultural background. The E-learning Circle also enables the teachers to evaluate their own practice and make their pedagogical choices more explicit and in addition it visualizes

the connection between theory and practice. The E-learning Circle makes teachers more conscious about the different aspects an e-learning course needs to cover, like identifying learning objectives and the needs of the students and selecting the most suitable teaching methods. The circle will then be useful e.g. in the process of ensuring individualization, variation and meta-learning in an e-learning environment.

The alternative use of the E-learning Circle to assure the instructional design quality may be seen together with rapid prototyping (Batane 2010), and the E-learning Circle can be regarded as a tool in the process of needs analysis within rapid prototyping.

Discussion

The E-learning Circle emphasizes the importance of content knowledge (knowledge about the subject taught) as a basis, which later is connected to pedagogical knowledge and technological knowledge (Koehler et al 2005) to achieve effective e-learning where learning resources, communication and collaboration take place via technology.

The pedagogical theories

The E-learning Circle uses specific pedagogical theories e.g. Bloom's (1956) taxonomy and Gardner's (1985) multiple intelligences. Some of these theories are controversial within the pedagogical field. The experience of this work, however, is that the theories are useful connecting technology to pedagogical theories. There is however possible to replace theories in the circle, for example the taxonomies used in the sector "learning objectives" could be replaced by Anderson's (2001) revised taxonomy for the cognitive domain, Harrow's (1972) or Simpson's (1972) taxonomies for the psychomotor domain. Such a replacement will not influence the outer circle in a large extent.

Also concerning the student there are many pedagogical theories; Coffield et al. (2004) identified 71 models of learning styles. Some of these models are alternatives on how to describe the student. The pedagogical discussion of different theories, e.g. student descriptions, is therefore not the main issue. The important issue is that we are able to describe the student and able to connect technology to these descriptions. This can be regarded as both a weakness and strength of the E-learning Circle. The strength is that the circle remains the focus on the subject's characteristics, and does not regard one pedagogical theory as the single most useful theory. The drawback is that the circle can be diluted if different users keep replacing the theories.

It can also be regarded as a weakness to use Dreyfus' (1998) proficiency stages since these originally are used in skill acquisition. In most learning situations the learners are on different stages in the learning process, and therefore Dreyfus' stages are used generically in the E-learning Circle. The E-learning Circle also shows that there are not many technological tools to support the fact that students are on different stages in the learning process, and indicates that more research should be conducted on these questions.

One may discuss whether meta-learning could be placed under 'skills'. Learning to learn, e.g. learning to work in groups, learning to give constructive critics etc. can be considered skills, but the E-learning Circle keeps meta-learning as an additional learning objective to face the challenges of e-learning in life-long learning. Adding meta-learning next to the traditional learning objective types (knowledge,

skills and attitudes) is one of the contributions to the e-learning field made through the E-learning Circle.

Reusability

Robson (2004) claimed that "context is the friend of learning and the enemy of reuse", and explains the problems of learning objects and reuse. The E-learning Circle suggests instead of specific context some generic student "types", similar to "personas", that we need to have in mind both when developing e-learning systems and when designing a course.

The E-learning Circle illustrates how learning objects must be retrievable for the students, based on different criteria like degree of difficulty, intelligence support and cultural dimensions. It is important that the learning objects are presented to the student without the danger of information overload. This is of great importance planning the human-computer interface of e-learning systems.

Individualization

One aim of the study was to implement the pedagogical principle of individualization and the question "Why is not the student placed in the circle's centre?" then becomes apparent. If the student is the main focus, many of the sectors would disappear. Focus on the subject taught is empirical-based and provides a holistic approach to e-learning, including learning objectives, assessment, student needs, learning objects, teaching methods and learning activities. The E-learning Circle implies an eclectic view of learning theories, and illustrates that different subjects have various characteristics and needs when it comes to learning theories and technology, but is still able to implement individualization.

Future predictions and the E-learning Circle

The UNFOLD project claims activity-based learning is the next generation e-learning (Griffiths 2004). The E-learning Circle shows that learning activities are just one of many factors that are important in e-learning.

Dye et al (2005) suggests that mobile learning is the next-generation e-learning. Their argument is understandable if the technological solution is the main factor in the transition from one generation to another. The E-learning Circle focuses on pedagogy connected to technology, and illustrates how mobile learning is one of many student group heterogeneities. If mobile learning is to be considered the next generation e-learning, it is important that lessons learned from computer-based learning are remembered when moving to another technological platform. The E-learning Circle can contribute to quality assure that pedagogical principles are covered also in a mobile e-learning environment.

Trustworthiness

Validating qualitative research is not as clear cut a matter as it is with quantitative research and some argue that the term 'validity' should not be applied to qualitative research (Thagaard 1998; Salomon & Vavik 2008). We prefer to use the term 'trustworthiness'.

To ensure credibility, we used Grounded Theory, a well-established research method within IS research (Orlikowski 1993; Pandit 1996; Urquhart 2001; Smit 1999). Triangulation also ensures credibility (Shenton, 2004) and this study uses

triangulation by data sources (Patton 2002). Accuracy is ensured as far as possible through the thorough description of the research process.

Data collection techniques

Wibeck (2000) argues that brainstorming is a technique which does not belong within the definition of focus groups, because it does not allow criticizing each other's ideas. The experience was, however, that brainstorming provided valuable data, encouraging creativity and creating new ideas. Data collection through focus groups was chosen because it provides multiple user perspectives, and because the group interaction allows creative ideas to thrive. This allows the researcher to 'step back' to a larger extent than in ordinary interview settings, because as focus group participants share insights and ideas, each individual member will respond, interact and continue the process. This was useful in an exploratory study in order to move ahead.

In this study, where focus is on how to improve the design process of e-learning systems, expert groups of software developers and the problem solving activities were valuable in order to stay close to the studied world (Charmaz 2005) and to provide data, which cover the intersection between pedagogy and technology. The aim of the study was to bridge pedagogy and software development, and expert groups were useful in order to bring pedagogical ideas into the situation of a software design process.

Dealing with literature

How to deal with the literature within Grounded Theory is often discussed, and Urquhart (2001) claims that "one of the oft quoted misconceptions about Grounded Theory is that the researcher does not do any literature searching", but emphasizes that the Grounded theory researcher has to relate to literature in a slightly different way to a conventional researcher. "So literature is used to help build the theory, and the substantive theory is related to the literature, but only once the substantive theory has been developed" (Urquhart 2001). The E-learning Circle includes well-known pedagogical theories, but these were included in a late stage of the development of the E-learning Circle and are based on the empirical data, where coding and comparisons revealed that the pedagogical theories were hidden in the empirical data.

Reflections on the Grounded Theory

The Grounded Theory divergence

Since the Grounded Theory approach originated with the work of Barney Glaser and Anselm Strauss in their book "The Discovery of Grounded Theory" in 1967, not only the two originators of Grounded Theory have moved in slightly different directions, but also other researchers have adopted and adapted the Grounded Theory, which has lead to alternative versions of Grounded Theory (Denscombe, 2003).

Smit (1999) describes the divergence between Glaser and Strauss, the two originators of the Grounded Theory method. "Strauss and Corbin mention that they set out to provide clear, straightforward, and basic information on the knowledge and procedures needed by researchers who want to build their first theory at a substantive level" (Smit, 1999). "Glaser argues that what Strauss and Corbin describe will not produce a Grounded Theory, but rather 'a forced, preconceived, full conceptual description, which is fine, but is not Grounded Theory' (Smit, 1999). Locke (1996) notes that there are no differences between Glaser and Strauss's positions on the key

analytical procedures (constant comparison and theoretical sampling) involved in Grounded Theory methodology. "However, they do write subsequently different renditions of researchers' relationships to the worlds they study" (Locke, 1996). "With the Glasarian approach the researcher allows the theory to emerge from the data, whilst the Straussian approach the researcher interrogates the data in order to arrive at a theory" (Smit, 1999). This research is inspired by the Strauss's version of Grounded Theory, based on the interpretive approach and the interrogation with the data.

Critics of the Grounded Theory

Critics of the Grounded Theory approach include the epistemological positions. Denscombe (2003) describes how Glaser's version is positivistic, while Strauss' version is interpretive. "Glaser's version rest on the belief that: (a) the researcher should maintain a distance and independence from the data; and (b) the meaning of the data will emerge inductively from the data if studied using a suitably neutral methodology... Contrasting with this, there is Strauss's version, which is more in line with interpretivism, in that the role of the researcher is to go looking for the meaning that the data hold, possibly probing beyond their superficial meaning" (Denscombe, 2003).

Pandit (1996) describes some of the problems with Grounded Theory; First, the Grounded Theory research is extremely time-consuming; second, the Grounded Theory research involves long periods of uncertainty. Third, Grounded Theory research requires certain qualities of the researcher e.g. confidence, creativity and experience. Accordingly, the novice researcher are likely to find the approach more difficult than more conventional methodologies and the more experienced researcher is likely to produce better theory" (Pandit, 1996).

One disadvantage using the Grounded Theory method is that "the approach does not lend itself to precise planning" (Denscombe, 2003). Not being strictly dependent on a plan created early in the project has been interesting, and our opinion this made the results of this project better. Grounded Theory is experienced as useful in this exploratory project, and instead of regarding no precise plan as a weakness of the method; this allows an exploratory and creative approach and strengthens the research project.

Also the fact that Grounded Theory allows a variety of qualitative data collection methods (e.g. interviews, observations, document analysis) is an advantage. Together with the rich tools and techniques, the method helps the novice researcher in the process of analyzing the data.

Grounded Theory research in IS

"Grounded Theory has been increasing in popularity in Information Systems as a research method. This is evidenced by the growing literature that is either discursive on philosophy and application or detailed about the method" (Hughes & Jones, 2003). Hughes and Howcroft (2000) point out that there are four inconsistencies in the understanding and application of the Grounded Theory method in IS research. First, the projects range from those concerned with organizational change to those concerned with the practical use of the method to inform knowledge based systems design. Second, some use the method prescriptively, whilst others use some of its procedures to supplement other research strategies. Third, the underlying assumptions made explicit by the researchers range from qualitative-interpretive to qualitative-

positivist and finally, Grounded Theory is used on its own or alongside other methods (Hughes & Howcroft, 2000).

Conclusions and further work

The aim of the study was to investigate how to assure the e-learning system design quality by implementing the pedagogical principles of variation, individualization and meta-learning. The proposed E-learning Circle is a tool in the design process of e-learning systems, bridging pedagogy and technology by providing a common language for teachers and system developers. It is also a tool dealing with complexity in the process of designing e-learning systems and has best practice embedded. The strengths of the circle are the compact presentation and the overview it provides. It does not only provide a pedagogical toolkit or a technology-based syntax, but in concrete terms illustrates the connection between pedagogical theories and technology. This is done by connecting specific technological tools to well-known pedagogical theories.

The E-learning Circle is not a prescriptive method, and may be used in different design models and different e-learning systems. This is exemplified by two projects; the PLExus prototype and stereotype modelling of ambient learners.

In the future it will be interesting to test the E-learning Circle in other design processes. Further work will also include making the circle user-friendly by designing questions belonging to each part of the sectors and by performing user tests.

There is a need for a holistic approach to the view of next generation e-learning, where the R&D focus must turn from small parts like "learning objects", "learning activities" or "mobile learning", to these parts understood in the relation to the whole. The E-learning Circle is such a holistic contribution to the e-learning field.

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Appendix B: Secondary papers (abstracts)

This appendix includes the abstracts of papers / reports I have contributed to, but fell outside the final scope of this thesis.

Kolås, L. and Staupe, A. 2006. "QUIS Requirement Specification for a next generation e-learning system", report, ISBN 978-82-8055-028-6, (http://www2.tisip.no/quis/public_files.php).

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QUIS Requirement Specification for a next generation e-learning system

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Abstract: The main goals of work package 6 were to develop a requirement specification for a next generation e-learning system and to provide experience and advice to system developers, content providers and researchers in order to enhance quality within e-learning. The QUIS requirement specification for a next generation e-learning system is divided into six main parts; 1) Project drivers, 2) Project constraints, 3) Functional requirements (and use cases), 4) Non-functional requirements, 5) Conclusions, 6) Appendix. The QUIS requirement specification includes about 70 functional requirements divided into the categories assessment, content, collaboration, teaching, student / learning environment and quality assurance. In addition, it contains about 30 use cases, where all scenarios are described from both a student and a teacher perspective. Qualitative methodology is used in the development of the requirement specification.

The main focus of the QUIS requirement specification is the pedagogical and the technological parts of a next generation e-learning system, not the administrative part. The QUIS requirement specification has a holistic pedagogical approach, and covers several theories of learning, pedagogical methods and learning activities. It also covers different types of learning objectives, taxonomies and assessment tools, and defines the heterogeneous student group through multiple intelligences and proficiency stages.
The QUIS requirement specification provides new insights within the e-learning research field. We conclude that a next generation e-learning system must be based on an eclectic learning view and not focus on a single learning view e.g. socio-constructivism. An eclectic learning view is important to ensure variation and differentiation, which are important pedagogical principles within e-learning.

A holistic pedagogical approach and an eclectic learning view require an online learning environment that provides possibilities for personalization. PLE (personal learning environment) has been suggested as a future goal within e-learning, but the concept of PLE has so far a variety of interpretations. Our definition of a PLE is an online learning environment where the student is able to customize his / her learning environment based on pedagogical and personal choices.

The need for a PLE within e-learning also entails that a next generation e-learning system must be based on other architectures than is found in existing learning management systems

(LMS) / virtual learning environments (VLE). A future e-learning architecture must handle extensive information structures. We suggest that topic maps could be one way to achieve a personalized user interface, and based on the introduced e-learning ontology we present a prototype of a pedagogical-based PLE.

We have also experienced that a pedagogical-based PLE requires new approaches to standardization of learning objects. Pedagogical elements of the existing standards are not extensively used. The experiment of using design patterns as a new metadata approach for learning objects is interesting because it focuses on pedagogical elements and uses free-text. An alternative learning object metadata standard that strengthens the pedagogical aspects is proposed.

We also conclude that there is a need for an "open source" mentality with collaborative development of learning activities, learning objects and assessment activities within e-learning. The "open source" mentality should be built into the e-learning systems to allow sharing among online teachers and online students. Marketing of learning objects could be done via PSI (Published Subject Indicators), available in the topic maps architecture.

The characteristics of a next generation quality assurance system (at the course level) are that it should be built into all parts of the e-learning system. A course QAS should be implemented for learning improvements, not for control, and must have both a student and a teacher perspective.

The QUIS requirement specification provides a concretization of the vague concept of a "next generation e-learning system". The project has used the Bologna process as a basis for the work and the QUIS requirement specification contributes with a European added value, by proposing new insights and input concerning the pedagogical quality within e-learning to the ongoing Bologna process and the e-learning field.

Online interactive learning arena over the internet

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Abstract: The paper describes the experiences and results from the pilot project called "Online interactive learning arena" at the Norwegian University of Science and Technology. The pilot project used an internet-based video conferencing system in a course with about 80 students. The system was used for online lectures, online tutoring and online group work, with focus on the integration of different media types (e.g. audio, video, text, shared whiteboard) and the interactivity possibilities between the lecture room and the distributed students (via e.g. shared applications, audio- and text communication). We experienced new communication possibilities compared to traditional learning environments, but also that nervousness in public communication via the video conferencing system was less than in traditional lectures. Another experience was that one should use the possibilities and added value of the technology as a starting point for the organization of the use, and not put technology in the same frames as traditional education. The pilot project was one of several experiments conducted in the QUIS project.

Online Tutoring
– distributed interactive learning arena with synchronous video and audio

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Abstract: "Online tutoring" was a pilot project carried out at NTNU in the spring of 2005. Through the pilot project online tutoring was fronted as an alternative to traditional tutoring of assignments. Traditionally tutors have been available in the computer labs for questions at specific times, which mean that the students explicitly had to go to the computer labs in order for their questions to be answered. Through the pilot project both the students and the tutors are distributed. They used a video conferencing tool called Marratech to communicate. The research project also considered experiences and results of the pilot project according to theories of Moore (1999) and Mantovani's (1996) conceptual model of social context.

Bruk av It's learning ved NTNU

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Sammendrag:
Målet med denne studien var å presentere et tidsbilde som viser bruken av It's learning ved NTNU våren 2007. Det er gjennomført to kvantitative studier og en kvalitativ studie. Tilgjengelig datagrunnlag er i hovedsak knyttet til lærer-initierte aktiviteter i It's learning, men viser i stor grad hvordan It's learning ble benyttet i vårsemesteret 2007, både med tall og tabeller fra statistikken generert i It's learning, men også med refleksjoner og betraktninger fra intervjuobjektene ved de ulike fakultetene.

Kvantitativ studie (del 1) presenterer bruken av It's learning ved NTNU våren 2007 i tall, diagram og tabeller. Datagrunnlaget er hentet fra statistikk som genereres i It's learning ved NTNU. Resultatene presenteres som total bruk av It's learning ved NTNU, bruk av It's learning i de ulike emnetypene (innføringsemner, grunnemner, videregående emner, masteremner, PhD-emner og EVU-emner) og bruk av It's learning ved de ulike fakultet og institutt ved NTNU. Kvantitativ studie (del 2) viser hvilke typer filformat og dokumenttyper som skjuler seg bak betegnelsen "filer" i It's learning.

Den kvalitative studien er basert på 18 ansikt-til-ansikt intervju med fagansatte ved ulike institutt ved NTNU, leverandør-representanter og en student. Intervjuene hadde som et hovedmål å få intervjuobjektene til å reflektere rundt pedagogisk bruk av It's learning i egen undervisning våren 2007.

Studien viser at It's learning brukes mer som et administrativt verktøy enn som et læringssystem ved NTNU. Intervjuene med faglærere viser et syn på It's learning om at dette er mer et emne-administrativt system enn et læringsfremmende system, sammenlignet med leverandørens syn på systemet om at dette skal være et pedagogisk system.

Det er en begrenset bruk av funksjonaliteten i It's learning. I hovedsak benyttes It's learning som et administrativt verktøy for å sikre informasjonsflyten til alle studenter og legge ut statiske filer. Den kvantitative studien viser at litt over 50 % av emnene har lastet opp minimum 1 fil i It's learning, mens 39 % av emnene har lastet opp flere enn 10 filer. 30 % av emnene har lastet opp i gjennomsnitt 1 fil pr uke og kun 16 % av emnene har lastet opp i gjennomsnitt 2 eller flere filer pr uke i vårsemesteret 2007. Det er også en generell tendens at dersom det ikke er lastet opp minimum 1 fil i et emne er det heller ikke benyttet andre It's learning-verktøy. Det er derfor mulig å antyde at ca 30 % av emnene har en jevn bruk av It's learning, selv om det er vanskelig å definere "jevnlig bruk".

De øvrige It's learning-verktøyene benyttes i liten grad. Diskusjonsforum, notat, pekere og oppgave-verktøyet brukes av ca 20 % av emnene ved NTNU, mens undersøkelser, tester, tekstsamlinger, forklaringssekvenser og konferanse-verktøyet benyttes av mellom 7 % og 0,2 % av emnene. Tallene viser liten bruk av diskusjonsforum og konferanser, og tyder på at It's learning ikke benyttes som en toveis kommunikasjonsløsning ved NTNU. Den kvantitative studien viser også at det ikke er sammenheng mellom stor bruk av ett It's learning-verktøy og stor bruk av de øvrige verktøyene.

Den kvantitative studien viser også at alle fakultet har tatt i bruk It's learning i større eller mindre grad, og at det kun er et fåtall institutt hvor ingen emner har benyttet It's learning våren 2007. Over 60 % av emnene ved NT- og SVT-fakultetet har aktivitet i It's learning. Lavest bruksfrekvens har DMF og AB-fakultetet med aktivitet i under 40 % av emnene.

Emnene ved NTNU er forskjellige blant annet med hensyn til læringsmål, antall studenter og om studenter er daglig on campus eller om de er distribuert over hele landet. I tillegg har noen emner studenter ute i praksis store deler av studietiden. Med hensyn til de ulike emnetypene benyttes de fleste It's learning-verktøyene (notat, pekere, filer, oppgaver, tekstsamlinger, forklaringssekvenser og konferanser) i gjennomsnitt mest i EVU-emnene, mens diskusjonsgrupper i gjennomsnitt pr emne er mest benyttet i grunnemner (bachelor) og tester i gjennomsnitt er mest benyttet i profesjonsemner.

Den kvalitative studien hadde fokus på de pedagogiske prinsippene variasjon, individualisering, differensiering og metalæring. Variasjon ble ansett som et viktig pedagogisk prinsipp, men først og fremst i undervisningen i auditoriet, ikke i It's learning. Med hensyn til bruk av ulike pedagogiske metoder viser den kvalitative studien at presentasjon er den pedagogiske metoden som benyttes mest i It's learning ved å legge ut skriftlige, billedlige og videobaserte presentasjoner. I tillegg benyttes utforskning / problemløsning i noen grad. De øvrige metodene f.eks spill, simulering og samarbeidslæring benyttes i svært liten grad. Studien viser også at It's learning ikke benyttes som et PLE (personal learning environment) for å individualisere og differensiere undervisningen. Dette kan nok begrunnes i at systemet ikke er laget som et PLE, men også fordi ansatte ved NTNU delvis ikke ønsker å individualisere undervisningen på universitetsnivå og at de ikke ser mulighetene for å bruke It's learning for å gjøre dette.

Ingen institutt ved NTNU har retningslinjer om felles menystruktur ved instituttet, og intervjuene viste at mange emner har menystrukturer som er lite planlagt og gjennomtenkt. Menystrukturene var delvis kronologisk, mediebasert og tematisk strukturert. Enkelte beskrev at faglærere og studenter hadde problemer med gjenfinning av informasjon i It's learning.

Intervjuobjektene hadde problemer med å beskrive funksjonalitet som de savnet i It's learning, selv om spesifikke funksjoner som synkrone konferanseverktøy (med applikjsonsdeling og videokonferanse) og formeleditor ble etterlyst. De fleste hadde lettere for å kritisere enkelte funksjoner i dagens system. Intervjuene viste at It's learning ble sett på som et noe ustabilt system. Det ble også tydelig at enkelte mangler tillit til sikkerheten og driftssikkerheten til It's learning.

Ressursmangel / mangel på tid kan betraktes som delvise grunner til at It's learning ikke brukes mer enn det gjøres i mange emner, men synet på It's learning som et emne-administrativt system begrenser også faglærernes jakt etter pedagogiske muligheter i systemet.

Multiple pedagogical methods in an LMS – a qualitative study

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Abstract: The paper aims to describe the use of multiple pedagogical methods in the LMS 'It's learning' at NTNU some years after the implementation phase of the system and is based on interviews of instructors in higher education. The pedagogical methods discussed are; drill and practice, presentation, tutorial, gaming, demonstration, discovery, problem solving, simulation, discussion and collaborative learning. Among my respondents, text-, image- and video-based presentations are the pedagogical method most commonly used in the LMS. Discovery and problem solving are also methods that to some extent are used. Other methods, such as gaming, simulations and collaborative learning, are not much in use. Variation of pedagogical methods is not a main focus among the respondents.

The representatives from It's Learning Ltd argue that It's learning is a learning system. These intentions are not much worth as long as the use of the system is developed in each course. If It's learning should be used as a learning system in the future, it requires not only focus on training in the use of the LMS, but also focus on ICT-pedagogical development. The Norwegian Ministry of Education and Research pointed out in their 'quality reform' that ICT should be used as a tool to improve teaching and learning. This paper describes how the goals of pedagogical use of It's learning are not yet reached. The paper shows that there may be a didactic potential with respect to the pedagogical use of LMS tools in higher education.