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Bridging the Gap between Learning and Teaching by Using Knowledge- Based Systems

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ACTA
UNIVERSITATIS
UPSALIENSIS
UPPSALA
2011

ISSN 1652-9030 0346-5462
ISBN 978-91-554-8163-6
urn:nbn:se:uu:diva-159135

Dissertation presented at Uppsala University to be publicly examined in Hörsal 2, Ekonomikum, Kyrkogårdsgatan 10, Uppsala, Wednesday, November 2, 2011 at 13:15 for the degree of Doctor of Philosophy. The examination will be conducted in Swedish.

Abstract

Akrawi, N. K. 2011. Bridging the Gap between Learning and Teaching by Using Knowledge-Based Systems. Acta Universitatis Upsaliensis. *Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Social Sciences* 72. i–viii, 89 pp. Uppsala. ISBN 978-91-554-8163-6.

The aim of this thesis was to enhance the learning and teaching in educational organizations by using knowledge-based systems. In the last few decades, considerable interest has been exhibited in applying information and communication technologies in educational settings in an attempt to enhance the process of learning and teaching. Surprisingly, however, a modest amount of attention has been directed towards supporting active learning and to accommodating different learning styles.

Different knowledge and reasoning strategies have been studied to determine, whether, and how they could satisfy users' learning styles. Moreover, on the basis of the pedagogical aspects identified, a knowledge-based system was designed to help students to learn about the subject actively and in the way they prefer. Through this system, students are able to choose different representation forms of the domain knowledge and can evaluate their understanding through the differentiated feedback given by the system.

In conjunction with the development of new information and communication technologies, the demands on teachers' didactical skills are also increasing. Adopting a student-centered approach can require teachers to reevaluate their teaching strategies and their leadership style because teacher takes on a different role to that of traditional teaching. Two knowledge-based systems have been designed to provide teachers with differentiated feedback enabling them to reflect on their current teaching strategies and leadership style in an active and individualized way.

The result of the research is the design of knowledge-based systems to bridge the gap between learning and teaching using knowledge-based systems. A conceptual map united all the important pedagogical aspects related to student-centered learning in making it possible to visualize these aspects and the relation between them. This conceptual map makes a meaningful contribution to designer's understanding of the way the systems support students' learning and, therefore, can be used as a guide when designing knowledge-based systems for learning. Students and teachers can also benefit from it by obtaining a common understanding of learning and some of its underlying concepts. This kind of awareness can bridge the gap between teaching and learning, and also advance educational organizations in the move towards the adoption of student-centered learning environments.

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ISSN 1652-9030

ISBN 978-91-554-8163-6

urn:nbn:se:uu:diva-159135 (<http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-159135>)

This thesis is dedicated to:

***Former Prime Minister of the Kurdistan Regional Government,
Mr. Barzani, Martyr Sheikh Yazdin, and my family.***

Shawkat Sheikh Yazdin was Minister of the Council of Ministers' Affairs of the Kurdistan Regional Government in Northern Iraq. He kindly assisted me in the search for financial sponsoring for my doctoral studies. Mr. Sheikh Yazdin was killed on February 1st 2004 in a suicide bomb attack in Erbil, Northern Iraq.

ACKNOWLEDGEMENTS

This dissertation is an end of a long and exciting journey, however, it would not have been easy to travel this long and challenging road alone. There have been some very dedicated individuals who assisted and guided me through this thought-provoking journey. Although, it is not easy to name each and every one of them, I feel compelled to mention those without whom this study could not have been accomplished. I would like to apologize if I forgot anyone.

I would like to express my deepest and most sincere gratitude to my supervisor Dr. Anneli Edman who gave me confidence and support in writing my master's thesis. Later, she guided me through my doctoral studies. Dr. Edman has not only supervised my master's thesis and doctoral dissertation, but has also welcomed me into her Swedish family. She and her parents made me a part of their loving family. I hardly can find words to thank them enough.

I owe my most sincere gratitude to co-supervisor Dr. Anne Håkansson. Her extensive knowledge, understanding, encouragement and guidance made my journey not only possible, but also blissful.

I also want to express my heartfelt thanks to Professor Andreas Hamfelt, my former supervisor for his encouragement and thoughtful guidance.

In addition, I wish to extend my deep and sincere thanks to Professor Else Nygren, Pär Ågerfalk, Dr. Jenny Eriksson, Dr. Lars Oestreicher, Dr. Stefan Hrastinski, doctoral student Fredrik Bengtsson, Sofia Brynste for constructive feedback. Furthermore, I would like to thank senior lecturers Torsten Palm, Dr. Mats Cedvall, Dr. Mats Nordström, Professor Vladislav Valkovsky, Professor Mats Lind, Dr. Lars Ostericher,, Dr. Göran Svensson, Dr. Amelie Hössjer, Dr. Christina Keller, and doctoral student Tobias Nyström for their help and encouragement. I also owe a special thank you to Lars Forsberg for his support, kindness, and advice. I am greatly in debted to Inga-Lill Haglund, Maria Frisch, Anders Petersson, Jens Personson, Ruth Lochan, Christian Sandström, Carina Boson and Cecilia Strand.

My warm gratitude goes to the head of department, Professor Mats Edenius as well as to the former heads of department Professor Andreas Hamfelt and Professor Bo Wallentin for their understanding and support. I also wish to express my thanks to the administrative and technical staff, Gunilla Klaar, Ann Skogh-Gunnarsson, Anna-Lena Torstensson-Kåberg, Tina Kekkonen,

Barbro Funseth, Ingrid Lukell, Eva Enefjord, Lars-Göran Svensk and Pierre Hjälms.

I am also deeply grateful for the support and encouragement I received from the Interior Minister of Kurdistan Regional Government, Mr. Karim Sinjari.

Additionally, I would also like to thank Prof. Roger Wiemers, Prof. Kirmanj Gundi and Dr. Pritchett at Tennessee State University, USA, Dr. Mohammad Sadik, former president of Salahaddin University in Kurdistan, Iraq, for sharing their knowledge and writing papers with me.

My special thanks go to Professor Ahmed Dizeye president of Salahaddin University and all of my friends and colleagues at this University.

I particularly, owe my heartfelt thanks to my sons, Lewend and Sehend. Without their love, patience, encouragement, and understanding it would not have been possible for me to finish this work. I would also like to send my gratitude to my family, specially my loving mother and sister, who took care of my sons when I was abroad working on my doctoral program. I thank all my friends and relatives for their understanding and patience over the past years.

Moreover, I want to particularly express my deepest regards to martyr Shewkat Sheikh Yazdin and former Prime Minister of Kurdistan Regional Government, Mr. Nechirvan Barzani who offered their support and encouraged me to follow my dreams. I can hardly thank Mr. Barzani enough for his generous morale and monetary support. Without his support, it would have been hard for me to make this dream a reality.

List of Papers

This thesis is based on the work conducted for the following papers:
(Note: I have changed last name from Mayiwar to Akrawi.)

- I. Mayiwar, N. (2005) Aspects of Consideration when Designing Educational Knowledge Based Hypermedia Systems. *Proceedings of Knowledge-Based and Intelligent Information & Engineering Systems, the 9th International Conference, KES'2005*, LNCS/LNAI, Springer-Verlag, Heidelberg, Germany, ISBN:3-540-28894-5, LNAI3681-II, pp. 393-402.
- II. Mayiwar, N., and Håkansson, A. (2004) Considering Different Learning Styles when Transferring Problem Solving Strategies from Expert to End Users. *Proceedings of Knowledge-Based and Intelligent Information & Engineering Systems, the 8th International Conference, KES'2004*, LNCS/LNAI, Springer-Verlag, Berlin, Heidelberg, Germany, ISBN:3-540-23318-0, LNAI3213-I, pp. 253-262.
- III. Edman, A., and Mayiwar, N. (2003) A Knowledge-Based Hypermedia Architecture Supporting Different Intelligences and Learning Styles. *Proceedings of the Eleventh PEG Conference, Powerful ICT-tools for Teaching and Learning. (CD-Rom) PEG-2003*. St. Petersburg, Russia.
- IV. Mayiwar, N., Pritchett, W. P, Edman, and A. Wiemers, R. (2005) Improving Leadership Styles Using Technology: A Discussion. *Journal of Interdisciplinary Education (JIE)* Vol. 7, No. 1. ISBN: 1092-7069, pp. 209-237.
- V. Mayiwar, N., and Edman, A. (2007) Mentor - a Knowledge Management System Supporting Teachers in Their Leadership. *Proceedings of the 2nd International Conference on Network-Based Education-NBE2007^h*. University of Lapland Press, ISBN 978-952-484-102-3, pp. 125-138.
- VI. Akrawi, N. (accepted) Enhanced Teaching Strategies- Elicitation of Requirements for a Support System for Teachers. 7th-10th April 2010. *In-*

ternational Conference on Computer Supported Education. Valencia, Spain.

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Other Publications:

1. Edman, A., Ericksson-Lundström, J., and Akrawi, N. (In press) Towards Context-based Explanations for Teacher Support. *CONTEXT '11: The 7th International and Interdisciplinary Conference on Modeling and Using Context*. Karlsruhe, Germany.
2. Edman, A., Ericksson-Lundström, J., and Akrawi, N. (In press) *CONTEXT '11: Modeling Context-based Explanations of an Intelligent Assistant System to Support Teachers. The 7th International Workshop on Modeling and Using Context*. Karlsruhe, Germany.
3. Mayiwar, N., Gundi, K., and Sadik, M. (2006) The Role of Technology in Improving Education in the 21st Century. *Proceedings of the 4th Annual Hawaii Conference on Education*. Honolulu, HI. On CD ROM (ISSN #1541-5880).
4. Mayiwar, N., and Sadik, M. (2006) Introducing ICT in Higher Education: The Case of Salahaddin/Hawler University. *Proceeding of first Network-Based Education, NBE-2005. Rovaniemi Finland*. University of Lapland, Publications in Education 17. Rovaniemi: University of Lapland Press, pp. 67-74.

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1. Thesis Overview

1.1 Introduction

In recent decades, considerable interest has been directed towards applying Information and Communication Technologies (ICT) in educational settings to enhance the teaching and learning process (Twining, 2002; Koun-tem Sun et al. 2008, Hikmet et. al., 2008; Spectro, 2008). During this time, however, relatively little attention has been paid to ICT intended to support students' and teachers' active and individualized learning. Wolk argues that the education must be redesigned around individualized learning to enable students to learn in their own pace and in their own preferred way (Wolk, 2011).

Studies show that there is a close relation between students' learning styles and the teachers' teaching strategies (Usdan et al., 2001, Trigwell, 1999). However, students and teachers may have different goals and their perspectives on how to learn and what to teach can create a gap between the teaching strategies and the students' learning styles (Hedin, 2006). Therefore, to narrow this gap as it can affect the quality of learning it is vital to consider both teachers' and students' needs when designing ICT for learning purposes.

Advances in new information technology have promoted learning and problem solving in various learning communities (Spectro, 2008). One of these communities is comprised of educational organizations. These organizations have endeavored to put students at the center of the learning process, creating so called student-centered learning (SCL) which has been demonstrated to facilitate the teaching and learning process (Land and Hannafin, 2000). In the SCL environment, the main task is to promote students' learning by giving them more control over their own learning and by disseminating new knowledge and skills (Alagic, Gibson and Doyle, 2004).

Many learning theories including the theory of multiple intelligences emphasize that students possess different learning styles. A categorization of students' different ways of learning is presented in the theory of multiple intelligences (Gardner, 1983; 1985; 1993; Gardner, 1999). However, despite the widespread use of these theories and the impact they have on learning, many teachers are unconvinced of their value and therefore, they continue to

use the teacher-centered approach to educate students (Lea et al. 2003; O'Neill and McMahon, 2005).

In a traditional classroom, it is common that the interaction between teacher and students is restricted and the teacher plays an autocratic role. This situation was epitomized by Kassim and Ali, in saying "The teacher is holding the power to knowledge, the power to deliver the knowledge, and the power to control the learning and teaching environment." (Kassim and Ali, 2007). In a SCL environment, in contrast the teachers become facilitators, and they encourage their students to interact, help others, and to learn from one another. This form of teaching enhances immediate communication between teachers and students. The communication becomes even more effective when integrated with ICT (Li, 2007) and this assists the students across the curriculum to work together and with other teachers to share their knowledge and experiences at a distance (NFS, 2005).

Unfortunately, regardless of the improved access available to ICT and of all the discussions about the importance of student-centered activities, the traditional approach still emphasizes text and memorization methods for the transmission of knowledge from teachers to students (Hofer, 2004). John and Sutherland (2004) argue that "ICT alone does not enhance learning; rather it is the ways in which ICT is incorporated into the various learning activities that is of fundamental importance". Here the role of the teacher is as important as ever (See e.g., Katzenmeyer and Moller, 2009; John and Sutherland, 2004; Sutherland et.al. 2009; Light, 2009).

In conjunction with the advances in ICT the demands on teachers' pedagogical skills are increasing (Department of Education and Training, 2003; Skolverket, 2006). In this new era, students need high level problem solving skills and an ability to apply knowledge to new and diverse situations which is dependent mainly on the quality of the teaching (Department of Education and Training, 2003). To meet the students' needs teachers have to gain profound knowledge of the relevant subject, comprehend the students' learning styles, and develop effective ways of teaching and leading a classroom. As a result of this, access to ongoing training is needed for teachers so they can develop and enhance their pedagogical skills.

As we know, the new generation of students has been growing up submerged in an environment replete with electronic devices such as computers, video-games, digital music players, video cameras, cell phones, and a multitude of digital toys. "Our students have changed radically. Today's students are no longer the people our educational system was designed to teach" (Prensky, 2001a, 2001b). Keeping this in mind, educators should become familiar

with these modern technologies to enable them to benefit from their usage as tools when educating students (Walls, 2005; Tucker, 2005). Jonassen (2000) underlines the importance of using computers as a tool to learn “with” not to learn “from”. He argues that computers should be used to help students to construct knowledge in an active and self-directed way, not as a tool for transmitting information. Thus, to help the new generation of students through ICT the pedagogical paradigm should move toward SCL to help students to construct knowledge (Bransford, et.al. 2000). However, moving toward SCL is not an easy task, particularly in countries where the educational system is based on a teacher-centered approach. In these kinds of educational systems many traditionally trained teachers are not prepared to take on the task of using ICT for the purpose of encouraging SCL (Barnett 2001; Sutherland et. al., 2009).

The 21st century education needs so-called smart classrooms, also known as technology enhanced classrooms (Northwestern University, 2004). A smart classroom is one equipped with networking, digital, and visual technologies (ibid.). Utilizing these technologies can increase students' knowledge and skills through a combination of individual but also collaborative work in class or at a distance (Wanak, 1999).

A smart classroom is comprised of a program that includes the core curriculum and latest technologies. On the technology side, the smart classroom introduces students to various forms of technologies, such as, multi-media, databases, visual devices, satellite TV, instant internet access, and instructional software (ibid.). These applications provide students with opportunities to effectively learn and to increase their knowledge. In such classrooms, teachers employ alternative methods of teaching, where they act as facilitators rather than instructors (Johnstone, 2002; Phuc et al., 2005).

The instructional software is a computer program through which students can learn new content, apply the already learned content and evaluate how much they know about a subject. These programs can also support teachers and students to show concepts, simulations, record and analyze data (Pashler et.al. 2007). One example of these types of programs is Knowledge-Based System (KBS) which has been judged to be useful instructional software (cf. e.g. Clancey, 1979; Nydahl, 1991; Jonassen, 1998; Edman, 2001, Cooper et al., 2004). A KBS “is a computerized system that uses knowledge about some domain to arrive at a solution to a problem from that domain. This solution is essentially the same as that concluded by a person knowledgeable about the domain of the problem when confronted with the same problem.” (Gonzalez and Dankel, 1993).

In the SCL environments, teachers should utilize appropriate teaching strategies to encourage active learning by individual students. Considering this approach to learning, it is important for educational settings to employ computer systems that support the users' active and different ways of learning. Accordingly, for ICT to be beneficial for teaching in a student-centered way, important aspects must be addressed, involving, for example, changes in the teachers' beliefs about learning and the development of new practices, new ways to engage students with content, relationships between students and teachers, and new ICT tools for learning must be made (Light, 2009). For this purpose, the research in this thesis comprises the following objectives:

- To support students' active and individualized learning
- To support teachers leadership style and teaching strategies
- To provide aspects vital for learning and teaching through KBSs.

These objectives will be investigated by answering the following questions:

1. What aspects should be considered in KBSs to bridge the gap between learning and teaching?
2. How can the transfer of knowledge and reasoning strategies be improved to support students' different intelligences and learning styles in a KBS?
3. Can KBSs be designed to help teachers to reflect on their leadership styles and teaching strategies in an individualized and active way?

ICT offers educators and students with unprecedented opportunities to enhance their abilities to make the kind of changes that affect the learning and teaching process (Sweder, 2002). To benefit from ICT in educational settings teachers and students both must be supported to be able to improve the learning process. Thus, the *hypothesis* is that it is possible to bridge the gap between learning and teaching by using KBSs that:

- can be beneficial for the student's active and individualized learning
- can support student-centered learning by assisting teachers to reflect on their teaching strategies and leadership style.

The assumption is that KBSs can make a real difference for learning and teaching but they must be deployed thoughtfully. Therefore, in this research the intention is to consider important pedagogical aspect when designing KBSs for learning purpose. The focus has been on two main aspects namely active and individualized learning which are considered in the three proposed system designs in the research. Individualized learning, in this thesis,

refers to a strategy to help different learners to learn in accordance to their intelligences and learning styles. This consideration raised the idea that system designers could be assisted by providing them with guidance on the kinds of vital pedagogical aspects to be employed in the knowledge-based systems that are specifically intended to support student-centered learning. For this reason, based on the literature reviews and the experiences gained during the process of designing the suggested KBSs, a set of design proposals has been put forward in this thesis. Teachers and students could also benefit from exploring these design proposals as this would enable them to obtain a common understanding of the learning process and its underlying concepts. This kind of awareness may promote learning and bridge the gap between teaching and learning.

1.2 Methodology

There are two commonly used approaches to scientific progress; *inductive* and *deductive* (See Figure 1.1). The inductive approach is an open-ended and exploratory, especially at the beginning of the research. When utilizing this approach, the researcher moves from specific observations to broader generalizations and development of theories (Trochim, 2006). The deductive approach, on the other hand, is narrower and concerned with testing or confirming hypotheses. Thus when using this method one moves from the more general to the more specific (ibid.).

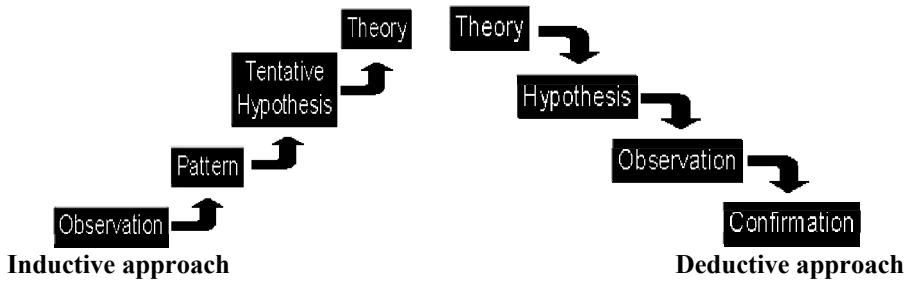


Figure 1.1 Two different approaches to research (Revised from the model in Trochim, 2006).

The inductive approach proceeds from a set of *observations* and moves towards a general conclusion. There are two kinds of observations: direct observations and participant’s observations (ibid.). In a direct observation, the researcher does not take an active part in the discussions and activities but is only observing and taking notes on the situation. The participant observer, on the other hand, gets involved in the work that is being observed. For many researchers, the best way to understand a situation is through direct observation. However, to ensure that the observations are not perturbed by the observer, the researcher should become a member of the observed context and get involved in the daily activities (Trochim, 2006). There are two kinds of participant observer; overt and covert (Dawson, 2002). In the overt participant observation, the researcher is open with the group about the fact that it is going to be studied. The groups will be informed about the aim, scope and the needed time for the research. In contrast, with the covert participant observation means that the researcher, studies the group secretly by performing the same activities as the group members without informing them that she/he is conducting research at the same time.

Researcher works to identify what is common to the data derived from the initial literature review and observations, thereby identifying the *patterns* within it (Trochim 2006). “A pattern is any arrangement of objects or entities. The term arrangement indicates that a pattern is by definition nonrandom and at least potentially describable” (ibid.). Based on the observation and the patterns identified, the researcher formulates some *tentative hypotheses* thereby obtaining a potential explanation for a phenomenon that can then be explored. Finally, the researcher deduces some general conclusion(s) or *theory(s)* about what is happening in the context. This general theory is assumed to be true. All theories imply the existence of some pattern in the data (ibid.). Andrew Sayer (1992) defines theory as an examined conceptualization of some objects. According to him theories are composed of concepts and statements of relationships.

In the deductive approach, in contrast the research begins with a general *theory* or question about the topic of interest. Theory provides a model of why the world is the way it is and provides an overview of the world, to clarify and explain some aspect of how it works (Strauss, 1995). After deciding the general *theory*, the researcher strives to develop a testable *hypothesis* based on the initial general theory, where, “A hypothesis is a specific statement of prediction. It describes in concrete (rather than theoretical) terms what you expect will happen in your study” (Trochim, 2006). To *confirm* (prove or disprove) the hypothesis, the researcher must collect the data necessary by taking advantage of different sources and techniques such as documents, observations, interviews, questionnaires, focus groups, workshops, and case studies (Davidson and Patel, 2003). The results of hypothesis testing while applying the deductive approach often lead researcher to generate new theories (Trochim, 2006).

As exemplified in Figure 1.1 Trochim argues that the two approaches can be combined to form a circular one (ibid.). In any experiment, the researchers may develop new theories through the identification of additional *observations* of patterns in the data develop new theories (ibid.).

1.2.1 The Research Methodology

The research in this thesis has been conducted by combining the inductive and deductive approaches in an iterative process starting from the inductive approach to study the following research topics:

- *Aspects for consideration when attempting to bridge the gap between learning and teaching by KBSs.*
- *Improving the transfer of knowledge and reasoning strategies to support students' different intelligences and learning styles in a KBS*
- *Means of designing KBSs to help teachers to reflect on their leadership styles and teaching strategies in an individualized and active way.*

Studies show that there are noticeable cultural differences in pedagogical approaches to education. For example, the UK and Northern Europe (the Netherlands, Denmark, Sweden, and Finland) are promoters of student-centered views (Reddy and Srivastava, 2003) while many other countries still emphasize the traditional teacher-based approach to teaching. To keep abreast with the challenges in 21st century many governments among them the Kurdistan Regional Government have seen the need for a change in the educational system. In one of his speeches former Prime Minister of Kurdistan Regional Government, Mr. Nechirvan Barzani said:

“Our teaching methods are too much like military instruction and not enough about developing our capacities to think. We need to modify our classrooms and our teaching styles to allow for more interaction with students, more group work and discussion, and more hands-on experience in the sciences, math, arts, and information and communication technology. The world in which we live is changing dramatically, and we must change our educational system with it.” (Barzani, 2007).

Thus, there is a need for research on appropriate means by which to improve the teaching and learning situation in this region. Employing new teaching methods can require teachers to adopt different teaching strategies and leadership style. However, changing teachers’ perspective on their teaching strategies and leadership style is often not an easy task especially for those teachers who have been traditionally trained. Starting with an inductive approach the research initiated from my own experiences of studying and teaching in Sweden, as well as, from observation of the teaching environment at Salahaddin University in the Kurdistan region of northern Iraq.

Coming from a teacher-centered and autocratic culture of studying to Sweden was an opportunity to experience and observe new and different ways of studying and teaching. Over a period of four years at high school, four years of studies at university, and two years of teaching and working as Director of Studies at Uppsala University I obtained a new perspective about learning through group works, seminars, labs, individual assignments etc.

As mentioned earlier observation of the context to be studied has been seen as an effective method during the early stages of the research. It will help the researcher to formulate a hypothesis that with further testing may be used to construct explanatory theories (Jorgensen, 1989). The information gathered during observations can also help researcher to create ideas about what or why something is happening e.g., observing the activities in the classroom will help the researcher to explore pedagogical dynamics within the classroom (Porter, 2004).

Accordingly, as the first stage of this research the teaching situation in Salahaddin University was observed through a combination of covert and overt participant observations. The aim was to take part in the daily activities by adopting the role of a teacher to observe the degree of students’ activities as well as their interaction with the teacher during the first year of my teaching (covertly). In addition, and at the same time as a new member of the teaching staff, I asked to participate in some of my colleagues’ lectures and labs to learn about their teaching methods (overtly). Three different courses were chosen at the Software Engineering Department at the College of Engineering of Salahaddin University: 1. Procedural Programming (first year) 2. System Analysis and Design (second year) 3. Engineering Analysis (third year). The number of the students participating in the courses was between 50-60.

It is worth mentioning that at this university courses run throughout the year. The observations of the teaching situation were planned to take place on 12 different occasions through which, each course was observed twice per semester. The main focus of the observations for all three courses was on the degree of interaction between the teacher and the students, the teaching strategies adopted, as well as, the degree of the students' involvement.

One frequent pattern that could be seen during the observation of the students and teachers was that teaching and learning material such as computers, projectors, the internet, and the library were available. Therefore, the main problem was not, as claimed by many, that the access to teaching and learning materials was inadequate, leading to a poor quality of education. The ways of teaching and the students' involvement in their learning process were deficient. Most of the students were very diligent at taking notes and actively listened to the teacher but unfortunately, as the teaching was mainly lecture-based the students did not had the opportunity to be active in the learning process. During the year of teaching of the course of Software Engineering at this university despite my efforts in incorporating different teaching methods for encouraging students' active learning the same pattern of a passive student role was observed. It could be noticed, in particular, that students were primarily focused on passing the exams by memorizing the content instead of attempting to comprehend the subject.

Because of the inevitable limitations in terms of both scope and time, participant observation can have restricted reliability (Trochim, 2006) therefore, these teaching observations were combined with unstructured interviews to further deepen the understanding of the teaching situation and to make it possible to address the most important needs at this university. The president of the University, the dean of the Department of Engineering and the dean of the Department of Education were interviewed. The result of the interviews showed that there is an enormous need for a change in the educational settings and particularly in the teachers' way of leading and teaching. The president of Salahaddin University stressed:

“We search for the new teaching approaches, tools, and skills that will help and equip our teachers to gain up to date leadership and teaching capabilities that will effectively address the needs of our students and prepare them for the challenges in the 21th century” (Sadik, 2005).

In 2005 a group of researchers from Exeter University conducted a needs assessment for five universities in the Kurdistan region. They presented a number of suggestions for improvement and among them was an improvement of the teaching methods. They argued that the contemporary teacher-

centered methods must be changed if Kurdistan's universities are to enter the twenty-first century.

Literature reviews were conducted to obtain a better understanding of the state of the art of KBSs and their importance for SCL. In the initial literature review, the aim was to get a better understanding of the central topics within computer and system science and pedagogy. Within computer science, KBSs, different kinds of knowledge and reasoning strategies in KBS, knowledge management, and hypermedia systems were studied. In relation to the pedagogy a literature review directed towards theories of learning, multiple intelligences and learning styles, constructivism, student-centered learning environments, Bloom's Revised Taxonomy regarding educational objectives, and leadership styles was conducted. The literature review encompassed different types of printed materials, such as journals, books, articles, as well as, electronic materials fetched via LIBRIS, DISA, e-journals, Google scholar, e-books, AltaVista and also found on well-known and relevant organizations' websites.

The main function of a KBS is to store the expert's knowledge and problem solving strategies and make them available to the end user. Therefore, it is vital to find the most appropriate way of presenting the domain knowledge and reasoning strategies to ensure that they correspond to the individual users' different ways of learning. For this reason, a literature review was performed on transferring problem solving strategies from the expert to the end-user directed toward understanding students' different ways of learning. Different kinds of knowledge and the reasoning strategies that are used in a KBS were carefully studied. The aim was to map how students' different intelligences could be supported by the knowledge and reasoning strategies in a KBS.

Drawing upon the data collected from the literature reviews, unstructured interviews, teaching and observations of the manner in which teaching was conducted in Salahaddin University, and also from my own experiences of teaching and studying in Sweden one common pattern that could be noticed is that the teaching methods applied at higher education in northern Iraq are mainly teacher-centered. However, many pedagogical theories, such as constructivism and multiple intelligences advocate for a SCL environment in which students are active in their own learning and at the same time, their different ways of learning are valued and supported. Therefore, there is a need to support teachers and students to assist them to move towards SCL. The starting point for changing the teacher-centered approach to learning is a challenge since people are usually resistance to changes therefore, it is important to start by raising the teachers and students' awareness of the new

approaches to teaching, learning and leading in the classroom and of their advantages. However, an important question arises that of how can current leaders in the many educational settings receive ongoing training that will promote actual, critical consideration of alternative approaches to teaching and leading. This issue has been examined in cooperation with Kurdish, Swedish and American teachers through dialogues to seek avenues for expanding the SCL lacking in the region.

One way to help the teachers and students to gain new insight into modern teaching strategies could be through the use of KBSs. This idea was discussed with pedagogues at Uppsala Municipality, Sweden, IT-pedagogues at the VLM (Virtual Learning Environment Institute) Sweden, two students at Uppsala University, Sweden and with educational leadership experts at Tennessee State University, USA. Interestingly, during the focus group discussions with the pedagogues and students at Uppsala University it was revealed that there is even a need for KBSs to support teachers' learning in Sweden.

Moreover, despite many efforts to move towards SCL in Sweden, a study carried out by VLM also showed that KBSs could be relevant for school organizations in Sweden too (Fredriksson, 2004). Fredriksson interviewed a number of school leaders, pedagogues, school health personal, and student counselors and the result of the study indicated that there is both a need for and an interest in such systems for learning purpose. Different areas of interest were defined in this study among them teachers' leadership. As mentioned earlier, in a SCL environment teachers working in a traditional manner should reconsider their teaching strategies and leadership style to facilitate the learning process. When teaching in SCL environments, students' different learning styles and their active learning should also be taken into account.

Thus, the *tentative hypothesis* is that KBSs:

- can be beneficial for the student's active and individualized learning
- can support student-centered learning by assisting teachers to reflect on their teaching strategies and leadership style.

As mentioned earlier despite the fact that ICT have been widely available in educational settings over the past couple of decades they are still underutilized. One reason for this is the lack of incorporation of pedagogical knowledge. The assumption is that without consideration of pedagogical aspects in the design process computer-based systems and among them KBSs become limited to the technical perspective of the designers' and cannot, there-

fore, fulfill the aim of supporting SCL. The initial general *theory* that can be derived from this first phase of the inductive approach is that KBSs can be designed to support both teachers and students if crucial pedagogical aspects are employed in the design.

Linking the result of the initial inductive research iteratively with the *deductive* approach the research continued by performing additional *observations* and tests of this general theory. The first step in this regard was to narrow the theory down into the following, more specific and testable, *hypothesis*, that it is possible:

- to identify relevant aspects when designing KBSs that will be able to support student-centered learning.
- to support the transfer of knowledge and problem solving strategies from the expert to the end user by considering students' different intelligences and learning styles in a KBS.
- to design KBSs that can help teachers to reflect on their leadership style and teaching strategies in an individualized and active way.

As a part of additional observation the relevant literature was reviewed to explore the possibilities of ICT in general, and of KBSs in particular, for SCL environments. In addition, through discussions with educational leadership experts at Tennessee State University, focus group discussions with IT pedagogues, dialogues between Kurdish, Swedish and American teachers, three prototypes of KBSs i.e., Analyse More (2nd version), Mentor and Leader Support System (LSS) were designed. The reason for designing these prototypes was to test the above-mentioned theory by illustrating pedagogical ideas about how to design KBSs as tools for SCL environments.

Drawing upon the literature reviews on learning theories and educational software particular aspects that appear to be important when designing systems supporting SCL environments were chosen. Examples of these aspects are: different learning styles, active learning, transparency of the learning material, problem solving, and differentiated feedback. In the three system designs, the above-mentioned aspects are taken into account.

According to Gardner (1983) students learn differently depending on the mix of intelligences they have. With the objective of offering active and individualized learning, KBSs, were chosen as a means of supporting students' different learning styles. To realize this idea, a KBS called Analyse More (2nd version) was designed. The design offers a new interface and new functionality for an already existing KBS, Analyse More developed by Edman et. al., 1993.

This system was chosen for three main reasons: 1) Analyse More was a part of a system development project for school improvement 2) this system was developed at Uppsala University, Department of Information Science, and therefore I had access to the domain knowledge and the expertise and 3) Analyse More has been tested and the findings from the test result could be utilized in the design of Analyse More (2nd version).

Unfortunately, however, despite the fact that, Analyse More was good at solving problems, it did not consider different individuals' ways of learning (Edman and Mayiwar, 2003). Moreover, the system did not offer the opportunity to work actively with it enabling students to perform analyses themselves, which is considered to be important when emphasizing a SCL approach. The domain knowledge was reused and further developed as a KBS to support different students' intelligences, utilizing hypermedia. This means that the domain knowledge in the new design is presented in different format such as picture, sound, and diagram.

From the perspective of multiple intelligences teachers need to know how the students learn best and teach in accordance with their intelligences. In this regard, teachers need to adopt different teaching strategies to ensure that each student's individual learning style can be met (Cisco, 2008). Meeting this objective is not an easy task especially for those teachers who are used to the teacher-centered approach. This group of traditionally trained teachers may find it easier to explore their current teaching and leadership styles by using a computer-based system rather than attending courses. For this purpose, the suitability of KBSs for teachers' learning was explored through two system designs, Mentor and LSS. These two systems have been designed as Knowledge Management Systems (KMS) intended to support teachers' learning by assisting them to learn about different teaching strategies and leadership styles. These systems will also let teachers to add their own knowledge to the system and in this way, it facilitates the sharing of knowledge. For the design of Mentor and LSS, additional knowledge from a variety of sources was needed. The design process requires the capturing of knowledge from different disciplines (Gero and Sudweeks, 1997), just as the research in this thesis required knowledge from pedagogy and cognitive science in addition to that from computer science. However, the knowledge is spread in many sources, for instance the burden of providing the knowledge falls on several experts as well as publications and databases.

The design process is iterative, involving the designer moving back and forth between different activities such as elicitation, analysis, and validation to

understand the requirements. These steps have been followed for the design of Mentor and LSS.

Design, according to some researchers, among them Gero and Sudweeks (1997), is a knowledge intensive activity. Transforming this knowledge into a working system requires designers to assure their users' needs and, at the same time, make it possible for the system developer to understand how the system should work (Pfleeger and Atlee, 2006).

Through the design process, a solution to a given problem is produced (Budgen, 2003). The kind of problem that should be solved by the system is decided when the requirements are determined. Therefore, it is very important to ensure that the requirements are as clear and well-defined as possible. For this reason the design process has been divided in two parts: the conceptual/system design and the technical design. The conceptual design helps the user to get an understanding of what the system will do once it is up and running and the technical design supports the system developer by making it possible for her/him to understand the exact functionality of the system (Gero and Sudweeks, 1997). They argue that at the early stage of the design process, the conceptual design involves most of the important decision making. At this stage of design designers select concepts to be used in solving a given design problem and decide how to interconnect these concepts to produce an appropriate system architecture. Therefore, in this research, a great deal of emphasis has been put on the conceptual design of the proposed system designs. Furthermore, the possibilities for the realization of these KBSs designs have been explored in two papers.

As discussed, designing systems imposes great demands on the process of knowledge engineering. Knowledge engineering is defined as “the acquisition of knowledge in some domain from one or more non-electronic sources and its conversion into a form that can be utilized by a computer to solve problems that typically can only be solved by persons extensively knowledgeable in that domain.” (Gonzales and Dunkel, 1993). The transfer of knowledge from the mind of the experts into a computerized representation involves the following steps (ibid):

- recognizing what knowledge will be used to solve a problem.
- categorizing this knowledge.
- determining the best way to represent the knowledge.

The authors argue that the last step is the most significant one in the knowledge engineering process, because if the knowledge is not represented prop-

erly the whole project will certainly fails (Gonzales and Dunkel, 1993). In this research, appropriate ways of representing domain knowledge have been explored to support students' different intelligences and learning styles particularly in the first system design, Anylase More (2nd version).

Earlier research has shown that the most demanding and difficult part of system design is knowledge acquisition (Peterson et al, 1990; Sandahl, 1992, Durkin, 1994; Håkansson, 2003). Many researchers (cf e.g., Hayes-Roth et al, 1983; Peterson et al, 1990; Gonzales and Dunkel, 1993; Durkin, 1994; Sommerville, 2004) suggest techniques from evolutionary or incremental developments to overcome the difficulties associated with knowledge acquisition.

According to Gonzales and Dunkel (1993) incremental development is based on two concepts: divide-and-conquer and iterative development. Through 'divide-and-conquer' a convenient and complete chunk of knowledge is selected and developed. In the iterative development, divide and conquer is applied iteratively to the various chunks of knowledge composing the complete problem. The incremental methodology comprises several cycles, where each cycle supports knowledge elicited from the expert, implements the knowledge within the system, reviews the resulting implementation with the experts and refine the implementation to address any problems uncovered (ibid). The incremental methodologies will be used for the development of the presented system designs.

There are two kinds of requirements: functional and non-functional (Pfleeger, 2001). Functional requirements define the action that a system must perform and do not take physical constraints into consideration (ibid.) Non-functional requirements, on contrast, describe a restriction on the system that limits our choices on the product to be developed such as performance, platform dependencies, maintainability, extensibility, and reliability (ibid.). In the proposed system designs the focus is on the functional requirements that include support for active learning, as well as, support for different learning styles.

Usually, the system developer gathers information on the user's requirements through questions, and through observation of the system's current behavior or by demonstrating similar systems (Sommerville, 2004). The requirements identified are then presented in a model or a prototype which enables both the user and the system developer to better understand the behavior required of the system. Moreover, this way of working often results in additional questions being asked about what the user wants to happen in certain situations. When the requirements are well understood, the specifica-

tion phase starts. In this phase, it can be decided which parts of the required behavior will be implemented (Pfleeger and Atlee, 2006). Additionally, during the specification phase, the system designer should validate the specification to confirm that the specification matches the user's expectations. Validation of requirements means that the requirements will be checked for validity, consistency, completeness, realism and verifiability (Sommerville, 2004). This process is an iterative one and may be repeated several times until there is a clear picture of the user's needs.

With the aim of collecting data about the opinions, the needs, and the requirements of the teachers' support system literature, observations and focus groups were used to capture a general picture of the current teaching situation and to highlight the most crucial aspects for improvement where teachers' teaching strategies and leadership styles are concerned.

In a SCL, the teachers' leadership style is an essential factor for successful teaching. Thus, to explore the means of assisting teachers to get insight into different leadership styles, a KMS called Leader Support System (LSS) was suggested. The domain knowledge for this system was chosen in cooperation with the educational leadership experts at the Department of Educational Administration and Leadership, College of Education at Tennessee State University, USA. At this point, it is worthwhile mentioning that a group of three educational leadership experts from this university visited the Kurdistan region in 2005 to help the government in its efforts to reform the educational system. Two of these were involved in discussions concerning the work conducted for this thesis.

The design work for the LSS initiated from the process of reviewing the relevant literature about new theories of leadership. There are many different theories about leadership styles e.g., it can be said to be democratic, human resource, formative, authoritarian etc. However, through discussions with experts at Tennessee State University, the theory of "Framing" developed by Bolman and Deal (1993; 1997) was introduced. According to this concept people 'frame' each situation they enter and the frame chosen will guide their actions and the reality that was experienced. Four leadership frames are presented: structural, human resource, political, and symbolic. According to these experts, the human resource issues are the core of education leadership that they recommend that one should emphasize. Accordingly this kind of leadership frame has been utilized in LSS.

Another system design, called Mentor, was developed to support teachers teaching strategies. For the design of Mentor, several focus groups were conducted with IT-pedagogues at the Virtual Learning Environments, and

pedagogues at the Regional Centre for the Coordination of Pedagogical Development, Uppsala, Sweden. The aim was to first check whether there was a need for such system outside Kurdistan, and to determine whether they might even be useful in Sweden, and to collect pedagogical knowledge for the design of the eventual system. Interestingly and as touched on earlier, the result of the focus groups confirmed that there is an equivalent need for such learning support systems even in Sweden.

As was the case for LSS, the requirements for Mentor were determined by conducting literature review, observations, interviews, and focus groups. The next significant phase was to validate the determined requirements, which involved showing that the requirements do define the system that the customer wants. This phase is very important since errors in the requirements can result in extensive reworking costs when they are only discovered in a later phase (Pfleeger and Atlee, 2006). One technique to describe the requirements elicited is that of “use cases”. A use case “describes particular functionality that a system is supposed to perform or exhibit by modeling the dialog that the user, external system, or other entity will have with the system to be developed” (Pfleeger, 2001). Through the utilization of such use cases the communication between the customer, system developer, and tester becomes much easier because it is possible for everyone concerned to envisage and work through a common scenario to see how a goal or task will be achieved. This technique has been utilized when designing Mentor (See Appendix 2).

As mentioned, determining a system's requirements is usually a difficult process. In this regard, producing a prototype of the system is useful because it enables one in understanding the requirements and to find out what requirements are missing as well as opening up the possibility of alternative designs (Sommerville, 2004). The prototyping process consists of several iterative cycles. In the first cycle a design is constructed based on the identified requirements. This design can be reviewed by the users. The first design will be refined based on the user's comments and suggestions. This is an iterative process and will be repeated for each design until the objective is accomplished. There are different techniques for prototyping some of which involve the exploration of the system design on paper, while others rely on software called interactive software-based prototypes. An interactive software-based prototype was chosen for confirming and validating the gathered requirements for Mentor. The requirements were validated in accordance to the aspects presented by Sommerville (2004) such as validity, consistency, completeness, realism and verifiability. At the Department of Informatics and Media, at Uppsala University, Sweden, the prototype of Mentor was tested and studied. Two groups of test pedagogues have evaluated the design

of Mentor. The tests were performed in a usability test lab where the entire sessions have been digitally recorded. The test persons' activities e.g., what they saw at the interface, the way they worked with the system, as well as their comments and reactions were recorded. After finishing the session, the tests were finalized by asking follow-up questions to get additional important information. Moreover, after each test the prototype was further developed in accordance to the testers' comments and suggestions. The result of the evaluation showed that this system could be used as a tool for school leaders at all levels in the educational system to help teachers to improve their teaching strategies.

According to Trochim (2006) additional observation can be made on the initial general theory. Thus through additional observations and notices during the design work a model comprising a set of vital pedagogical aspects has been put forward. These design principles e.g., individualization, active learning, multiple intelligences, differentiated feedback, and cooperation are generated and the relationship between them is described in a model (presented in chapter 6). It is worth to mention that without experiences from the KBSs designs it would be a difficult task to put forward the design proposals.

Finally, an overall evaluation of the hypothesis is performed by discussing three main contributions of this research that are:

- Knowledge-based systems can be beneficial for student's active and individualized learning.
- Knowledge-based systems can assist teachers to improve their leadership style and teaching strategies.
- Bridging the gap between learning and teaching by using knowledge-based systems.

A summary of these contributions is intended to provide a holistic picture of the result of the research (*confirmation*) and discuss suggestion for further work.

1.3 Scientific Contribution

The key findings derived from the research conducted in this study are summarized in this section.

1.3.1 Support Students' Learning

In conjunction with the use of knowledge-based technology, to support the process of learning and teaching, several design aspects have been suggested, such as the need for individualization, visualization of knowledge, learning support, and feedback. The fact that these design proposals are put forward can be seen to be in accordance with the SCL view of learning. In this work, the importance of active and individualized learning has been emphasized when designing a KBS for learning purposes. According to the theory of multiple intelligences theory learners possess different intelligences and therefore have different approaches to learning. Many learning theories among them constructivism put the student at the centre of learning and underline the importance of active learning. Thus, it is important to offer systems that consider users' different ways of learning and provide them with an active learning environment.

Designing KBSs as tools for teaching and learning in SCL environments is not only about designing different user interfaces and specifying the relationship of the interfaces to one another, but also about pedagogical efforts. In this regard, different kinds of both problem solving strategies and knowledge in a KBS were studied to see whether and how they can support students' different intelligences. The result of the study showed that several intelligences can be supported by employing appropriate kinds of knowledge, such as declarative, procedural, structural, and meta-knowledge as well as different kinds of problem solving strategies such as deductive, inductive and analogical ones.

In a traditional classroom, it is difficult to support students' different intelligences because of the limitation on the teachers' time and resources. Therefore, in this thesis a KBS is designed to illustrate the possibilities of supporting students' active and different ways of learning through ICT. To this objective, based on the theory of Multiple Intelligences, a KBS, Analyse More (2nd version) was designed. The new design has been compared with the theory of multiple intelligences. The result of the comparison indicated that presenting the domain knowledge and the explanations in different representational forms could help students having different intelligences. Moreover, Analyse More (2nd version) can provide an active learning environment where, as the name implies, students work actively with the system and compare their result and conclusions with the system. This way of working with the system is considered to be desirable in a SCL because of the students' active involvement in the learning process.

1.3.2 Supporting Teachers' Leadership and Teaching Strategies

With the intention of facilitating students' active and individualized learning, teachers could need to reconsider their teaching strategies and leadership styles. In SCL environments the teacher is considered a facilitator rather than an instructor. As teachers grow in their professional role as a facilitator, they need to develop more leadership skills, with which to complement their teaching strategies.

Two different KMSs, Leader Support System and Mentor have been designed in the form of KBSs to support teachers' learning in an individualized and active way.

Leader Support System provides teachers with an ongoing leadership development program. One demand imposed on this system is that it should provide easy access to knowledge about leadership and another is that it should provide feedback regarding discipline, and decision-making to improve their leadership style. As mentioned earlier, the theory of leadership frames introduced by Bolman and Deal (1993, 1997) which categorizes leadership in structural, human resource, political, and symbolic frames was chosen for the design of Leader Support System. Human resource frame is emphasized as the basis to define the domain knowledge.

Mentor aims to provide teachers with differentiated feedback to reflect on their current teaching strategies and obtain insights into alternative ones. The system provides users with a set of questions related to teaching methods. Every answer is interpreted and mapped to the Revised Bloom's Taxonomy (Andersson and Krathwohl, 2001). When the user has answered all of the questions, the system presents an overview of how the answers have been evaluated according to the taxonomy. The system presents two kinds of feedback. The first one is dynamically generated in relation to the user's result and the second itself comprised of two types; explanations of the different objectives in the taxonomy and suggestions about teaching methods.

1.3.3 Providing Design Proposals for KBSs to Bridge the Gap between Learning and Teaching

At risk of repeating myself, the various pedagogical ideas put forward in conjunction with bridging the gap are discussed here to enable them to be considered coherently in the context of designing KBSs for learning.

The new paradigm of learning puts students in the center of learning. In this new era students must learn how to take responsibility for their own learning and at the same time teachers must adapt their leadership style and teaching

strategies accordingly. As mentioned earlier ICT opens up a multitude of opportunities to the educational system, yet it is, at the present underutilized. In my opinion, the reason for this is that there is still a considerable gap between the students' ways of learning and the teachers' ways of teaching. KBSs can be designed to facilitate learning with the specific intention of bridging this gap, however, for each KBS to be designed, knowledge from other disciplines, such as those of, educational and cognitive science must be taken into consideration. For this reason, in conducting this research vital aspects of learning and teaching have been studied. Based on these ideas a set of design proposals has been put forward including suggestions such as individualization, introducing different forms of representation, giving differentiated feedback, promoting active learning, and considering the capacity of the short-term memory. These aspects could be helpful when designing KBSs for student-centered learning. These proposals could also provide both teachers and students with a common understanding of the most fundamental concepts of learning and thereby bridge the gap between the students' and teachers' perspectives on learning. The design proposals presented in Chapter 6 are based on the literature review and the experiences from the design work conducted in this research.

1.4 Structure of the Thesis

The thesis is organized as follows:

In Chapter 2, entitled Theories Regarding Learning, fundamental background theories, such as learning and teaching strategies, the theory of multiple intelligences and Bloom's Revised Taxonomy are introduced. Since the teacher's leadership in the classroom is a key element for successful learning, the theory regarding frames of leadership is also presented.

Chapter 3, called Knowledge-based Systems' Technologies, begins with a brief description of knowledge and reasoning strategies. Thereafter different types of systems containing knowledge such as KBSs, knowledge-based hypermedia systems and knowledge management systems are introduced. Finally, the terms knowledge management, knowledge transfer, and knowledge sharing are discussed.

In chapter 4, Related Work, some other systems or models that can be employed to support teachers' and students' learning emphasizing users' active and individualized learning as approaches are presented.

In Chapter 5 the papers included in the thesis are summarized.

In the first paper, the central design aspects, which I argue should be considered when designing KBS supporting learning, are addressed.

Papers two and three are directed towards students' active and individualized learning. The second paper discusses the process of knowledge transfer in a KBS and the manner in which such a system can support different intelligences through different types of knowledge and reasoning strategies.

In the third paper, a knowledge-based hypermedia system incorporating most of the design aspects presented in the first paper, has been designed.

In papers four, five and six, the focus is changed, from considering the students to adopting the perspective of the teachers, but still based on the same set of design proposals, namely those presented in the first paper. The fourth paper discusses leadership in educational settings and also presents a design for a KMS intended to help teachers to receive ongoing leadership training. The system is called the Leader Support System.

Paper five describes the design of a prototype of a KMS, Mentor. The aim of this system is to provide teachers with feedback about their current teaching strategies and to obtain insights into other kinds of teaching strategies in an active and individualized way. With the assistance of this system, teachers are given the opportunity to reflect on their current teaching strategies and are given guidance on how to improve their teaching. In paper six, the elicitation of the requirements for Mentor are described and evaluated in the light of the system's requirements.

The final chapter summarizes the research and discusses the results and the central topics covered in the thesis. The set of design proposals are presented in this chapter. These proposals are produced based on the findings of the literature review, as well, as the design work conducted during the research. In this chapter, suggestions for further work are given.

1.5 Papers

The thesis is based on the research conducted for the following publications:

1. Mayiwar, N. (2005) Aspects of Consideration when Designing Educational Knowledge Based Hypermedia Systems. *Proceedings of Knowledge-Based and Intelligent Information & Engineering Systems, the 9th*

International Conference, KES'2005, LNCS/LNAI, Springer-Verlag, Heidelberg, Germany, ISBN:3-540-28894-5, LNAI3681-II, pp. 393-402.

2. Mayiwar, N., and Håkansson, A. (2004) Considering Different Learning Styles when Transferring Problem Solving Strategies from Expert to End Users. *Proceedings of Knowledge-Based and Intelligent Information & Engineering Systems, the 8th International Conference, KES'2004*, LNCS/LNAI, Springer-Verlag, Berlin, Heidelberg, Germany, ISBN:3-540-23318-0, LNAI3213-I, pp. 253-262.
3. Edman, A., and Mayiwar, N. (2003) A Knowledge-Based Hypermedia Architecture Supporting Different Intelligences and Learning Styles. *Proceedings of the Eleventh PEG Conference, Powerful ICT-tools for Teaching and Learning. (CD-Rom) PEG-2003*. St. Petersburg, Russia.
4. Mayiwar, N., Pritchett, W. P, Edman, and A. Wiemers, R. (2005) Improving Leadership Styles Using Technology. A Discussion. *Journal of Interdisciplinary Education (JIE)* Vol. 7, No. 1. ISBN: 1092-7069, pp. 209-237.
5. Mayiwar, N., and Edman, A. (2007) Mentor - a Knowledge Management System Supporting Teachers in Their Leadership. *Proceedings of the 2nd International Conference on Network-Based Education-NBE2007^h*. University of Lapland Press, ISBN 978-952-484-102-3, pp. 125-138.
6. Akrawi, N. (accepted) Enhanced Teaching Strategies- Elicitation of Requirements for a Support System for Teachers. 7th-10th April 2010. *International Conference on Computer Supported Education*. Valencia, Spain.

Six papers are presented in this thesis. The first of these, “Aspects of Consideration when Designing Educational Knowledge Based Hypermedia Systems” is written by me.

In the second paper “Considering Different Learning Styles when Transferring Problem Solving Strategies from Expert to End Users” both authors contributed.

In the third paper “A Knowledge-Based Hypermedia Architecture Supporting Different Intelligences and Learning Styles” both authors have contributed equally.

The idea for the fourth paper “Improving Leadership Styles Using Technology” was mine. The discussion in the paper is divided into two major parts: the first part which is a theoretical background on leadership is written mainly by Will P. Pritchard and Roger Wiemers at Tennessee State University Nashville, USA, but both Anneli and I are responsible for the knowledge management and the system design part.

The fifth paper “Mentor– A Knowledge Management System Supporting Teachers in Their Leadership” I had the major responsibility and provided the largest input.

The research in paper six "Enhanced Teaching Strategies- Elicitation of Requirements for a Support System for Teachers" was conducted by me.

2 Theories Regarding Learning

The design of KBSs to support learning required that general principles from learning theories and instructional science must be considered. In this chapter, a selection of the core principles suitable for designing KBSs as tools for learning support, e.g., constructivism and the theory of multiple intelligences has been put forward as explained in Section 2.1.

In addition, other theories used in this research are learning strategies, Bloom's Revised Taxonomy, and teachers' leadership.

2.1 Learning

There are many different definitions and approaches to learning, for example Kolb (1984) defines learning as “the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience”. In the same article, Kolb models learning in the form of a cycle that includes four phases: concrete experience, observation and reflection, forming abstract concepts and testing in new situations. The concrete experience provides a basis for the learners' observation and reflections. On the basis of these reflections, the learners form concepts and generalizations that they can then test in new situations (Kolb and Fry, 1975). Learning takes place when people acquire and apply knowledge, skills and feelings in a relevant setting or when people reflect upon events (Kolb, 1984). The means by which people learn are often referred to as learning styles (Davidson, 1990).

According to prior research, theories of learning have been helping teachers to become successful in the classroom (Deeds and Allen, 2000; Emmer and Gerwels, 2002; Casas, 2008). This research shows that in order to improve teaching and learning activities, principles of learning must be taken into account.

There are many different theories of learning e.g., cognitive theory, reinforcement theory, socio-cultural theory, and constructivism. In the past decade, there has been an emphasis on constructivism as an effective theory of learning (Morphew, 2002; Karagiorgi and Symeou, 2005). Constructivism is more than just a learning approach. It includes a set of learning theories and pedagogical approaches that have come from the field of cognitive learning psychology. Central to this theory is the belief that students must be active in the learning process. Constructivists view knowledge as something that a learner actively constructs in a knowledge-building process (Savery and

Duffy, 1995). According to constructivism, learners must be active in their learning, and in this regard, teachers guide and facilitate their learning.

According to Jonassen (1998) a constructivist learning experience can be characterized by:

- Engagement in an authentic task that encourages knowledge construction
- Opportunities for collaboration
- Tutors who serve as guides and facilitators
- A series of ‘scaffolding’ activities or tools, to guide learning.

The constructivism learning theories have been further developed based on theories presented by Dewey, Bruner, Papert, Piaget and Vygotsky. For instance, the Russian psychologist Lev Vygotsky laid the foundation for the socio-cultural learning theory (Vygotsky, 1978). This theory emphasizes the active interdependence between the social and individual processes in learning. According to this theory higher order learning occurs through humans’ activities in their social context, mediated by language and other symbolic systems, which are referred to as artifacts (Säljö and Rystedt, 2008). Artifacts can be psychological or physical. The computer is an example of a physical artifact that is placed in the category for digital artifacts. Another example is instant messaging, a new way of communication through internet. Communication is a fundamental aspect in the socio-cultural perspective (Ahlström, 1996). Cobb (1994) argues that we should not consider learning only from socio-cultural or constructivism perspectives. According to Cobb (1994) these two learning theories can be perceived as being complementary to each other.

The constructivist approach can support learning as it is seen in a literature study conducted by Koc (2005), which showed that when technology is used in a constructivistic way, it will engage and facilitate students’ critical thinking and higher order learning. The author also states, that “...the contribution of technology to teaching and learning is just beginning to be seen”. The advances and inventions in new technology impose new demands on teachers and these technological advances require educators to rethink and reevaluate their perceptions about their knowledge base and expertise with the intention of delivering suitable educational services. This has imposed great expectations upon teachers to adapt to the changes that are introduced with the new educational and technological challenges in the 21st century.

2.2 Multiple Intelligences and Learning Styles

The theory of multiple intelligences emphasizes students' different ways of learning. In this theory, the most significant aspect is the categorization of different human abilities, ranging from verbal intelligence to existentialist intelligence. This theory extends the constructivist approach to learning, by considering students' different intelligences (Gardner, 1983; Gardner, 1993; Gardner, 1999). According to Gardner (1983) the mind is not comprised of a single representation or a single language of representations. He states that we have different internal representations in our minds. This theory can be related to constructivism or other "student-centered" theories and pedagogies (Peariso, 2008).

Learning styles refer to the means by which people learn. A learning style can be defined as the way we begin to concentrate, process and retain unfamiliar, difficult information (Davidson, 1990). As can be seen there are close similarities between the theory of multiple intelligences and learning styles, and sometimes these two concepts are equated (Lane, 2000).

Gardner (1989) defines intelligence as "Intelligence is a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture". Traditionally, two kinds of intelligences have been the focus of the attention, *verbal-linguistic* and *logical-mathematical* (ibid.). To these intelligences Gardner added five other categories of intelligences: *bodily-kinesthetic*, *interpersonal*, *rhythmical-musical*, and *visual-spatial* (Gardner, 1983). However, since our understanding of the brain and human performance changes, the number of intelligences recognized is increasing. Research has shown that there are students who are not covered by these categories, therefore, two other intelligences were added to the list: *naturalist* and *existentialist* (Gardner, 1999). The following bullet list gives a short description of the nine types of intelligences, together with their corresponding learning styles:

- *Verbal-linguistic intelligence*: A person with verbal-linguistic intelligence has an ability to use language and words. These learners think in words rather than in pictures. They learn best by telling and listening to stories, reading, taking notes, attending lectures, and participating in discussions and debates.
- *Logical-mathematical intelligence*: People with this kind of intelligence have the ability to analyze problems, logically, and carry out mathematical operations. Persons who manifest this form of intelligence learn best by categorizing and working with abstract patterns and relationships.

- *Rhythmical-musical intelligence*: This is an ability to think musically. People with this ability show sensitivity to rhythm, melody, and sound and acquire material better if they study and have music in the background.
- *Visual-spatial intelligence*: This is an ability to represent the spatial world internally in the mind. People with visual-spatial intelligence learn by drawing, reading maps, studying graphs and from other visual representations.
- *Bodily-kinesthetic intelligence*: This intelligence is an ability to use the body in a skilled way. These people learn by moving, doing and touching.
- *Interpersonal intelligence*: This is an ability to perceive and understand other people's feelings. Learners with this kind of intelligence learn through interaction with other people.
- *Intrapersonal intelligence*: This is an ability to understand one's own feelings. These persons work best alone.
- *Naturalist intelligence*: This is an ability that enables human beings to recognize, categorize, and draw upon certain features of the environment. They relate to the outdoors and to animals and they respond well to field trips. These students are interested in understanding the natural environment and learn by being outside.
- *Existentialist intelligence*: Is an ability and capacity to deal with deep questions about human existence, such as the meaning of life or asking questions like: Why are we born? Why do we die? These students need to have a learning process that is deep and wide, for instance discussing questions about life, religion and other spiritual questions, and they want to understand the value of what they learn.

According to Gardner (1999) humans possess all of these intelligences to some degree, but one or more of the intelligences can dominate. This theory has been considered when designing the KBSs designs.

The theory of multiple intelligences has received criticism, from within psychology and educational theory communities. The most common critic is that the theory is based on Gardner's own intuitions and reasoning than on empirical data (Willingham, 2004). Despite the criticism the theory has been successfully used in classrooms (Armstrong, 1994; Wilson, 1998; Campbell and Campbell, 1999; McKenzie, 2002; Smith, 2002; Chen, 2004). One important impact that this theory has had is its influence on the curriculum by moving away from traditional teaching strategies and to introduce a more multi-faceted approach. Many authors consider that computers can be a val-

uable and vital tool when combined with Gardner's first seven multiple intelligences to enable educators to reach students by opening up the way for them to use a variety of ways of learning. (see e.g., Davis, 1991; Townsend and Townsend, 1992; Carlson-Pickering, 1999; McKenzie, 2005; McCoog, 2007). In this respect, Carlson-Pickering (1999) stated that "One of the reasons multiple intelligences and technology work so well together is because researchers now know that when an individual wants to deeply understand something complex in nature, they should triple code their learning experiences. This means if you are exposed to new ideas that are presented to you through a minimum of three different intelligences you will have a better chance of remembering the information" (ibid.).

Moreover, Trepanier-Street (2000) stresses the importance of teachers' understanding of using different representation forms to facilitate learning for students. She states that children become more skilled when using symbols to represent their thinking. According to her, children who have difficulties using words can represent their thinking by showing what they mean through actions. In this way, they can represent their concepts about the world through symbolic play.

Bloom's Revised Taxonomy can be utilized to provide teachers with a tool to reflect upon their teaching strategies in accordance with the theory of multiple intelligences.

2.3 Bloom's Revised Taxonomy

Bloom's taxonomy classifies different learning objectives and skills that educators establish for students (Anderson and Krathwohl, 2001). In 1956 Benjamin Bloom identified six levels of cognitive processes: knowledge, understanding, application, analysis, synthesis, and evaluation.

The first and simplest level is "knowledge", which involves recognizing and reproducing facts. Through understanding, application, analysis, and synthesis, the complexity of the levels increases to "evaluation", and at this level, students can evaluate, criticize and give recommendations. However, to attain this, all the lower levels must be accomplished.

Bloom's taxonomy was revised by Anderson and Krathwohl (2001) with, the dimensions cognitive process (the process used to learn) and knowledge (knowledge to be learned) being combined (see Figure 2.1). The dimension knowledge comprises factual, conceptual, procedural, and meta-cognitive knowledge. Both of the dimensions can be used to help write clear, focused

objectives for teaching. Furthermore, the dimensions in the taxonomy are aimed at supporting teachers to enable them to clarify and communicate what they want their students to learn as result of the instructions that they will be given.

The knowledge Dimension	1.Remember	2.Understand	3.Apply	4.Analyze	5.Evaluate	6.Create
A.Factual Knowledge						
B. Conceptual Knowledge						
C. Procedural Knowledge						
D. Meta-cognitive knowledge						

Figure 2.1 Bloom’s Revised Taxonomy (Anderson and Krathwohl, 2001).

According to Athanassiou and McNett (2003) the taxonomy has been shown to be of significant use when developing the students’ critical thinking and creative skills. Moreover, the taxonomy has supported the growth of the students’ ability to get engaged in the learning activity and to take responsibility for their own learning. The authors also state that “The use of the taxonomy has helped our classrooms become more student-centered, as it helps our students gain increased awareness and control of their own cognitive development. In doing so, it addresses that frustrating problem so familiar to most learners: how to figure out what it is one does not know” (ibid.).

2.4 Learning and Teaching Strategies

Learning strategies refer to “the ways in which students go about their academic tasks, thereby affecting the nature of the learning outcome” (Biggs, 1996; 2001). Individual students’ learning strategies can be categorized as either a ground or a deep approach (Marton et al., 1996). In a ground approach to learning, the students focus on memorizing sets of facts, reproducing parts of the content and, thereby, developing an atomic view. The deep approach to learning takes place when the students focus on significant is-

sues in a particular topic. They reflect on what they have read, and relate it to their previous knowledge. The students look for the overall meaning of the material and develop a holistic view, which is desirable (ibid.). When a student takes a deep learning approach, high quality learning outcomes can be achieved. To achieve high quality learning, higher order cognitive thinking skills, such as analysis, and synthesis are required. Ground learning, on the other hand, is generally focused on comprehension and reproducing knowledge and, therefore, results in poorer learning (Marton and Saljö, 1984).

The teaching strategies have a great impact on students' approaches to learning (see e.g., Entwistle and Tait, 1990; Kember and Gow, 1994; Kember and Kwan, 2000; Eley, 2006). For instance, the teachers who chose a constructivist strategy encourage students to take responsibility for their own learning process. They give the students the opportunity to construct their learning in relevant environments where it is the students who decide what they need to learn and what kinds of activities are desirable (Wilson, 1996). The result of such an active learning environment can be a deeper understanding of the subject studied and the accomplishment of a higher level of learning according to the taxonomy. According to Bonwell and Eison (1991), there are five characteristics for an active learning environment:

- Students are involved in more than listening.
- Less emphasis is placed on transmitting information and more on developing students' skills.
- Students are involved in higher order thinking such as analysis, synthesis, and evaluation.
- Students are engaged in activities such as reading, discussing, and writing.
- Emphasis is placed on students' exploration of their own attitudes and values.

Teachers' leadership styles in the classroom have also been considered as a key element in achieving improved learning (Harris and Chapman, 2002, Murphy, 2005). The traditional teaching strategies put the teachers in focus where they have the total control and the students' outcome of learning is memorized content (Trigwell et al., 1999). Vermunt and Vermetten (2004) argue that students are not satisfied with the traditional approaches to teaching and learning environments. Therefore, the demand on teachers, to adopt innovative teaching methods in the classroom, is increasing.

2.5 Teacher's Leadership Styles

The key aspect to be addressed when educational improvements are being sought, is teacher's leadership (Wilmore, 2007; Alger, 2008) therefore, the focus ought to be on improving their leadership capacity.

Many researchers consider the relationship between teacher and students from an organizational perspective, where the classroom is considered as a small organization consisting of a group of students and a teacher. In this organization, the class teacher is the leader and the students are the followers (Maehr, 1990; Yin Cheong Cheng, 1994; Harris, 2003, McGoran, 2005; Wilmore, 2007). In this small organization called classroom it is important to keep in mind the fact that, the teachers' leadership style affects the educational outcomes (see e.g., Usdan et al. 2001; Harris and Chapman, 2002; Harris and Muijs, 2003, Harris, 2003). Given the importance of leadership style, it is vital that adequate attention is given to ensuring that teachers have a good knowledge of effective leadership theories. As Simkinis (2000) states "I now live in a world dominated by the idea that leadership is one of the major factors—sometimes it seems the only factor—that will determine whether an educational organization, be it a school, a college or a university, will succeed or fail" (ibid.).

Bolman and Deal's four frames of leadership have been considered as useful organizational theory for viewing and studying leadership orientations (Figure 2.1). The authors state that, people frame each situation they enter and the frame that they have chosen to use will guide their actions and the reality that is experienced (Bolman and Deal, 1992). In the first frame, the *structural frame*, goals and efficiency are emphasized which is represented by clearly defined goals. The structural leaders will provide a clear set of directions by which they can hold people responsible. The second frame is the *human resources* frame. Leaders who use this frame value relationships and feeling and seek to lead through facilitation and empowerment.

Characteristics	Structural	Human Resource	Political	Symbolic
Metaphor	Machine	Family	Jungle	Carnival
Central Concepts	Rules, roles, policies	Relationships, needs, skills	Power, conflict, competition	Culture, rituals
Decision Making	Rational	Commitment	Gain or exercise power	Confirm values
Leader	Analyst, architect	Catalyst, servant	Advocate, negotiator	Prophet/poet
Process	Analysis, design	Support, empowerment	Advocacy, builds coalitions	Inspiration
Communication	Transmit facts	Exchange needs and feelings	Influence others	Tell stories
Motivation	Economic	Growth	Coercion	Symbols
Challenge	Attune structure to task	Align needs	Develop agenda/ power base	Create meaning

Figure 2.1 Table displaying the characteristics of the Bolman and Deal Four Frame Model. Adapted from Bolman and Deal, 1992; and Monahan, 2004.

The third frame is the *political* one. The political frame considers individual or group interests that often displace organizational goals. Leaders with a political bent to value negotiation and pragmatism. This kind of leaders invest a considerable amount of effort into networking, creating coalitions, building a power base, and negotiating compromises (Bolman and Deal, 1984; Bolman and Deal, 1992; Bolman and Deal, 1993; Bolman and Deal, 1997). The final frame is the *symbolic* one. Symbolic leaders encourage enthusiasm and commitment through charisma and drama. They concentrate on ritual, ceremony, stories, and other symbolic forms (ibid.).

As mentioned earlier, there are different types of leadership styles. Lewin and his colleagues categories leadership in three categories: autocratic, democratic and laissez-faire (Lewin et.al., 1939). Autocratic leaders focus on their own ideas and will do what they consider right, ignoring other members' suggestions and ideas. An autocratic leader tries to convince other

members that she or he has the best ideas and solutions to a current problem. These leaders do not consider other team members to be of equal importance to themselves, and they may force members to obey their decisions by rewarding or by punishing them. In contrast, democratic leaders have a close relationship with other group members and they can encourage all the members to participate in planning, and at the same time they value members' ideas and suggestions when making a decision. Finally, laissez-faire leaders have confidence in other group members and do not try to control them. They do not establish any concrete goals to be achieved by members and, therefore, the members are free to decide what to do by themselves. This kind of leadership style will work if the group members are extremely competent in their field (ibid.).

It is also considered that the teacher's leadership is a key element in sustaining meaningful changes in schools (Katzenmeyer and Moller, 2009). By adopting a democratic leadership style teachers can give the students control over their own learning which ought to result in deep learning (Alagic et al., 2004).

3. Knowledge-based Systems' Technologies

Humans have a long tradition of utilizing systems, containing knowledge to help them to make decisions, as well as to search for new information in various domains (Durkin, 1994). Systems can be categorized depending on their purposes, modularity and architectures, e.g., they can be classified as decision support systems, expert systems, knowledge-based systems or knowledge management systems. Some of the oldest and also most commonly encountered terms are KBSs and expert systems (see e.g., Hayes-Roth et al., 1983; Waterman, 1986; Wiig, 1994; Durkin, 1994; Awad, 1996).

In this chapter the concept of systems containing knowledge will be clarified. First, a brief description of knowledge and reasoning strategies is given. Then, those types of systems that are most important for this research are introduced, i.e., KBSs, knowledge-based hypermedia systems, and knowledge management systems. Finally, the terms knowledge management, knowledge transfer, and knowledge sharing are discussed.

In the KBS genre, knowledge is the heart of the system (Awad, 1996). The quality of knowledge is important since it determines a system's capability in the problem solving (David et al., 1993).

Knowledge is not information and information is not data (Awad and Ghaziri, 2004). Awad and Ghaziri (2004) define data as unorganized and unprocessed facts, which are static and do not lead anywhere. Information, on the other hand, is data, which has been assigned a meaning (Liebowitz and Wilcox, 1997). In contrast, the concept of knowledge has been defined in different ways depending on the discipline in which it is used (Awad and Ghaziri, 2004). For example, knowledge has been defined as a "fluid mix of framed experience, values, contextual information, and expert's insight that provides a framework for evaluating and incorporating new experiences and information." (Davenport and Pursak, 2000).

In a KBS, knowledge is acquired from a domain expert. The domain expert "is the person who possesses the skills and knowledge to solve a specific problem in a manner superior to others" (Durkin, 1994). Since the system operates on this knowledge, it needs to be elicited, structured and imple-

mented in the system. In a KBS it is important to extract knowledge from the domain expert. The acquired knowledge is presented in a KBS in the form of information. The user must use and work with this information in order to attain personal knowledge. This way of working with the system is considered to be in accordance to the constructivist view of learning, where users are active in their learning.

3.1 Knowledge and Reasoning strategies

In this subsection, the most important elements in a KBS, i.e. knowledge and reasoning strategies are introduced.

3.1.1 Knowledge in the System

The knowledge elicited for a KBS can be categorized e.g., as procedural, declarative, meta-knowledge, heuristic, and structural (Durkin, 1994).

Procedural knowledge refers to the skills required to perform a task or an action. Commonly, knowledge is automatic and reactive. Thus, this type of knowledge is used over and over again and becomes automatic (Awad, 1996).

Declarative knowledge refers to the knowledge that an expert can verbalize. It describes what is known about a domain. This includes simple statements that are either true or false. Declarative knowledge also includes a list of statements that more fully describe some object or concept (Durkin, 1994).

Meta-knowledge is knowledge about knowledge (Negnevitsky, 2005). This kind of knowledge is used to choose the other, existing, knowledge that is best suited to solve a problem (Durkin, 1994). Hence, this knowledge can enhance the efficiency of since it can direct the reasoning (Waterman, 1986).

Heuristic knowledge, also called rules-of-thumb, refers to the knowledge compiled by the expert through his or her previous experience (Awad and Ghaziri, 2004). Heuristics describes the rules that make it possible to by-pass large parts of the reasoning process (Durkin, 1994).

Structural knowledge describes knowledge structures, i.e., through providing a model of a problem. The model includes concepts, sub-concepts and objects and their relationships (Durkin, 1994). It also consists of rules, their referents and interrelationships, and of algorithms for manipulating symbols,

concepts and relations. This knowledge includes one's ability to memorize vocabulary, concepts, facts, definitions and relationships between facts (McGraw and Harbison-Briggs, 1989).

In a KBS, the procedural and declarative knowledge types are commonly covered (Durkin, 1994).

3.1.2 Reasoning Strategies

Reasoning is the process of drawing conclusions by utilizing facts, rules and problem solving strategies (Durkin, 1994). Commonly used reasoning strategies are: deductive, abductive, inductive, analogical, common sense and non-monotonic reasoning.

Deductive reasoning refers to deducing or working out new conclusions from logically related information. In such reasoning facts (axioms) and rules (implications) are used to draw conclusions. The basic form of reasoning is based on Modus ponens rules of inference, which uses the syntactic form: IF (conditions)-THEN (conclusion) When the conditions are satisfied, the conclusion is also true. According to Awad and Ghaziri (2004) deductive reasoning is called exact reasoning since it deals with exact facts and exact conditions.

Abductive reasoning is a form of deduction that allows plausible inferences to be made (Durkin, 1994). Plausible conclusions are drawn from available knowledge, but they might be wrong. From an implication and a fact, abductive reasoning can infer an explanation of that fact (ibid).

Inductive reasoning refers to arriving at a conclusion from a limited set of facts by using generalization. The abstract general rules are hypothesis explaining a set of facts. From a limited number of rules and/or cases, a general rule is generated. This general rule applies to all cases of that particular type, and therefore the reasoning is based on a limited number of cases (Durkin, 1994).

Analogical reasoning relates one concept to another (Awad, 1996). People build a mental model of some concepts through their experiences. This mental model helps them to understand similar situations or objects through analogical reasoning. Thus, the people concerned draw analogies between two situations or objects by looking for similarities and also differences (Durkin, 1994).

Common sense reasoning is a combination of analogical and inductive reasoning (Awad, 1996). Common sense reasoning is the strategy by which problems can be solved efficiently through experience. Human beings use their common sense to derive a solution so the reasoning relies on good judgment rather than on exact logic.

Monotonic reasoning assumes that the state (i.e., whether something is true or false) is static during the problem solving, i.e., the facts remain constant. However, sometimes the facts change and already derived conclusions may have to be withdrawn since they no longer follow logically and therefore it is said to be non-monotonic. This strategy addresses the problem of changing beliefs. A system that adopted this kind of reasoning handles uncertainty by making the most reasonable assumptions in the light of uncertain information (Luger, 2005). Luger argues that non-monotonicity is an important aspect of human problem solving and common sense.

3.2 Knowledge-based Systems

The term KBS refers to many of the organizational IT applications that are useful in managing the knowledge assets of an organization. KBSs comprise systems that use knowledge-based techniques, such as expert systems, rule-based systems, groupware, and database management systems (DBMS) (Laudon and Laudon, 2002) to support human decision-making, learning and action. One characteristic of these systems is that they cooperate with users in the process of reasoning. Thus, the quality of support given and the way this support is presented are considered to be important issues.

To understand the difference between a KBS and other similar computer systems, it is important to understand their architecture. The KBSs were named after their architectures which are comprised of a *knowledge base*, a *user interface*, and an *inference engine*. The knowledge base contains facts and rules related to the problem. Moreover, one or several reasoning strategies are implemented in the inference engine, which interacts with the knowledge in the knowledge base, as well as, the user's input to solve a problem (Figure 3.1).

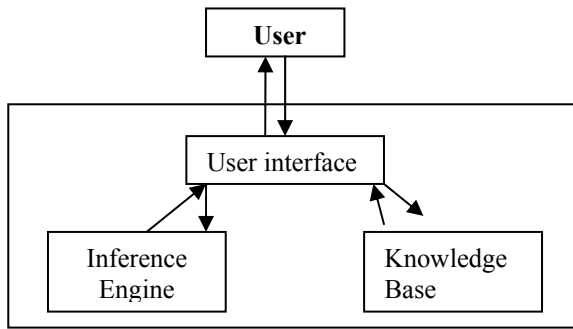


Figure 3.1 A KBS' architecture (Negnevitsky, 2005).

The communication between the user, who seeks a solution to a problem, and the system takes place via the user interface. This communication should be meaningful and user supportive to assist him or her to the greatest extent possible (Negnevitsky, 2005). In the knowledge base, explicit domain knowledge may be represented as facts, production rules, or heuristic rules for reasoning within the domain and meta-rules, i.e., rules about rules. With this exception of the rules, the knowledge can be represented as structured objects, such as, frames, and decision tables (Awad and Ghaziri, 2004).

The inference engine carries out the reasoning by linking the rules and the facts in the knowledge base, with the user's input, and driving new information about the problem (Negnevitsky, 2005). There are two methods by which rules can be executed, which are backward and forward chaining (Durkin, 1994). Backward chaining is a goal-driven form of reasoning. A system using this method establishes a goal or hypothesis, and then attempts to find evidence to prove it. The forward chaining method is a data-driven reasoning, which means that the reasoning starts with the known data and then attempts to infer conclusions from this (ibid.).

KBSs can offer a successful technique when focusing on well-established, limited sub-domains, where knowledge can be properly modeled (Hanley, 2003). In this respect, such systems should only be implemented in situations where they can solve a clearly identifiable problem (ibid.). Edman and Hamfelt (1997) propose software architecture for co-operation between a user and a system. They argue that a well working cooperative system should be able to 'collaborate' with the user and, thereby, extend the system's knowledge base with the user's contribution. Moreover, Stolze (1991) emphasizes that in KBSs the process of problem solving must include inputs from the user and, therefore, should not be fully computerized.

Edman and Hamfelt (1999) have developed a system architecture combining techniques from knowledge and hypermedia systems. They argued that, by combining these two techniques to form a so called knowledge-based hypermedia system, the systems could offer an improved user interaction, reduce the problems caused by missing knowledge, and improve navigation by means of problem solving, reducing the weakness associated with static links (*ibid.*). A combination of techniques from hypermedia with KBSs makes a system more informative, functional and user friendly (Rada and Barlow, 1989; Liu et al., 1995; Edman, 2001). In this thesis, the term knowledge-based hypermedia system will not be used since this technique can be included within the concept of the KBS, as this is a broader term.

3.3 Knowledge Management Systems

Owing to the vast amount of knowledge being tapped throughout the world on a daily basis organizations have realized the importance of knowledge as a significant organizational resource (Liebowitz, 2001). Knowledge is the key resource in today's knowledge-intensive organizations and through the increasing interests of organizational knowledge the concept of knowledge management has emerged (Maier and Sametinger, 2002). Knowledge management is the process of capturing and making use of the organization's collective expertise (Awad and Ghaziri, 2004). Different tools have been developed with the intention of transferring and sharing the knowledge among the employees. The tools take the form of, for example, databases, intranets, document management systems and, knowledge management systems.

3.3.1 Knowledge Management

Knowledge management (KM) can be defined as the management of organizational knowledge to create business value and generate a competitive advantage (Tiwana, 2001). As a result of this, the intellectual capital is a significant component of the market value of all companies (Awad and Ghaziri, 2004). Thus, the main component of companies' value is no longer located in the equipment, buildings, or receivables, instead it is associated with the people's intellectual capital of the employees (Housel and Bell, 2001).

Nowadays, KM has even been accepted in the field of education (Petrides and Nodine, 2003, Edman, 2005). This has brought new demands on educational institutions to think like businesses (Brown and Duguid, 2000). "For educational institutions, the full promise of KM, lies in its opportunities for improving students' outcomes", (Petredies and Nodine, 2003), which will

help students, teachers, and the entire education community. However, KM comprises three co-dependent parts (Figure 3.2); people, organizational processes, and technology (Awad and Ghaziri, 2004). In order to support people by means of technology different organizational processes have to be considered.

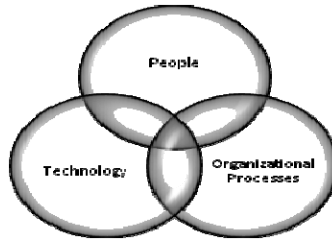


Figure 3.2 Conceptual View of Knowledge Management (Awad and Ghaziri, 2004)

Davenport and Prusak (1998) argue that an organization has three main objectives where knowledge management is concerned. The first of these is to make the knowledge visible and demonstrate its importance in the organization. The second objective is to develop a culture of knowledge sharing. Then, with the intention of fulfilling these two objectives, one encounters the next objective, which is building a knowledge infrastructure in the organization. People with knowledge provide content by using technology to transfer and share knowledge (Awad and Ghaziri, 2004). The power of knowledge management lies in the focus placed on people's combined knowledge in, e.g., educational settings, and on faculty, staff, and students and their needs (Awad and Ghaziri, 2004; Petrides and Nodine, 2003, Edman, 2005; Liebowitz, 2001).

As mentioned earlier, one of the biggest challenges for knowledge management in educational organizations is to move towards a more student-centered learning environment. According to constructivism, deep learning and critical thinking can be achieved if the students are active in the learning process, which mainly takes place in a student-centered setting. It is a reasonable assumption that, in student-centered schools, the teachers' teaching strategies and the role they adopt as a leader will be of great importance. For instance, to achieve the greatest success, a democratic style is advised, rather than an autocratic one.

3.3.2 Knowledge-based Systems for Knowledge Management

A KBS is one of many tools that can facilitate the process of knowledge management in an organization (Avram, 2005). Liebowitz and Wilcox (1997) emphasize the importance of KBSs for lifelong learning. The authors mean that in a time of economic and organizational changes, many people, and especially those in their upper age 40s and 50s are forced out. If they are

to be able to get a new job many of these people need to be reeducated. In this respect, Liebowitz and Wilcox state that “If the knowledge in the KBSs is complete, consistent, and validated, people could be supported by such systems to learn more about different subjects in a short time.”(ibid.).

KBSs can be offered as tools to support the process of knowledge management in a learning environment. When a KBS is used in this manner, thereby integrating IT tools and knowledge management one refers to the result as a knowledge management system (Avram, 2005). Knowledge management systems (KMS) are designed to help organizations to capture, codify, store, and disseminate organizational knowledge (Alavi and Leidner, 2001, Haag et. al., 2006).

3.4 Knowledge Transfer and Knowledge Share

The terms *knowledge transfer* and *knowledge share* are correlated to each other (Awad and Ghaziri, 2004). Knowledge transfer is a mechanistic term refereeing to the process of providing knowledge for someone else (ibid.). When knowledge is captured and codified, it could be transferred to the other users in the organization (ibid.). The recipients of the knowledge can be a group, a team or individuals. The term *share*, on the other hand, is defined as the exchange of knowledge between, e.g., individuals, teams, or even within teams, and between individuals and knowledge bases (Alavi and Leinder, 2001).

When related to KBSs, the term knowledge transfer is the activity of moving knowledge from the knowledge base, created by the expert and the knowledge engineer, to an environment where it is made available to the end user (Sandahl, 1992). The result should be able to be interpreted by the end user so that he or she is able to understand and apply the knowledge and the reasoning strategies (Håkansson, 2003). The interpretation could, for example, provide some advice to the end user, that might be able to increase the performance of the end users work.

Davenport and Pruzak (2000) illustrate the goal of knowledge transfer as:

Transfer = Transmission + Absorption (and use)

According to Andersson (2002) if one is to achieve transfer, knowledge not only needs to be sent to a recipient but also be absorbed and put to use. Andersson (2002) argues that, if we design a representation of knowledge that can be understood, the chances that the knowledge will be absorbed will

improve. Moreover, if the representations of the knowledge can be used by the computer in solving a task, then we increase the chance that the knowledge will be used, and therefore learned by the user of the system (ibid.). It is worthwhile noting that this way of working with the knowledge via a KBS is an active process and that it can be seen to be suitable for SCL environments. The transmitted knowledge can not be absorbed and personalized unless the user works actively with the knowledge.

In knowledge management, knowledge sharing refers to using existing information to create new knowledge or to reframe knowledge to achieve some goals (Hawryszkiewicz, 2007). Thus, knowledge sharing must combine the explicit information, stored in documents, with the specialized tacit knowledge possessed by human beings (ibid.). Kjellin (2002) argues that the success of knowledge management projects depends on the extent of the employees' motivation to share their knowledge.

In an earlier work about knowledge transfer, Hawryszkiewicz (1999) argues that the effectiveness of knowledge transfer strategies depends on two major factors: 1) the organizations ability to shape appropriate approaches to knowledge transfer and 2) activities conducted in partnership with their various communities to respond productively to the individual needs of those communities. The process of knowledge sharing between individuals in an organization will contribute to an overall learning for the entire organization (Andrews and Delahaye, 2000).

4 Related Work

A great deal of research has been carried out in the field of computer science for educational support, with the results that different tools have been developed, such as intelligent tutoring systems, hypermedia systems, and KBSs. The focus of these systems is most often on supporting students' learning, and only few systems exist supporting teachers providing education. In this chapter, examples of support systems for students and teachers are presented. The similarities and differences between these and my proposed systems designs are also discussed.

The idea of using a KBS as a tool for learning is not new and goes back to the MYCIN project (Van Melle, 1978; Buchanan and Shortliffe, 1983). MYCIN was developed at Stanford University to help physicians diagnose bacterial infections in the blood and then recommend treatments (ibid.). Based on the rules in MYCIN the system GUIDON was developed to teach medical students problem solving techniques and to improve their skills (Clancey et al., 1979) later on, and still within the field of medicine the NEOMYCIN system (Clancey and Letsinger, 1981) was released with the aim of facilitating the student's own problem solving and learning to make diagnoses. In this thesis, KBS's technologies have been used to support both students' and teachers' individualized and active learning.

A KBS for students' learning, influenced by the idea of active learning, is *Mission: Water* developed by Kylberg (2001). The aim of the system is to support students as they are to learn how to analyze lake water. In order to motivate the students, Kylberg uses ideas from games to encourage them to perform the analysis themselves for a given assignment (ibid). To perform the analysis, students are required to find relevant information both during the session and afterwards. Moreover, measurements from tests of the lake water are needed and the intention is that students perform tests of lake water to obtain the required measurements. If it is not actually possible to perform these tests in a lake, the system can provide test data. The assignment is performed under constraints of time, money and instruments.

In the design of *Analyse More* (2nd version), which is described in article 3, some of the ideas from *Mission: Water* (Kylberg, 2001) has been adopted.

The most important is the emphasis on getting the students to be active by directing them to perform the analysis themselves and providing feedback to the analysis. Furthermore, *Analyse More* (2nd version) supports the students by making available different kinds of information and in different representation forms, which is similar to *Mission: Water*. Both designs, *Mission: Water* and *Analyse More* (2nd version), utilize different kinds of media and have a uniform user interface as a central node. In *Analyse More* (2nd version) the game metaphor is not used. In this research, the domain knowledge has been used to investigate whether and how different kinds of knowledge can support the students' different types of intelligences that user can have, which was not something that was taken into account in *Mission: Water*.

My approach, to supporting students' individualized learning, based on the theory of multiple intelligences in *Analyse More* (2nd Version), is related to the system *EDUCE*, which is an intelligent tutoring system (Kelly and Tangney, 2002; 2003). This system is based on the view that users have different ways of learning. The system can dynamically identify user's learning characteristics and adaptively provide a customized learning material tailored to the user. *EDUCE* supports four different intelligences: verbal-linguistic, visual-spatial, logical-mathematical and musical-rhythmic intelligences. *EDUCE* uses descriptions, highlighted keywords, and terms to support verbal-linguistic intelligence-related explanations. For logical-mathematical content the system uses numbers, pattern recognition, relationships, questioning and exploration. For visual-spatial content, photographs, pictures, visual organizers and color are used. For the musical-rhythmic content, *EDUCE* uses musical metaphors, raps and rhythms. The system has a set of tutorials that consist of learning units explaining a particular concept. Each unit includes four different sets of learning resources based on one of the intelligences. These different resources explain a subject from several perspectives or display the same information in different ways.

Student-centered approach to teaching advocate the provision of an active learning environment for students. In this sense, my work differs from the underlying *EDUCE*. No Student models, categorizing the user, has been used in any of my designs and instead of letting the system take control of the learning, based on the student model the user has control. As a result of this decision, the user can be provided with an active learning environment where he/she controls the learning process by choosing what to learn and when to get feedback on the chosen subject. In an Artificial Tutoring System (ITS), such as *EDUCE*, the system usually plays the teacher's role and has control over the teaching process and therefore, does not offer active learning that is considered to be essential for deep learning.

However, there are several ideas in EDUCE which are similar to mine. In both system designs, the domain context is presented in different representation forms to support different intelligences. EDUCE offers support by adjusting the content presented to the students and, in my designs, the user has the freedom to choose the representation form that suits his/her intelligence. In EDUCE, a subject can be presented from several perspectives. A KBS can also be designed to offer different views of the domain, different views of reasoning strategies, and different ways to work with the domain knowledge (Håkansson, 2001; Mayiwar and Håkansson, 2004; Håkansson, 2005a; Håkansson 2005b).

Support for students' individualized learning can be offered in the system *eTeacher* (Schiaffino et al., 2008), which is an intelligent agent intended to provide personalized assistance to students through e-learning. *eTeacher* utilizes Felder and Silverman's (1988) model for categorizing learning styles. This model categorizes students as intuitive-sensitive, global-sequential, visual-verbal, and active-reflective. The system observes a student's behavior when taking online courses and automatically builds a student profile. The profile comprises the student's learning style and information about the student's performance, such as, the exercises done, topics studied, and exam results. *eTeacher* uses the information in the student profile to proactively assist the student by suggesting personalized courses of action that can help during the learning process. According to Schiaffino et al, (2008), the agent always gives the students some recommendations. The agent is proactive, which means that it can take initiatives based on a student's profile. This approach has certain benefits, but it also has drawbacks, as the agents can support those users who want a proactive agent to help them with computer-based tasks, however other users may prefer to be in complete control and the agents will take that control away from them (ibid.).

eTeacher's aim is to support users with different learning styles. In my designs the focus is not only on specific learning styles, but multiple intelligences and active learning. *eTeacher* generates proactive feedback during the learning process. In my system designs the feedback is given on the users' request. Giving proactive feedback could be an effective way to support students who can't take the control over their learning and who need to be directed in the learning situation. In my designs, I offer mixed-initiative dialogues, and these could direct the user's learning. The proactive feedback is probably a stronger form of support than that offered in my systems designs, but, on the other hand, one disadvantage, in my view, is that the users are controlled by the system and thereby are not given the opportunity to decide when and what kind of feedback to get.

Regarding support to teachers, the hypermedia system *Perspectives in Emotional and Behavioral Disorders* has been dedicated to teachers' learning (Fitzgerald and Semrau, 1996). It has been developed to improve problem solving skills among teachers who work with children with behavioral problems. It helps users to seek and explore the information, listen to different perspectives of experts, and engage in problem solving activities by adopting multiple roles. In order to fulfill the constructivist approach the design of the system includes building on the users' prior knowledge, providing real activities, scaffolding, modeling reasoning processes of experts, and reorganizing information. The authors argue that the system supports users with different learning styles (ibid.).

Similar to my approach, this system offers support for teachers' learning in an active way by offering an authentic learning environment. In the system different real life cases are presented to the user. One of my KBSs designs, Leader Support System, is aimed at implementing different movies based on different leadership styles in the system with the intention being to offer real life scenarios to the user. Another similarity between this system and my research is that the system supports users' different intelligences through the richness of the hypermedia environment. Moreover, in one of my designs, Mentor, the system tries to build on the user's prior knowledge, where questions are based on teacher's current teaching strategies and the system will give feedback and insights to new alternatives. However, this system is a hypermedia system for improving problem solving skills among teachers. Utilizing both hypermedia and KBS techniques is more powerful than only hypermedia because of the possibility of performing advanced problem solving in a KBS. In Mentor, Bloom's Revised Taxonomy has been used with the aim of classifying different objectives and skills that educators need to reflect upon and, thereby, enabling them to improve and adapt their teaching strategies in accordance with the student-centered view of learning.

My work is centered on the design of systems supporting SCL that is influenced by constructivism. Solomonidou (2009) proposes an approach to design and evaluation of constructivist educational software based on students' ideas. This approach consists of three stages: (1) conducting research on students' ideas and conceptual needs, (2) designing software based on students' conceptions and conceptual needs, and formative evaluation of this design, and (3) implementing and evaluating it in a constructivist learning environment. What is unique in Solomonidou's model is that she describes the role and tasks for researchers, teachers and designers when designing constructivist educational software. The author argues that this model improves the collaboration between researchers, designers and teachers, which could result in an enhancement to the quality of educational software (ibid).

The similarity between this model and my conceptual model presented in chapter six is that I also strive to integrate important aspects of student-centered learning that constructivist advocate for into the design of KBSs for learning in educational settings. The aim is to design KBS in a way that supports active and individualized learning for both students and teachers. The conceptual model that has been suggested in this thesis presents a set of design proposals to help designers when designing KBS for SCL. In Solomonidou's model, the core building blocks for learning are comprised of students' existing ideas and conceptions. Moreover, the model is general and identifies the role of the researcher, designer, and teacher in the development of educational software. The design proposals presented in this research are based on aspects that I believe are important to take into account when designing KBSs for learning purposes. Students' different intelligences and the promotion of active learning are important for the design proposals. Moreover, Solomonidou is focused on the students learning in general but in my research the design of KBSs is such that it strives to provide support for students' and teachers' learning.

The common objective in all of the systems introduced is the improvement of the learning and teaching process.

5 Survey of Papers

The research in this thesis is focused on bridging the gap between learning and teaching by tackling two different aspects of education, teaching and learning by addressing:

- students' individualized and active learning which is the topic of the three first papers and
- teachers' teaching strategies and leadership styles which are examined in the three last papers.

5.1 Paper 1: Aspects of Consideration when Designing Knowledge-Based Hypermedia Systems

The purpose of this paper was to identify and present aspects from other disciplines such as pedagogy and cognitive science, which are important to consider for the design of effective knowledge-based systems for student-centered learning.

When developing KBSs as a support for SCL environments, designers should take the students' active and individualized ways of learning into consideration from the beginning of the design of the system as this is desirable in SCL environments. In this paper, mixed initiative dialogue, cooperation, transparency, different representation forms, differentiated feedback, and the capacity of short-term memory have all been highlighted as important pedagogical aspects to be considered when designing KBSs for SCL.

By offering, e.g., *mixed-initiative dialogues*, a two-way communication can take place between the user and the system when solving a problem. Through a mixed-initiative dialogue both the user and the system can control the interaction. Thus, this kind of '*co-operation*' between the student and the system encourages and supports active learning. It is, therefore, important that the knowledge in the system is *transparent*. If it is not, the user will have to put more effort into finding the appropriate knowledge instead of concentrating on solving the current problem.

Another important aspect to be considered when developing a KBS supporting SCL is to employ *different representation forms*, e.g., text, pictures, animation, and digitized speeches to offer support for different users' preferred learning styles. The domain knowledge and the feedback provided from a KBS should be reproduced in different forms.

Furthermore, the capacity of the users' short-term memory must be considered since it imposes limitations on the storing and processing of information. The designers of KBSs should consider chunking information, organizing the domain knowledge, and assigning meaningful names to icons and links.

To conclude, it is important to take into account different pedagogical aspects when designing KBSs for SCL environments. By considering the proposed aspects in KBSs, it is possible to support students' individualized and active learning, which, in turn could support students' deep learning. These aspects have been considered throughout the design of the proposed KBSs in this thesis.

5.2 Paper 2: Considering Different Learning Styles when Transferring Problem Solving Strategies from the Expert to the End Users

This paper examines knowledge representation and reasoning strategies in a KBS to check whether they can be used to support students' various learning styles. A comparison has been made between different intelligences and the knowledge and reasoning strategies in a KBS in this research.

By mapping different kinds of knowledge and reasoning strategies to intelligences, the following information was revealed during the research, but will be repeated here for completeness.

Declarative and semantic knowledge can support *verbal-linguistic intelligence*, as can deductive reasoning. The reason for this is that students with verbal-linguistic intelligence learn by using reading and taking notes, and declarative knowledge is described through words to present facts, rules and conclusions to the end user, and semantic knowledge can be described through words and the meaning of these words. Deductive reasoning can also support this kind of intelligence, since facts and rules presented in the form of words are used when drawing conclusions.

Semantic knowledge is ideal for students with *logical-mathematical intelligence* as they are attached to logic and reasoning and can be supported by semantic knowledge. Semantic knowledge consists of rules, their referents, and interrelationships, and of algorithms for manipulating symbols, concepts and relations. In addition, knowledge and heuristics should support logical-mathematical intelligence by presenting production rules and rules of thumb. Moreover, deductive reasoning can assist logical-mathematical intelligence where new information is deduced from logically related information. The logical-mathematical intelligence should also be supported by other reasoning strategies e.g., common sense reasoning which is close to the way we think logically.

Visualization of concepts aid those with *visual-spatial intelligence*. Students with this intelligence learn best through drawings and visual aids. Episodic knowledge is often described in terms of perceptual characteristics; indeed it can support this intelligence if the knowledge is expressed as icons or metaphors. These icons or metaphors support visual-spatial intelligence, since the system uses pictures with inherent meanings.

Bodily-kinesthetic intelligence could be supported by procedural knowledge and by analogical reasoning. Students with this intelligence learn best through movement and experimentation. They can be supported by procedural knowledge, which, demonstrates a skill and by analogical reasoning, which presents a similar task during problem solving. Procedural knowledge can be presented as a form of step-by-step performance, which can be more easily understood by people with bodily-kinesthetic intelligence than others. Additionally, common sense can also support this kind of intelligence.

Considering knowledge and reasoning strategies from the above-mentioned point of view could help designers to represent the knowledge and reasoning strategies in a way that can accommodate the students' learning styles.

The findings, derived from these two first papers, have been considered in the design of Analyse More (2nd version), which is presented in the following paper.

5.3 Paper 3: A Knowledge-Based Hypermedia Architecture Supporting Different Intelligences and Learning Styles

This paper demonstrates some of the pedagogical aspects presented in 5.1 and 5.2, which are: different intelligences, visualization, different kinds of

feedback, different representation forms, and constraints on the memory. These aspects have been illustrated in a system design called Analyse More (2nd version). This system co-operates with the user in a problem solving task that classifies the status of water in a lake.

The main goal of Analyse More (2nd version) is to help students to learn about the subject actively and in the way they prefer based on their unique intelligences. Through this system, students will be able to choose different representation forms of the domain knowledge and evaluate their understanding through the differentiated feedback given by the system. For this reason, the system's domain knowledge is reproduced in a new graphic interface aiming to visualize the domain knowledge. The emphasis has been given to the design of an interactive map intended to visualize and reinforce the conceptual structure, connections, and concordance among important objects of the domain. Considering the limitation in the short-memory, the main interaction with this system is concentrated on one single interface by chunking the most relevant information in the form of concepts.

Effective representations require the designer to make the most relevant information visible directly to the user. In Analyse More (2nd version), the structure and the connections between the objects of the domain are visualized in such a way that they support students' different ways of learning. To facilitate the user's understanding of the system's functionality, each concept is symbolized by a clickable icon. Moreover, different colors are used to visualize the status of the lake.

The feedback is provided upon request from the student to avoid disturbing students when they are working with the system and also to avoid controlling the learning activities. The feedback is presented in various representation forms considering student's individualized ways of learning. As a help for those students who are not yet able to take responsibility for their own learning the system offers a guided tour, which will give them a path to follow.

First the design of the system has been compared with the theory of multiple intelligences to study how it can support students' different ways of learning. Second, the way the students work with it has been compared with Kolb's experimental learning theory (Kolb, 1984) to see how learning can take place by using this system. This theory defines learning in the form of a cycle starting with concrete experiences, reflective observations, abstract conceptualization and active experimentation through which, the learners observe a situation and then reflect on it. Based on the reflections, the learners form concepts and generalizations that they can test in new situations.

The first comparison showed that since the system presents the domain knowledge and the feedback in different representation forms by combining hypermedia and KBS technology, it was able to facilitate student's individualized learning.

The second comparison indicated that, in making a trip to the lake, the observations and measurements could be performed. This first step of taking measurements supports students in building up concrete experience from the real environment and the system will further support their understanding by providing information about the different status of the lake and measurements. The gathered data is used as an input to the system, based on which conclusions can be made. The objects' values and status are estimated by the system, from which provides material for a reflective observation. The system presents the result of the student's evaluation and upon a student's request can also explain its evaluation. By visualizing both the student's and the system's evaluations the user could be assisted in constructing an abstract conceptualization of the domain. An active experimentation is also supported since the student can change one or several inputs and the evaluations, and thereby test new situations over and over again. This way of working offers students the opportunity to experience all four steps of Kolb's learning cycle.

Based on the above-mentioned comparisons between Analyse More (2nd version) and the theory of multiple intelligences, and Kolb's learning theory, it can be concluded that it is possible to develop knowledge-based hypermedia systems that support students' active and individualized way of learning, when pedagogical aspects are considered.

5.4 Paper 4: Improving Leadership Styles Using Technology: A Discussion.

The previously presented papers aimed at supporting students' individualized and active learning. In this and the following two papers, the focus moved towards assisting teachers' to reflect on their didactical activities, thereby considering aspects such as teaching strategies and leadership style.

In the work conducted in conjunction with the fourth paper, a knowledge management system (KMS) was designed in the form of a knowledge-based system intended to help teachers, to gain an insight into different leadership styles. The aim was to assist the teachers enabling them to receive ongoing leadership training and promote critical consideration of alternative approaches to leadership in the classroom.

Observations and interviews were conducted for the design of this system, called the Leader Support System (LSS). The observations showed that most of the teachers at Salahaddin University are accustomed to using an autocratic leadership style; their teaching strategies are mainly teacher-centered, and often lean strongly toward memorization by students, which results in surface learning. The president, the dean of the Department of Engineering and the dean of the Department of Education at Salahaddin University were interviewed. They discussed an enormous need for a change in the educational settings in the region.

Considering the classroom from an organizational perspective, teachers are seen as leaders. Four leadership frames were suggested by the collaborating educational leadership experts for consideration in the LSS: structural, human resource, political, and symbolic. In this paper KBSs have been explored as a means of representing knowledge relevant to the four frames. Up to now, information technology has been proved to be good at supporting structural information, e.g. in databases and enterprise resource management systems. For the human resource frame, the assumption is that the KBS techniques could be suitable and this may also be the case for the political frame. In contrast, there is more doubt about whether it is possible to reproduce knowledge regarding the symbolic frame in a system.

Human resource issues have been considered to be the core of educational leadership. Some important aspects relating to this kind of leadership include: the capability to organize, creativity, general leadership qualities, and the ability to build good relationships. This frame has been considered in the LSS.

The way the user works with the system has been checked for the LSS to determine whether it can facilitate active learning, and the findings have been compared with Jonassen's (1998) characteristics of a learning experience of constructivist design, which are as follows:

- Engagement in an authentic task that encourages knowledge construction
- Opportunities for collaboration
- Tutors who serve as guides and facilitators
- A series of scaffolding activities or tools, to guide learning.

First, offering real leadership issues provides the user with authentic tasks that can encourage knowledge construction. Second, the session can be seen as a co-operation with the user and the system utilizing mixed-initiative di-

alogues. Third, the explanations given by the system can be perceived to represent the guidance of a tutor. Fourth, by using this system, teachers could be assisted to learn in a constructive way through their own reflections based upon their personal knowledge, earlier experiences and the sessions spent with the Leader Support System. In this way, the learner could be directed towards obtaining a holistic view of the subject, which is emphasized in relation to deep learning.

Collegial discussions were conducted with educational leadership experts at the Tennessee State University to further evaluate the usefulness of this system. These experts were also involved in the design of the system by providing domain knowledge mainly about leadership frames. They considered the LSS to be useful for teachers and for other leaders, too, since it offers an authentic learning environment where they can learn actively and at their own pace. On the basis of discussions with educational leadership experts and the above-mentioned comparison with the constructivist learning experience, it can be concluded that this system assists teachers to reflect on their leadership style and to learn about alternative leadership styles.

LSS could also be used in educational organizations for the purpose of knowledge management. The teachers can practice the knowledge gained by using the system in their daily activities. They can also share their knowledge with others. This way of sharing knowledge can be related to the knowledge spiral presented by Nonaka and Takeuchi (1995). This spiral consists of socialization, externalization, combination and internalization comprising a continuous, but permanently changing environment. When working with the LSS, *socialization* can take place during the interviews with experts and through conducting observations. The knowledge captured in the system, which is involved in the system's reasoning, is represented in the form of explicit rules. These rules are based on the experts' implicit knowledge. This kind of knowledge is in focus during the socialization phase. Thus, it can be argued that knowledge is represented in a form of *externalization*, e.g., going from tacit to explicit knowledge. *Combination* occurs when the user combines the different views of the knowledge presented by the system through the questions, information and feedback with other chunks of information. This phase is an example of explicit to explicit communication. In the *internalization* phase, the user creates personal knowledge based on his or her own previous knowledge and experiences in conjunction with the new knowledge gained during the combination phase. As a result, the user may derive tacit knowledge from explicit knowledge in this phase. The user could share this new knowledge with others through the socialization phase, and, in this way, another circuit of the spiral starts, resulting in the creation of new knowledge within the organization. To con-

clude, knowledge-based systems can serve as knowledge-management systems through the act of sharing and creating new knowledge between an organization's members and in this way, enable them to deal with present-day demands more effectively.

5.5 Paper 5: Mentor- a Knowledge Management System Supporting Teachers in their Leadership

As explained before, teaching in a SCL environment can require teachers to adopt a different leadership style and different teaching strategies. In so doing, teachers need to get new insights into different ways of teaching, as well as, leading, in the classroom. For this purpose, Mentor, a knowledge-management system, was designed in the form of a knowledge-based system.

The aim of Mentor is to give teachers individualized feedback based on their answers to questions that the system poses regarding the design of courses. Additional feedback can also be generated upon teacher's request.

The feedback is based on Bloom's Revised Taxonomy, which is used for the classification of different objectives and skills that help teachers to support students' deep learning. The revised taxonomy consists of two dimensions: the knowledge to be learned (the 'knowledge dimension') and the process used to learn (the 'cognitive process dimension'). Both of these can be used to help write clear, focused educational objectives.

The questions to the user are based on a paper published by Brinko (1991) and are available on the Instructional Resource Center's website (Instructional Resource Center, 2005). As part of the design of Mentor, the questions were re-evaluated by two focus groups of pedagogues from Uppsala University to further establish the relation between the didactical instructions and the pedagogical objectives of Bloom's Revised Taxonomy. In Mentor, each answer given by a teacher will be interpreted and mapped to Bloom's Revised Taxonomy. When the teacher has answered all the questions, Mentor will present an overview of how the answers have been evaluated according to the taxonomy. This overview will help teachers to reflect on their teaching methods and to get insights into different teaching strategies.

The support for the teachers' reflection is given through different kinds of feedback and by explanations provided by the system. Two kinds of feedback are given: dynamic and static. The dynamic feedback is dynamically generated in relation to the conclusions made on the basis of the teacher's

input; in contrast, the static feedback is general, explains different objectives in the taxonomy, and gives suggestions about teaching. Moreover, Mentor engages teachers in the problem solving activities by providing assistance to enable them to conduct an analysis of their current teaching strategies and compare the result of the analysis with the feedback provided by the system.

Research has shown that one obstacle to trying out new teaching methods could be the teachers' insecurity about the methods and the outcome of using them. Mentor can serve as a tool in this regard by assisting teachers to reflect on their current teaching strategies and explore the benefits of applying alternative teaching strategies on their own before attempting them in the classroom.

As mentioned earlier, some important pedagogical knowledge regarding the design of courses has been captured in Mentor. This will facilitate the knowledge management in the educational organizations. Teachers will be encouraged to reflect on their own teaching strategies and to gain an insight into other. The system can also be used as a tool for managing the knowledge in an organization by the creation of new knowledge that can be applied in the classrooms, with obvious benefits for teachers. It is also possible that teachers create new knowledge when applying different teaching strategies in the classroom. This new knowledge can then be captured and stored in Mentor for subsequent sharing with other teachers. This means of capturing and enabling access to knowledge gained through a lifetime's teaching experience could be the most valuable tool in any teacher's armory. Therefore, Mentor can be seen as a useful knowledge-management system.

5.6 Paper 6: Enhanced Teaching Strategies: Elicitation of Requirements for a Support System for Teachers

In this paper, the requirements defined for Mentor have been validated. The process of requirement validation has been used to check whether the captured requirements define the system that the customer really wants. This process involves checking the validity, consistency, completeness, realism and verifiability (Sommerville, 2004). Based on these checks, two tests were performed.

The tests were conducted in a usability test lab in which test participants' ways of working with Mentor, their entire discussions, and the communication between the test participants and the testers were all recorded. The observations were further completed by asking additional questions related to validity, consistency, completeness, realism, and verifiability, when the test

participants had finished testing the prototype. These questions were prepared in advance. The answers and the test participants' discussions have all been transcribed and analyzed.

In the first test, two IT-pedagogues, one from the municipality of Uppsala and the other from Virtual Learning Environment (VLM), participated. In the second test, two pedagogues from the Regional Centre for the Coordination of Pedagogical Development (RCCPD), representing teachers at high schools in Uppsala, Sweden contributed. The latter pedagogues had functioned as domain experts when designing Mentor and, therefore, it was important to involve them in the tests so they could compare the system's reasoning with their own, thereby contributing significant information to the system's domain knowledge.

The result of the tests showed that Mentor is a useful tool for teachers to use to reflect on their current teaching strategies and to explore other ones. Educational leaders could also benefit from using the system because it would give them a fresh perspective on the way schools should be managed. Some comments from the studies are:

“The system is a tool that provokes reflections”.

“This system can be used as a tool to make the way we run our schools visible and to help us to reflect upon this.”

“In the traditional teaching environment, teachers are often alone. When they need feedback on a particular issue, they can use the system.”

The tests also showed that this system could be used as a tool for school leaders in the educational system. Furthermore, the feedback given by the system in the form of explanations and tips was evaluated and determined to be very useful, and to be essential for encouraging reflection on the part of the teachers.

6 Results and Concluding Discussion

The concluding chapter is divided into two subsections: the first of these presents the results of the research and the second discusses the work and gives suggestions for further work.

6.1 The Results of the Research

The main idea underpinning the research conducted in conjunction with this dissertation was to bridge the gap between learning and teaching by using KBSs. The endeavor brought vital ideas from constructivism, multiple intelligences, leadership styles, teaching strategies, and KBSs together to support student-centered learning and teaching. The student-centered approach to learning emphasizes active and individualized learning. In SCL environments, the role of the teacher is to facilitate and encourage students to interact and learn both from the teacher and from other students. In doing so, teachers should consider students' intelligences and learning styles. The students' preferences for different learning techniques have been categorized in the theory of multiple intelligences which is used in the system designs presented in this research to help students to learn in accordance to their learning styles.

There are many computer-based systems available for supporting and facilitating students' learning, however, they are not usually influenced by ideas related to active and individualized learning. These concepts are fundamental to theories of learning, including constructivism and the theory of multiple intelligences, where they are perceived to be essential for students' deep learning. In attempting to incorporate these theories, the development of computer-based systems suitable for SCL requires the system designer to consider pedagogical and cognitive aspects of students' learning throughout the entire design process.

Various pedagogical tools are available to enable teachers to improve their didactical skills, and most of them include applications to connect teachers with one another with the intention of enabling them to discuss strategies. There are other tools in existence that include systems by which the teachers

can get access to different types of material that can help them to reflect over their teaching strategies. These kinds of tools do not support teachers' to learn in an active and individualized way. Thus, in the research presented here, the means of utilizing KBSs for teachers' active and individualized learning has been explored.

The hypothesis is that it is possible to bridge the gap between teaching and learning by using KBSs that:

- can be beneficial for the students' active and individualized learning
- can support student-centered learning by assisting teachers to reflect on their teaching strategies and leadership style.

The two subsections 6.1.1 and 6.1.2 address the results from the research relating to the students' individualized and active learning and teachers' teaching strategies and leadership styles. In 6.1.3 a set of design proposals for KBSs intended to support student-centered learning are presented.

6.1.1 Knowledge-based Systems Can Be Beneficial for Student's Active and Individualized Learning

In this subsection, the second research question is addressed, namely:

How can we improve transfer of knowledge and problem solving strategies to support students' different intelligences and learning styles?

As discussed earlier, as a result of the existence of different intelligences and learning styles, each student learns in a unique way. Educational studies show, that for students to achieve deep learning, the teaching strategies should be adapted to individuals' learning styles and the students to be active in the learning process. In the light of the desire to adopt a student-centered perspective to learning, some important pedagogical aspects, such as individualization, the use of different representation forms, the visualization of knowledge, and the short-term memory capacity and the need to receive feedback, have been highlighted for the design of KBSs. These pedagogical aspects contribute to the designers' understanding of the way the systems can support students' learning, and therefore, can be used to provide guidance when designing KBSs for learning and teaching purposes.

Different types of knowledge and reasoning strategies have been studied to see whether and how they can satisfy students' different intelligences. Through the adoption of an analytical approach, each type of knowledge and reasoning strategies were examined based on the nine different intelligences defined in the theory of multiple intelligences. The result of the comparison

showed that majority of these intelligences can be supported by incorporating knowledge using different representation forms. Adopting this point of view can help designers to represent the knowledge and reasoning strategies in a way that can support the end users' preferred learning styles. This study highlighted two important factors for consideration when designing KBSs for learning. The first of these is the need for a better understanding of different kinds of knowledge and reasoning strategies in a KBS and the second is the role of the students' different intelligences and learning styles. Once the designer pays attention to these two factors, the system developed will be more effective at supporting learning, because, the students will be able to pursue and understand the knowledge and reasoning strategy provided by the system more easily.

The idea of individualized and active learning is illustrated in a KBS, Analyse More (2nd version). In this system, the domain knowledge is reproduced in different representation forms, e.g., as text, pictures, sound and animation to support users' different learning styles. As far as the altered functionality in Analyse More (2nd Version) is concerned, the users are given the opportunity to work actively with the system to perform an analysis themselves, which is important for the implementation of a student-centered approach. Moreover, co-operative problem solving takes place within the domain by involving students in the problem solving activities.

Through a mixed-initiative dialogue, the user can solve problems based on the user's input in the form of measurements and observations in the domain. Moreover, during the session, the user can, e.g., ask the system about the method for measuring, get hints about how to solve a problem, and get different forms of feedback after the user has suggested a solution.

The new interface in Analyse More (2nd version) has been evaluated, as has the way students' work with the system examined in the context of the theory of multiple intelligences, which showed that most of the intelligences could be supported when the domain knowledge and the feedback are presented in different representation forms. Kolb's experiential learning theory was also used to find out how learning can take place by through the adoption of Analyse More (2nd version). This theory defines learning in the form of a cycle starting with concrete experiences, reflective observations, abstract conceptualization and active experimentation, through which, the learners observe a situation and then reflect on it. Based on the reflections, the learners form concepts and generalizations that they can test in new situations in an iterated manner. It could be concluded that, when working with the system students could experience all four steps of Kolb's learning cycle.

On the basis of student-centered view of learning and the above-mentioned comparisons, it can be concluded that including important pedagogical aspects in a KBS, especially in the form of co-operation, mixed-initiative dialogue, and different representation forms of knowledge and feedback can facilitate students' active and individualized learning on the part of the students.

6.1.2 Knowledge-based Systems Can Assist Teachers to Improve their Leadership Style and Teaching Strategies

The student-centered approach to learning increases the demands on the teaching' profession, especially by imposing demands on the adoption of new teaching strategies and often unfamiliar leadership style. The result of the literature review showed that different kinds of computer-based systems have been aimed at supporting teachers' pedagogical skills in different ways, but these systems are often focused on connecting the teachers with one another, thereby enabling them to discuss teaching strategies, or with the intention of giving them access to different types of material that can help them to reflect over the most suitable teaching strategies. These kinds of tools do not support teachers' active and individualized learning. Drawing on the benefits of KBSs, the means of supporting these kinds of support has been explored by answering the following research question:

Can KBSs be designed to help teachers to reflect on their leadership styles and teaching strategies in an individualized and active way?

Two KBSs have been designed with the aim of supporting teachers to encourage them to reflect on their leadership style and teaching strategies. The goal is for the first system to support teachers to become democratic leaders and adopt a student-centered approach. For the second system, Mentor, the aim was to facilitate teachers' learning about different teaching strategies.

The first system, LSS, provides teachers and other educational leaders with an ongoing leadership development program. Leadership styles are considered to be the most important aspects in the design of the LSS. This system provides users with individualized feedback on the teacher's current leadership style and offers suggestions about alternative ones. The first design of LSS was discussed with educational leadership experts at Tennessee State University for gathering relevant domain knowledge and also to analyze the feasibility of this system. The experts considered it to be helpful for teachers wishing to improve their leadership style. Furthermore, the way one works with the system has been compared to the constructivist learning experience presented by Jonassen (1998). The result of this comparison indicated that, by presenting a real leadership issue, the user will get engaged in authentic

tasks which support knowledge construction. The system also offers a kind of ‘co-operation’ between the user and LSS through mixed-initiative dialogues. The system’s explanations can be considered to be equivalent to having a teacher. The system assists teachers to get a holistic view of leadership styles by letting the user to reflect on the issue under consideration by incorporating his or her personal knowledge, and previous experiences, as well as through the use of the LSS. In this way, the user could be directed towards a holistic view of the subject and learn in an active way.

In addition to the teachers’ leadership style, their teaching strategies are important elements for promoting student-centered learning. It was with this in mind that Mentor was designed. This prototype is especially important for teachers who still use a teacher-centered approach in the classroom. They should be supported to facilitate the attainment of a new insight into alternative teaching strategies. Mentor reflects this need as it was intended to provide teachers with feedback to reflect upon their current teaching strategies and to give suggestions about how to utilize different approaches to teaching. Since, the teachers’ leadership style affects the teaching strategies, this system can be seen to be complementary to the LSS. When defining the function of the system, aspects such as, active and individualized learning were emphasized.

In the development of Mentor, Bloom’s Revised Taxonomy was used to provide the basis for the classification of different objectives and skills that are important for teachers to reflect upon. Moreover, the revised taxonomy was used to relate the teachers’ teaching strategies to the taxonomy and to afford a basis for generating feedback to the teacher because feedback is essential for learning.

Two groups have evaluated the design of Mentor in a usability test lab at Uppsala University. The first of these was comprised of two IT-pedagogues from the municipality of Uppsala, and in the second test, two pedagogues from Uppsala University participated. One common statement made by all those involved in the test was that Mentor could be used as a tool for teachers’ reflections on teaching strategies. In particular, the individualized feedback was highly appreciated. Furthermore, the participants in the test suggested that groups of teachers could use the system as a base for discussions about the teaching strategies used in their schools.

From the above-mentioned evaluations, it can be concluded that Mentor and LSS are KBSs capable of supporting teachers in the move towards student-centered teaching.

Mentor and LSS can also be considered to perform as knowledge management systems when supporting the process of sharing knowledge between individuals in an educational organization, which ought to contribute to the learning of both the individuals and the organization. For example, in Mentor, the teacher can add his/her own experience-related knowledge to the knowledge base to enable other teachers to benefit from it. KBSs can seldom be ‘completed’ as the additional knowledge is almost always open-ended. Therefore, Mentor offers the users the opportunity to contribute through the addition of their knowledge. Besides, the aim is to encourage users to be active and to share their knowledge with other users, e.g., using Mentor in groups will encourage teachers to share their knowledge. The power of being able to access the experiences and solutions of a multitude of teachers who have encountered a whole mass of experiences and attempted a variety of solutions will provide an invaluable resource for the modern teacher guiding his/her students’ learning. Therefore it can be concluded that it is possible to see KBSs as a tool for supporting the teaching process by providing teachers with a means of reflecting on their current leadership styles and teaching strategies actively and in an individualized way.

6.1.3 Bridging the Gap between Learning and Teaching by Using Knowledge-based Systems

As mentioned earlier many learning theories and educators advocate for the use of SCL, and therefore, this research has been permeated with the view that students need to be active and could be assisted in learning in an individualized way through KBSs. In this regard, an answer to the third research question has been sought, this being:

What aspects should be considered in KBSs to bridge the gap between learning and teaching?

During the design work several aspects of importance *for designing KBSs for teaching and learning* have been addressed. These aspects are multiple intelligences, differentiated feedback, cooperation and problem solving related to “active learning” and “individualization”. The idea under consideration in this subsection is to describe these aspects and to try to relate them to one another in a form of a conceptual map. This conceptual map can be perceived as a set of design proposals; in my opinion, these design proposals concern the issues that it is most important to take into account when designing KBSs to support learning and teaching.

The design proposals corresponding to the higher levels in the conceptual map are: individualization, active learning, multiple intelligences, differentiated feedback, and cooperation (see Figure 6.1). Among the design propos-

als at the lower levels are human memory’s capacity, the transfer of knowledge and problem solving strategies, transparency, mixed initiative dialogues, and meaningful tasks. In this subsection, each design proposal is described and an explanation is given for why the proposals are considered to be important when designing KBSs for learning and teaching.

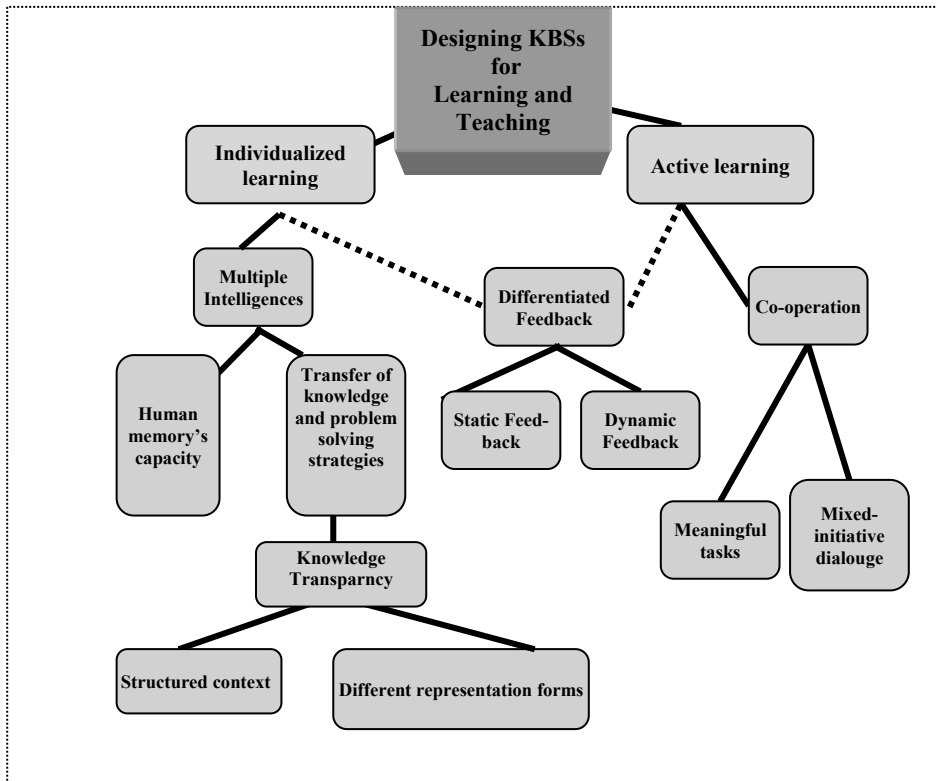


Figure 6.1 A conceptual map for designing KBSs to support learning and teaching.

For teachers to be able to teach in a SCL environment, consideration must be given to the fulfillment of the requirements for students to engage in active and individualized learning as they are important factors to help students to learn deeply and to become critical thinkers. However, in a traditional learning environment it is difficult for teachers to support all forms of intelligence, which means that the needs of some students’ probably will not be satisfied. Learning has to be *individualized* to give the students the opportunity to learn in accordance with their abilities and in their preferred manner. Therefore, it is important to offer systems that consider users’ different ways of learning and provide an active learning environment. Thus, *active learning* is important when designing learning support (see Figure 6.2).

In recent years, many different computer-based systems have been developed to support students' learning. During the period in which the current research was conducted, a series of these systems was studied (some of them are mentioned in Chapter 4). The result of the study showed that active learning on the part of the students is often not considered. KBS techniques can be utilized to offer active learning by including the possibility to let the user perform problem solving. Moreover, it is possible to let the user choose suitable views of the system's knowledge. Different kinds of feedback can also be provided at the user's request, which is related to the desire to ensure that the system allows *individualization*. With individualization, it is meant that the system considers students' different ways of learning and their learning styles. The reason may be that the users of the system have different intelligences and have, therefore, adopted different learning strategies. It is also important that teachers adapt their teaching strategies and leadership style in accordance with students' different ways of learning.

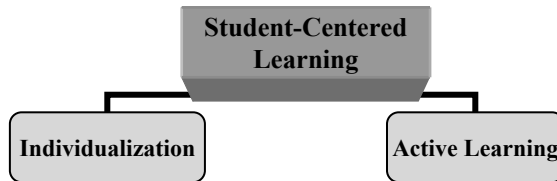


Figure 6.2 Important aspects of student-centered learning support.

Students' learning styles and the feedback provided by the system are significant to be taken into account when designing KBSs for learning and teaching if it is to be possible to obtain a better understanding of individualization of the learning process (see Figure. 6.3).

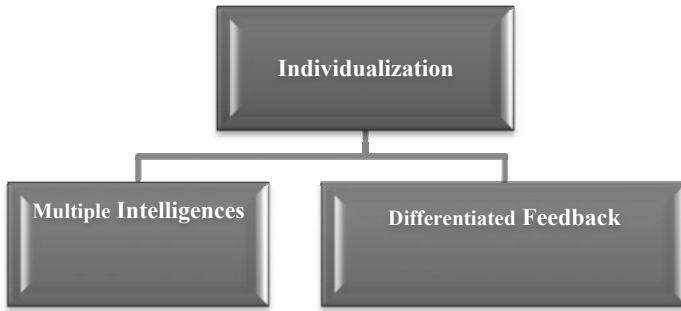
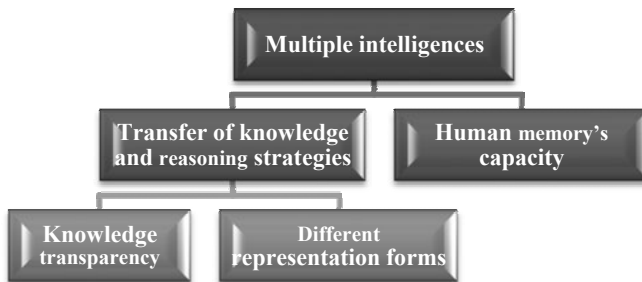


Figure 6.3 Factors to be considered regarding individualization.

As far as the students' different ways of learning are concerned, the theory of *multiple intelligences* has been taken into account in the design of KBSs for SCL environments. The main purpose of developing KBSs is to *transfer knowledge and problem solving strategies* from the experts to the end users (see Figure 6.4). Knowledge transfer comprises the transmission of knowledge together with its absorption and use. A variety of problem solving exercises adapted for solution by multiple intelligences could be incorporated in different ways and the knowledge could be presented in different forms to support users.



6.4 Important aspects regarding multiple intelligences

As the user is supposed to work actively with the knowledge in the KBS, the *knowledge transparency* is also an important aspect of the design. This means that the user should be able to grasp the content with ease. For this reason, the knowledge presented must be well structured and well organised in a logical manner in accordance with the domain in use. The presentation of the knowledge should also be adapted to be accessible to users' with different intelligences and learning styles. Owing to the demand for transparency of the system's domain knowledge, two design proposals have been explored. When utilizing different representation forms, the domain knowledge may be presented as, e.g., text, pictures, animation, diagrams, and

sounds. Through the combination of using different representation forms of the knowledge and ensuring the transparency of knowledge it is, possible to present domain knowledge from different perspectives and in different ways, thereby making the knowledge in the system readily available to different users and thus, enhancing learning.

Moreover, the *capacity of the short-term memory* should be taken into consideration by designers (see Figure 6.4), since the short-term memory has a limited ability to store and process information (Miller's, 1956). Miller's theoretical review of a "magical number seven, plus or minus two" shows the limitation on short-term memory storage capacity. Therefore, it is important to consider this limitation when designing KBSs for learning, e.g. by chunking information, which can support students both in terms of remembering and working efficiently at problem solving.

Differentiated feedback is another fundamental factor in the learning and teaching process and one of importance in relation to individualization and to active learning (see Figure 6.3 and 6.5). The feedback can be seen as being of two types, *static* and *dynamic*. The static feedback is based on the domain context that is always present in the knowledge base. The dynamic feedback, on the other hand, is generated in relation to the user's interaction with the system. Since people learn in different ways, differentiated feedback should be used to appeal to user's different intelligences and maintain their motivation. Therefore, it is important to provide feedback when the user asks for it. Moreover, the feedback should provide a reasonable description about the domain context through a combination of different media, e.g., in form of pictures, text, colors, sounds, and animation. This kind of feedback should make it more straightforward for teachers to provide each student with the kind of feedback adopted to their learning style. This is usually a difficult task in a traditional classroom because of the time pressures.

In my opinion, both differentiated feedback and *co-operation* with the user in the problem solving activities are related to active learning (as illustrated in Figure 6.5). In order to achieve co-operation, users must work with and use the system to solve problems. When the system and the user direct the interaction, together the dialogue is perceived to be *mixed-initiative dialogue*. In a KBS for learning, it is common to use mixed-initiative dialogues, since they seem to resemble the interplay between a tutor and a student best, and be able to engage students in the problem solving.

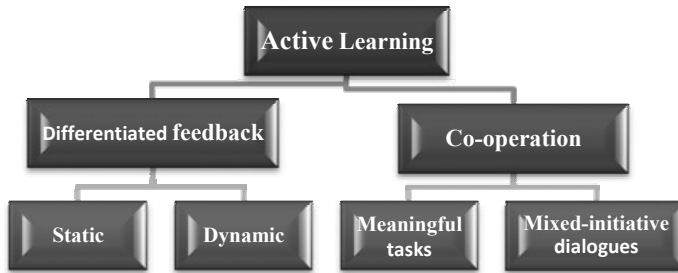


Figure 6.5 Important aspects of active learning.

If students are to become engaged in the learning process, the system must offer *meaningful tasks* for problem solving. The task, or problem, should be user-adapted, which means that it should be described in an appropriate way for the user in question at any one time. Moreover, the knowledge level required to perform task provided must be knowledge adapted to ensure that each user has the prerequisites for solving the problem at hand. This is an important point since people construct new knowledge based on prior knowledge according to the theory of constructivism. Differentiated feedback should be given on the problem to be solved to motivate and support students while they work with the system.

The presented design proposals emanate from the theoretical background presented in the first and second papers, and the practical work performed during the design work in the third through to the six papers. I do not claim that the set of design principles is complete or that the relations between them are the only possible ones. These proposals have been utilized in this work, though, and by putting them together incorporating them in a conceptual map, it could assist the system designers when designing and implementing KBSs for student-centered learning and teaching purposes. Furthermore, this map could help both teachers and students to gain insights into some important aspects of learning. This, in turn, may facilitate the development of a mutually comprehensible language between students and teachers with which to define effective ways of teaching and learning, and thereby, bridging the gap between learning and teaching in educational settings.

6.2 Concluding Discussion

Knowledge-based systems can engage users in the performance of problem solving activities by providing an authentic situation where they are able to perform an analysis and compare the result of their analysis with the feed-

back provided by the system. This way of working with a KBS is in accordance with the student-centered approach.

The common denominator, in the design of Analyse More (2nd version), Leader Support System and in Mentor is support for learning and teaching in SCL environments. These KBS designs could fulfill the characteristics of Jonassen's constructivist learning experiences (Jonassen, 1998), which are:

- *Engagement in an authentic task that encourages knowledge construction*
- *Opportunities for collaboration*
- *Tutors who serve as guides and facilitators*
- *A series of scaffolding activities or tools, to guide learning.*

In the first of these, referring to the design of, KBSs, the designs are able to support the user's active learning by providing him or her with authentic tasks related to the real-life issues. Users are enabled to contribute by inserting their own answers as the input required to solve a problem, rather than selecting pre-defined answers. Example of authentic tasks in this thesis, are analyzing lake water, working with leadership issues, and evaluating teaching strategies. Incorporation of authentic tasks in the system encourages knowledge construction. The user learns about the domain context when working actively with the systems, e.g., in the system designs proposed, this occurs through the performance of measurements or observations, from questions and the answers provided, the information given in relation to the questions and the suggestions made by the system.

Where the second characteristic is concerned, the usage of the system alone, does not result in co-operation between users, but it can be seen as a kind of co-operation between the user and the system, in utilizing the form of mixed-initiative dialogues. Through the mixed-initiative dialogues, a co-operation takes place between the system and the user with the user's input contributing to the solution of a problem using the system. However, the system can offer a form of co-operation between individual users when it is used by two or more users at the same time, and these users are working together. In this regard, the KBSs designs can be even more beneficial by encouraging more and deeper discussions and reflection.

For the third of the characteristics listed, the feedback, presented in different kinds of representation forms constitutes a form of tutor's guidance.

Concerning the fourth and final characteristic, the learning can take place in a constructive way through individual reflections based upon the personal knowledge, previous experiences and the usage of a KBS. The learner can be supported to enable him or her to build a holistic view of the subject under consideration, which is emphasized as something that is desirable in relation to deep learning. By incorporating different types of data representation forms in the systems, such as speech and movies the system designs can offer a series of different activities and help users to gain more and deeper knowledge.

As mentioned earlier, in the past couples of decades, there has been extensive use of ICT in educational settings to assist the teaching and learning process in a SCL environment. However, studies show that ICT alone does not enhance learning and that to take advantage of its potential for learning, teachers need to rethink and reevaluate their perception about their knowledge of teaching and ICT. Moreover, teachers, who choose to adopt a SCL approach, need to have teaching strategies that are in accordance with this approach to be able to involve students in a variety of activities and guide them to higher order thinking, such as analyze, create, and evaluate.

As one might anticipate research has revealed, however, that rethinking and reevaluating one's own expertise critically is a difficult task. Despite the emphasis on constructivism and SCL, studies show that many teachers continue to apply the teacher-centered approach. According to Hedin (2006), there are different explanations for not incorporating a student-centered approach: 1) teachers have limited time and resources in the classroom; 2) teachers who use new teaching methods, which are different from traditional ones, often meet critique both from colleagues and students; 3) teachers are insecure about the new methods and the result of using them. The Leader Support System and Mentor both give the teachers the opportunity to explore other teaching strategies and leadership styles, and thereby reevaluate their own predominant teaching strategies and leadership style.

The proposed KBSs designs, Mentor and Leader Support System, can also be used for knowledge management. As stated earlier, knowledge management comprises capturing, sharing, applying, and creating new knowledge in organizations. For example, in Mentor, knowledge relevant to teaching strategies has been captured, and can be shared by the teachers. Thus, the knowledge captured can be applied by the teachers in the classroom. Applying acquired knowledge to the classroom may create new knowledge, such as how to deal with a particular subject in relation to new teaching strategies. The new knowledge created by the teacher can be captured and stored in Mentor through a knowledge management lifecycle. Knowledge added can

be shared by other teachers, and so on in a spiral of ever-increasing knowledge. Thus, a KBS like Mentor can be considered as an integral part of a knowledge management system for educational organizations. As mentioned earlier, using Mentor in group work can also have an effect on the process of knowledge sharing in the organization through discussions and deeper reflections.

Finally, if it is to be possible to teach and learn in accordance with a student-centered approach, both the students and the teachers should be supported by KBSs. Students need to be provided with teaching materials that offer support for their different preferred learning styles and involve them actively in the problem solving process. Moreover, teachers must utilize teaching strategies and leadership styles that are complimentary to this approach. As mentioned earlier, the teacher's role is the key element in this context. Accordingly, in this thesis support is offered for both students' and teachers' learning through the three KBSs presented. Thus, I have satisfied the hypothesis that it is possible to design KBSs that can be beneficial for the student's individualized learning and can support SCL by assisting teachers to reflect on their teaching strategies and leadership style.

6.3 Further Work

This thesis is focused on the means for designing KBSs for individualized and active learning. The two most important elements in the learning process namely teachers and students have been considered. Three KBSs designs are offered as tools to give both students and teachers new insights into democratic and student-centered approach to learning and teaching.

Three KBSs designs, Analyse More (2nd version), Leader Support System and Mentor are presented. Certainly, the plan is to further develop, implement and test all three proposed system designs, starting with the Mentor and Leader Support System which provide support for teachers. The reason is that despite great emphasis on the teachers' important role for the success in a SCL environment yet there are not many systems that offer support for teachers' active and individualized learning. The designs will be further developed in cooperation with pedagogues and tested on users, to improve the pedagogical ideas in the system architecture.

In supporting students' different intelligences and learning styles the explanations should be presented in several media and tailored to the user, which is part of further work. For example, Leader Support System could easily be expanded with speech in the dialogues. Another attempt could be anima-

tions, to illustrate good examples regarding leadership, but also bad examples. After showing a short movie the system and the user could together go through the shown situation. Furthermore, it would be valuable if the user could alternate between playing the role of a leader and the role of an employee. This will support the human resource frame in a natural manner. The educational leaders can have an opportunity to explore leadership frames in their own cultural context when equipped with systems like Leader Support System.

The process of requirements validation for Mentor has been done. This process is considered to be the most important part when designing a system since the success of an implemented system is depending on clear and well-defined requirements. Thus by the lessons learned during this process we have got good support for the implementation of the design in a working system.

A set of design proposals has been presented for designing KBSs to support learning and teaching. These design proposals will be used in the development of new KBSs to further investigate the usefulness of the design proposals and also to further develop them. In this regard, additional discussions with pedagogues, tests by system developers in several applications, and end users' tests, are needed to be able to see the design proposals as generally usable.

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Appendix 1

Visioning Your Course: Questions to Asked as You Design Your Course

1. What are my course goals? What do I want my students to learn primarily?
 - Content (facts, applications, theories, etc.)
 - Skills (writing, library, computer, research, critical thinking skills, etc.)
 - Attitudes (appreciation for field/subject, global perspective, tolerance, etc.)
 - Other, or some specified combination of the above.
 2. At what level (s) do I want my students to perform?
 - Knowledge (ability to recall facts)
 - Comprehension (ability to understand ideas and translate them into other formats)
 - Application (ability to use ideas in particular and concrete situations)
 - Analysis (ability to dissect ideas into constituent parts to make the organization clear)
 - Synthesis (ability to integrate parts into a unified whole)
 - Evaluation (ability to judge the value of an idea, procedure, etc., using appropriate criteria)
- Note: Each higher level assumes the mastery of lower levels of performance.
3. What class activities will help my students meet these goals and levels?
 - Lecture
 - Large group discussion/problem solving
 - Demonstration
 - Small group discussion/problem solving
 - Debate
 - Laboratory exercise/experiments
 - Case methods
 - Programmed learning
 - Role-play
 - Library research
 - Games, simulations
 - Field research
 - Other, or some specified combination of the above

4. How will I support my students in their efforts to meet these goals and levels?

- Administrative handouts (syllabus, course policies, etc.)
- Content handouts (outlines of lectures, illustrative examples, tables, charts, etc.)
- References, bibliographies
- Practice sessions
- Models, demonstrations
- Review sessions
- Individual conferences
- Other, or some specified combination of the above

5. What assignments will I use to evaluate my students' success with these goals?

- Exams, quizzes
- Oral presentations
- Papers
- Performance of skills
- Projects
- other, or some specified combination of the above

6. How much uniformity of assignments will best serve my students' needs?

- Standardized (students have no choices)
- Menu (students have choices from a fixed list)
- Individualized (students have large range of choice)
- Some combination of the above

7. What evaluation approach will best help my students to meet these goals and levels?

- Summative, for grades and evaluation
- Formative, for feedback

8. What evaluation unit for each assignment is consonant with these goals and levels?

- Individual (each student works independently)
- Small groups (students work in pairs, triads, groups)
- Some combination of the above

9. What type of class atmosphere will foster students' success?

- Competitive
- Cooperative
- Some combination of the two (in what percentages and how combined?)

10. What kind of participation will foster students' success?

-Teacher, 95%; students, 5% (lecture with an occasional student question)

-Teacher, 75%; students, 25% (lecture with some group discussion)

-Teacher, 50%; students, 50% (teacher-led discussion, as in a seminar)

-Teacher, 10%; students, 90% (student-designed and -directed projects)

11. What policy for class attendance will foster students' success?
- Mandatory and graded
 - Mandatory, but not graded
 - Expected
 - Voluntary
12. What pace of the course will foster students' success?
- Fixed (no deviations from syllabus)
 - Flexible (accommodate to skills students bring to the class)
 - Some combination of the two
13. What criteria will I use to determine the student progression throughout the term?
- Achievement of preset goals (comparison with standards)
 - Achievement of norm (comparison with others)
 - Progress made from the beginning of the term (comparison with self)
 - Some combination of the above (how calculated?)
14. How will I calculate final goals for my students?
- Percentage of work satisfactory completed
 - Contracts mad with individual students
 - Competency-based evaluation
 - Some combination of the above (in what percentages?)
15. What qualities do I expect of my students to possess s they enter my class?
- E.g.: prerequisite content, prerequisite skills, appreciation for discipline/field
16. What behaviors do I expect of my students while they are in the class?
- E.g.: willingness to participate in class activities, prompt and consistent attendance, prompt and consistent completion of assignments, responsibility for the participation of others
17. What contingencies have I planned in case my students don't meet expectations?
- E.g.: reprimands (what kinds?), additional coursework, adjustment of syllabus
18. How will I convey all of the above information to my students?
- Administrative handouts (syllabus, Course policies, etc.)
 - Content handouts (outlines of lectures, illustrative examples, etc.)
 - Introductory session to course
 - Pretest
 - Verbal and nonverbal cues throughout term
 - Other, or some specified combination of the above

Appendix 2.

A Use Case for Mentor

Scope: MentorLevel: User goal

Primary Actor: - Teacher, school and university

Stakeholders and interests: Principals, University teachers training teachers, Students and Parents of students

Preconditions:

The user has an account in Mentor.

Success Guarantee (Post conditions):

The user should have answered all questions and gotten feedback. Answers and results should have been saved in the system. The user should have logged out.

Main Success Scenario (Basic Flow):

1. User logs in to Mentor, providing identification information.
2. System returns the start page, presenting the purpose of Mentor.
3. User confirms that he/she has read the information by proceeding to the next page.
4. System presents Blooms revised taxonomy, showing the cognitive dimension and the knowledge dimension, with links to definitions.
5. User explores the definitions in Blooms revised taxonomy.
6. System presents definitions.
- User repeats step 3-4 until he/she is satisfied.*
7. User confirms that he/she has understood the definitions by proceeding to the next page.
8. System presents the connection between the questions and the taxonomy.
9. User confirms understanding by proceeding to the next page.
10. System presents a multiple choice question with different answers.
11. User answers the question and proceeds to the next page.
- System and user repeat step 10-11 for all nine questions.*
12. System presents the result, where the answers are mapped to Blooms revised taxonomy through numbers for each combination of dimension items.
13. User explores a combination number.
14. System presents individual feedback depending on the user's answers as well as general information about definitions and tips for improving the current combination of dimension items.
- User repeats step 13-14 until he/she is satisfied.*
15. User chooses to save his/her answers and result.
16. System saves the answers and the result.
17. User chooses to log out of the system.

18. System logs out the user automatically.

Extensions (Alternative Flows)

*a. At any time, the user can choose to return to a previous page.

1. System presents the previous page.

11a User chooses to return to a previous answer to change his/her answers.

1. System presents the previous question and shows the previous answers.

2. User changes answers to the question.

15a. User chooses to not save his/her answers and result.

1. System asks the user for confirmation.

2a. User confirms that no answers or result should be saved this time.

2b. User regrets the decision and chooses to save the answers and result anyway.

1. System saves the answers.

17a. User forgets to log out.

1. System saves the answers and result and logs out the user automatically after a certain period of inactivity.

17b. User wants to do the questions all over again and chooses to restart the questions.

1. System shows the first question together with the user's previous answers to that question.

Special requirements:

- New users to Mentor should be able to create an account.
- System should have a function to provide new passwords in case of forgotten passwords.
- System should be self-instructing and so intuitive to use, so that no manual is needed.
- System terminology should be adequate for the teaching domain.
- System must be easy to use even for users without much experience of computers.
- It should be possible to choose several answers at the same time.
- There should be an inactivity timer preventing that the user leaves in the middle of running the application, possibly exposing the answers to others passing by the computer.

Technology and Data Variations List:

- Mentor should use hypermedia techniques, possibly web based.
- Result should be generated through knowledge-based techniques.

Open Issues:

- Is an English version enough, or should Mentor support several languages?

Acta Universitatis Upsaliensis

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Editor: The Dean of the Faculty of Social Sciences

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