Applying Knowledge Management in Education:

Teaching Database Normalization

A thesis presented in partial
fulfilment of the requirements for the degree of

Master of Science
in
Information Science

at Massey University, Palmerston North, New Zealand

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2004

Abstract

In tertiary education, Information Science has been attracting more attention in both teaching and learning. However, along the course on the database design theory, learners always find it hard to grasp the knowledge on database normalisation and hard to apply different levels of the normal forms while designing a database. This results poor database construction and difficulties in database maintenance.

In regard to this teaching and learning dilemma, academic teaching staff should, on the one hand, pay more attention to organising different teaching resources on database normalisation concepts and making the best use of the existing and newly developed resources so as to make the teaching environment more adaptive and more sharable, and on the other hand, apply different teaching methods to different students according to their knowledge levels by understanding the nature of each learner's behaviour, interests and preferences concerning the existing learning resources. However, at present there is no effective Information Technology tool to use in considering the dynamic nature of knowledge discovery, creation, transfer utilisation and reuse in this area.

This provides an opportunity to examine the potentiality of applying knowledge management in education with the focus on teaching database normalisation, in terms of knowledge discovering, sharing, utilisation and reuse. This thesis contains a review of knowledge management and web mining technologies in the education environment, presents a dynamic knowledge management framework for better utilising teaching resource in the area of database normalisation and diagnoses the students' learning patterns and behaviours to assist effective teaching and learning. It is argued that knowledge management-supported education can work as a value-added process which supports the different needs of teachers and learners.

Acknowledgements

This thesis has been another milestone in my life. I have received a tremendous amount of encouragement and support in the past one year for which I am really grateful.

I wish to especially thank Bhavani Sridharan, for agreeing to supervise me, and for her comments and invaluable criticism during the course of this dissertation. Many thanks go to Alexei Tretiakov for his guidance and scholarly support. I have greatly appreciated their ongoing commitment, dedication and patience with helping me complete this thesis.

A special 'thank you' to Gloria, Mona, all those colleagues and friends who have offered support. Your unique responses have helped to ease this journey.

Finally, but by no means least, a hearty 'thank you' to my Mum, Dad and elder brother, for providing me with endless inspiration and love from China. This thesis would not have been what it is without your input.

List of Publications Appeared as Part of Work on this Thesis

Zhang L., Sridharan B. & Kinshuk (2003). On-line Knowledge Management Search Engine. In V. Devedzic, J. M. Spector, D. G. Sampson & Kinshuk (Eds.) *The 3 rd IEEE International Conference on Advanced Learning Technologies Conference Proceedings* (July 9-11, 2003, Athens, Greece), Los Alamitos, USA: IEEE Computer Society, 304-305 (ISBN 0-7695-1967-9).

Zhang L., Sridharan B. & Kinshuk (2003). Knowledge Management on Database Normalization. In K. T. Lee & K. Mitchell (Eds.) *Proceedings of the International Conference on Computers in Education 2003* (December 2-5, 2003 , Hong Kong), Norfolk , VA , USA : AACE, 804-805 (ISBN 1-880094-51-7).

Table of Contents

List of Figures and Tables

Figures

Tables

CHAPTER 1

Introduction

A reliable, consistent approach to solving problems makes it possible to:

- *use the new concepts presented,*
- *study the solutions of the problems,*
- *think about the new concepts,*
- *come to a true understanding of the subject.*

-- McAllister, 2003

1.1 Background

The 'knowledge economy' in recent years has popularised the concept of knowledge management (KM). KM includes the processes by which the conversion of tactic knowledge into explicit knowledge occurs, or the processes by which an individual's knowledge is converted into shared knowledge. KM is becoming widely accepted and regarded as one of the most powerful management tools to bring together intellectual resources and make them reusable and sharable across organisation (Davenport & Prusack, 1998; Hinds & Kiesler, 1995).

Because of the development of Information Technology and the spread of the database in industry and government, spanning commercial and a variety of scientific and technical applications, more and more organisations need a sound database to support their day-to-day business operation. Thus, database design plays a central role in the information resource management of most organisations, and has become a part of the general background of computer scientists, much like the ability of building algorithms using a conventional programming language (Batini et al., 1992).

For more than two decades database normalisation – as an important part of database design theory – has attracted more and more educational and research input, but for a long time database design was considered a task for experts (Michener, 1997). In order to overcome this obstacle, courses on database design and database normalisation are considered as important teaching and learning tasks in tertiary education. Along this teaching and learning process, teachers devote lots of effort to curricula design, and search for the proper teaching approaches and right level of knowledge for the students at different course levels. However, research shows that students are still having difficulties in grasping this database design knowledge (Sridharan & Kinshuk, 2003).

With regard to this teaching and learning scenario, academic instructors are searching for solutions to the problems of how to customise teaching materials to meet teaching objectives and students' expectations – and trying to ascertain whether there is a suitable information technology available to assist with education in database normalisation. Thus, questions like: "What should be taught regarding database normalisation?", "Is there a suitable Information Technology available to fulfil this teaching task?", and "How can teachers achieve a better understanding of students' learning expectations so as to refine the teaching objectives and meet students' learning needs?" are being raised among the academic faculties in the universities (Sridharan et al., 2001).

In summary, the potential is there to develop an integrated framework that exploits synergies of KM in order to monitor and manage the full lifecycle of knowledge: discovery and capture, representation, storage, retrieval, refinement and reuse in the educational environment. By using this framework, different aspects of the teaching resources can be effectively stored, shared and reused; learners' browsing behaviour – down to individual mouse clicks – is captured for educational instructors to provide customised and effective teaching curricula for students, thereby improving retention and enhancing teaching and learning experiences.

1.2 Problem Definition

In the tertiary educational environment, every individual teacher develops curricula and teaching resources, classroom activities, pedagogical techniques, and practical insights into learning, development and teacher / student relations (Carroll et al., 2003). These are the *knowledge assets* that are potentially sharable and reusable. However, it is widely recognised that teachers work in relative isolation from their professional peers, which reflects the obstacles like inadequate knowledge sharing expectations, implicit knowledge cultures encouragement, resource hoarding, and a lack of effective communication among teachers and students, etc (Goodlad, 1984; Rosenholtz, 1991; Tyack & Cuban, 1995). Thus, it becomes vital for teachers to develop and refine techniques that work best for their personal classroom culture.

Further, within this tertiary environment, different learning channels are open to students, such as traditional face-to-face learning and modern web-based learning. Although the knowledge volume is in a bulky vast area, learners still find it difficult to locate the right knowledge appropriate to their own learning styles. Few teachers give serious consideration to the importance of understanding learners' learning interests and patterns. The result is, in the short term, teachers will not be capable of evaluating learners' understanding levels and will have difficulty in predicting students' learning patterns – which will end up in students losing learning motivation and tense relationships between teachers and students. In the long-term, this will result in a lesser number of students with satisfactory qualifications in the area, and a lack of database experts or not enough personal input in the related research. Hence, it is very important for teachers to organise the corresponding learning materials in an efficient and effective way such that students can access the knowledge and understand the knowledge in a professional manner.

According to previous research by Sridharan and Kinshuk (2003), courses on database design-related topics are quite popular with business and science students, but the results are not always satisfactory. This reflects an inactive learning attitude, a passive learning environment, non-effective knowledge capture and re-utilization - and is more time and effort consuming. This situation increases the difficulty for students in fully understanding the knowledge. The literature and researchers have addressed such situations as stated above and recommended that solutions need to be explored to resolve this teaching and learning dilemma (Carroll et al., 2003; Chiya, 2003; Trigwell & Prosser, 1998).

In regard to the teaching and learning on database normalisation, although more and more IT students and professionals expend lots of effort in learning the related knowledge, some of them still encounter difficulties along the learning process. So, more and more expectations are pointed out for better teaching and learning methods (Sridharan & Kinshuk, 2003). The ease and speed with which learning resources can be accessed over the web has been a key driving force in the rapid growth of electronic learning (Huang, 2002). Unfortunately, at this stage, a tool designed to take into account this dynamic nature of knowledge discovery, creation, transformation, utilisation and reuse in this particular teaching scenario is not available yet.

Thus, the question that is proposed (and that will be answered) in this thesis is: "Is there any suitable information technology available to provide reasonable solutions to (i) effectively manage the normalisation-related teaching assets; (ii) pass this knowledge on to the learners in a professional manner; and (iii) diagnose students' learning patterns for better customisation of the teaching curricula.

In the past decade, KM has become widely accepted and regarded as one of the most powerful management tools in managing intangible organisation assets. Although KM is a new field and experiments are just beginning in higher education (Kidwell et al., 2001), more and more real-life projects have proved it is a successful means to manage knowledge assets, promote knowledge creation and sharing, shorten the knowledge acquisition time, innovate self-learning motivation and enhance teaching and learning flexibility and adaptation.

Web mining takes the concept of data mining into the Internet environment. By analysing data sourced from the Internet and integrating it with data from traditional data stores, a level of knowledge previously not possible can be achieved. In this light, web mining can be viewed as an approach to solving a special case of the general problem of knowledge discovery in databases (Nasraoui et al., 2002).

Since database normalisation is important in constructing an Information Technology project, and there are lots of online resources which can be used for learners, KM and web mining techniques show potentialities for managing educational assets. This gives a huge opportunity to apply the above-mentioned technology in the educational environment: teaching database normalisation.

Based on the results of investigation, the answers will be presented in the contents of this thesis.

1.3 Purpose

The purposes of this Masters thesis are: (i) to review KM and web mining technologies, obtain an understanding of the teaching and learning relationship and issues in order to better understand the problem domain, identify the feasibility of developing a KM system to enhance learning proficiency and conclude the mission statement; (ii) to design the KM framework for this specific teaching and learning environment, conduct and analyse the survey on teaching database normalisation as a source of knowledge input, apply KM and web mining technology to improve the learner's learning experience; (iii) to deliver system architecture, implement a prototype based on the system requirements such that it can be used in the educational environment, and set up a system evaluation plan; (iv) to propose further actions based on the users' feedback on this prototype and form conclusions; and (v) to present recommendations for future development in this area.

Throughout this thesis, KM and web mining technology are explored and applied to the educational environment: teaching database normalisation. Thus the key aspects of this thesis cover the importance of organising teaching resources for better sharing and reuse; the impact of understanding students' learning patterns to assist with teaching, the possibility of applying KM to teaching and learning situations – especially focusing on teaching database normalisation – and the possibilities of deploying web mining techniques to assist knowledge discovery in the teaching and learning environment. Based on the discussion and justification of the following points, a KM framework including knowledge discovery, creation, utilisation and reuse to be applied in teaching database normalisation is set up.

Further, based on all the findings, a web-based system deploying KM and web mining techniques is implemented and evaluated.

Each chapter in this thesis contributes to the development of this system within which the knowledge of database normalisation becomes more meaningful along the database design process.

1.4 Scope

This thesis covers the concepts, terminology, and general structure of KM and web mining with their major functional components. There is a literature review on both KM and web mining technique in the context of teaching database normalisation; a section on system requirement identification by conducting a survey designed for the purpose, an analysis of the results and then the system prototype implementation and evaluation. The thesis ends with the conclusions and recommendations for possible future developments.

1.5 Audience

The intended audience of this thesis are the KM and web mining researchers as well as others who are interested in (i) computer-aided database normalisation learning along database design development; (ii) KM development in the educational field; (iii) other KM development technology which underpins the work of KM; (iv) web mining technology application used in web-based learning resources; and (v) web mining technology application to the specific KM system environment.

1.6 Thesis Organisation

This Masters thesis is written for advocates of integrating KM and web mining in education with a special focus on teaching database normalisation as part of the database design theory. It is not intended to be a deep theoretical study on extended normalisation theory learning. Instead, it is geared toward developing KM and web mining techniques to improve teaching and learning outcomes. Opportunities are explored to apply KM and web mining techniques in the education environment.

This thesis has been arranged in the sequence of a logical understanding from 'understanding of KM and web mining from the literature', to 'justifying the application of KM and web mining techniques in teaching database normalisation', to 'applying suitable techniques and implementing a prototype' and then to 'evaluating the prototype and formulating the conclusion and outlook'.

Chapter 1 begins with the background of this project. Chapter 2 provides a general introduction to the concepts of KM and its functionality, KM advantages and what KM can bring to education. Then, a conceptual KM framework is developed to guide integration of KM techniques with existing education activities. Further, web mining techniques are illustrated in detail in terms of tracking users' browsing patterns and behaviours.

In Chapter 3, knowledge discovery is emphasised, as the beginning of the knowledge life cycle. The application of data mining and knowledge discovery techniques are explained and compared. With the vast usage of web-based education, it becomes vital to understand students' learning patterns to prepare the teaching curricula in a professional manner. Thus, web mining with web usage mining as the main focus of this thesis is further illustrated in detail..

Chapter 4 focuses on the survey on teaching database normalisation. It first reviews the different knowledge capturing techniques and then compares two schools of survey approaches, the classic approach versus the interpretative approach. By identifying the classic survey approach – the more suitable option for this thesis – a survey on teaching database normalisation is designed, and answers by the lecturers are analysed. The survey findings serve as the tacit knowledge input in Chapter 5.

Chapter 5 concentrates on the system prototype design and implementation. According to the review and discussion of existing approaches to KM system design in the business environment, an educational KM system design methodology is described. Based on this approach, a series of system architectures is explained, which includes KM life cycle architecture, a KM action diagram, the system architecture, and learning pattern profiler design. In regard to the prototype implementation, lists of user interfaces and main coding languages are illustrated.

Chapter 6 contains a system prototype evaluation, assessing the benefits and drawbacks of this prototype. The survey evaluation method is chosen as the suitable approach for this KM system, by comparing and contrasting four existing system evaluation methodologies. Based on the analysis of the survey responses, it is concluded that the prototype system offers advantages in assisting teaching and learning in database normalisation.

Chapter 7 contains a summary of the findings and it is concluded that by using KM techniques in teaching database normalisation, both teaching and learning outcomes are enhanced. Future outlook is provided based on these findings.

Knowledge Management in Education

In an economy where the only certainty is uncertainty, the one sure source of lasting competitive advantage is knowledge.

-- Nonaka, 1991

2.1 Introduction

KM is focusing on bringing together intellectual resources and making them available across organizational boundaries (Davenport, 1997).

The needs and opportunities for KM in Education are analogous to those in business organisations. The principal educational resources offered to students is knowledge, as learning and teaching, which are not independent in nature, are focusing on the process of student learning and understanding supported by the teachers' knowledge of their research (Ramsden, 1992), which can be claimed as *knowledge assets*. This is particularly true of tertiary educational institutions that deliver knowledge and skills from their academic staff to their students.

This chapter contains a review of the KM technologies and discusses the importance of organising teaching resources for better sharing and reuse, and the impact on teaching of understanding students' learning patterns. Further, a KM framework is set up as the foundation of further discussion of the following chapters, within which web-mining techniques are deployed to contribute to the knowledge discovery stage.

2.2 Knowledge Definition

In order to obtain a better understanding of KM, it is necessary to first define knowledge. In the present socioeconomic situation, knowledge is the prime organisational asset (Arora, 2002), and knowledge flows are regarded as the most important factors in our society (Sunassee & Sewry, 2002). Knowledge is the lifeblood of decision-making within an organisation.

Wigg (1996) defined knowledge as 'the insights, understandings and practical know how that we all possess – (it) is the fundamental resource that allows us to function intelligently'. More often in the information system literature, the definition of knowledge makes a distinction among *data*, *information*, and *knowledge*. For example, Flemming (1996) defines *information* as the collection of data, and *knowledge* as the collection of information – so knowledge and information are not identical. Dillingham (2002) argues that information is atomic and static, but knowledge is associative, rich, multilayered, multifaceted, contextual, accessible, and dynamic. Thus, in this thesis, 'information' is distinguished as documented or codified concepts, and 'knowledge' is the personalised understanding / view / experiences. In the scenario of teaching database normalisation, answers like 'the first normal form is…'are identified as information, while individual experience of how to ensure that the database is in the third normal form is considered as knowledge.

Although each conceptualisation interprets different aspects of the three terms, it is very important to understand when information becomes knowledge. Alavi (2000) explains that the distinction between information and knowledge is not found in the content, structure, accuracy, or utility of the supposed information or knowledge. Hence, throughout this thesis, knowledge is regarded as the human expertise stored in a person's mind, gained through experience, and interaction with the person's environment (Sunassee & Sewry, 2002). Knowledge is also highly subjective depending on a number of factors such as the culture, beliefs, values, insights, intuitions, and emotions of the individual. Furthermore, as knowledge is shared and disseminated throughout the organisation, it increases in value, as argued by Davenport & Prusack, 1998; Sveigy, 2000a; Tiwana, 2000; Zack, 1999).

Figure 2.1 further illustrates the relationship among data, information, knowledge and wisdom.

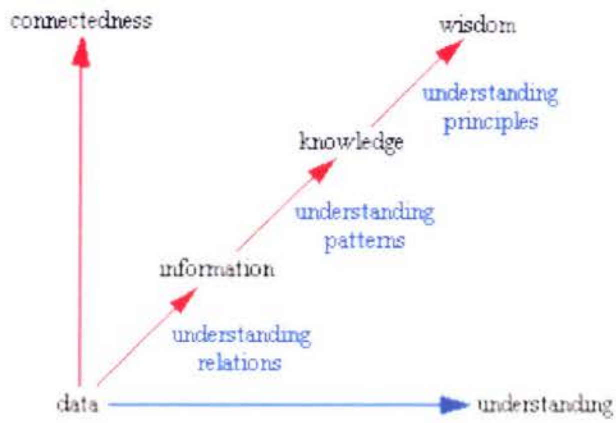

Figure 2. 1 Progression from data, to information, to knowledge, and to wisdom (from Ackoff, 1989)

Further, two forms of knowledge are identified by the philosopher, Michael Polanyi, and the Japanese organisation researcher, Ikijuro Nonaka: explicit and tacit, which have some similarity to Stewart's hard and soft knowledge assets (Nonaka & Takeuchi, 1995; Polanyi, 1964; Stewart, 1997)

Explicit knowledge is the knowledge that is written, sketched, spoken about, and recorded. It can be expressed in words and printed in documents. Tacit knowledge is, on the other hand, hidden, inaccessible, embodied, almost unknown, and often unconscious. It is mostly deeply located in human beings' brains. Knowledge can not be directly transferred (Hunter 2002). Transmitting knowledge from one person to another requires that the sender create data containing information that is sufficiently manifest for the receiver to comprehend the new distinctions and / or norms being communicated. Since communication is a subjective process, the same data that informs one person and changes his or her knowledge of a situation may be too latent for someone else, whose knowledge then remains unaffected after receiving the same data (Argyris, 1993).

The main challenge of managing knowledge is less in its creation but more in its discovery and integration (Davenport, 1997; Grant, 1996). Thus, it is vital for organisations to invest their efforts in discovering, integrating, sharing and reusing the knowledge from organisational members. Through the development of modern computer techniques, the methods of knowledge discovery and transfer have largely changed from the traditional face-to-face interaction to electronic means, which gives more flexibility and effectiveness in managing knowledge assets. As stated by Brown and Duguid (1991), 'knowledge will not necessarily circulate freely firm-wide just because the technology to support such circulation is available'.

In order to give more insights on knowledge assets within the tertiary environment, a survey was conducted of different aspects on teaching database normalisation. The survey details are fully illustrated in Chapter 4.

2.3 Knowledge Management Review

KM is an attempt to deal with the collective knowledge of an organisation and individuals' knowledge within the organisation, i.e. what an individual does with his / her own knowledge (Wiig, 2000). This includes storing, cross-linking, categorising, conceptualising, retrieving, and further presenting. Thus the knowledge to be managed is not the knowledge of a single individual being available to that individual whenever it is needed, but the knowledge of at least one individual being usable by at least one other.

KM is not just about businesses, although it is a heavily commercialised notion. Student management systems like Blackboard are also forms of KM systems. Think of a classroom as a sort of organisation with the goal of increasing the knowledge of the organisation and of the individuals within it.

KM deals with the organisational optimisation of knowledge to achieve enhanced performance, increased value, competitive advantage and return on investment, through the use of various tools, processes, methods and techniques. KM is not synonymous with concepts such as 'organisational learning' and 'learning organisations'. KM can be seen as a process that involves the creation, capture, storage, dissemination, sharing, utilisation, and retirement of knowledge. This process should, however, lead to organisational benefits (e.g. innovation, improved performance and competitiveness).

Duffy (1999) defines KM as 'the identification, growth and effective application of an organisation's critical knowledge'. However, Takeuchi (1998) proposes a contradictory view of KM which advocates less control over employees and involving everyone in the organisation to create and share knowledge, which - in turn - fuels the organisation's innovative strategy. This different philosophy is shared by Sveiby (2000a) who argues that knowledge is not something that can be 'managed', and that the term to be 'Knowledge Focused' is preferable. Sveiby (2000b) also emphasised that it is the environment in which knowledge is created that initiates the task of managing knowledge, but the knowledge managers are not capable to manage knowledge.

In line with this review, in this thesis KM is defined as identifying and mapping knowledge for the use of an organisation, that is, teachers and students; generating new knowledge from competitive advantage based on existing knowledge, making vast amounts of knowledge accessible, sharing best practices and technology that enables all the above.

2.4 Knowledge Management Application in Education

In the educational environment, KM often encompasses identifying and mapping intellectual assets, transmitting knowledge to learners, improving knowledge sharing, and providing a new environment in which new knowledge is to be created (Carroll et al., 2003).

KM in teaching is closely related with the innovation of a mutual learning culture wherein teachers' communities of practice work together as teachers and, in the course of their professional collaborations, these communities will better understand their own knowledge sharing practices, as well as their frustrations, needs and desires. Innovations in knowledge sharing practices will enhance the social experience of working together, which - in turn - will promote a better teaching and learning environment and benefit both teachers and students.

In a perfect class, using a KM system, all of the knowledge and information generated by the students and teachers would be distributed, shared, catalogued, and available, all the time. Teachers would lay out something interesting and valuable, interpret the concepts based on their own teaching experience and understanding, and then store the knowledge in the KM system. That means sharing not only the explicit knowledge such as notes, keywords, categories, and links to other related knowledge, but more importantly, discovering, sharing and re-utilising the active / update-to-date human knowledge / experiences.

The benefits from the use of various forms of KM tools such as action teaching, retrospect and lessons learned meetings are adding value to both the teaching and the learning processes. Further it can improve the functionality in the educational institution, such as: reduce communication cycle times, provide an effective and efficient teaching and learning process (learners, facilities, network), shorten knowledge acquisition time, and improve the quality of services provided to the students / teachers. If it can be successfully used by the campus students, it can also be used for distance education; it can provide a different kind of education environment which innovates and delivers learners' self-learning motivation, enhances flexibility and adaptation and encourages sharing and communication.

The foregoing discussion shows that there are huge benefits in applying KM in teaching to achieve higher teaching and learning expectations. Therefore, in the specifically educational scenario, by appropriate justification / modification, the idea of what KM does for business can be applied to teaching database normalisation in order to explore an effective way to manage teaching resources and to help students to better understand knowledge of database normalisation.

2.5 Knowledge Management Frameworks in the Literature

KM frameworks emphasise the focus for consideration in KM efforts (Earl, 2001). These frameworks can help one to approach KM methodically and consciously, which can help identify a specific approach to KM, to define goals and strategies, to understand the various KM initiatives, and then to choose the best ones in the particular circumstances (Maier & Remus, 2001).

Rubenstein-Montano et al. (2001) classify KM frameworks in three categories: descriptive, prescriptive, and hybrid. Prescriptive frameworks provide direction on the types of KM procedures without providing specific details of how these procedures can, or should, be carried out. Descriptive approaches describe KM, and identify attributes of KM that can influence the success or failure of the initiative. Finally, hybrid approaches are a mixture of both the prescriptive and the descriptive approaches.

The literature review and an analysis of six current KM frameworks reveal that six can be classified as descriptive ones (Carlson, 1999; Mentzas et al., 1998; Skyrme, 1999), four as prescriptive (Macintosh, 1999; Van Der Spek et al., 1994), and one as a hybrid framework (U.S. Army, 1999).

Upon analysing these frameworks, three main characteristics were observed. Firstly, the analysis revealed that the prescriptive frameworks (Macintosh, 1999; Van Der Spek et al., 1994) do not place any emphasis on the alignment of the KM strategy with the organisational strategy, whereas all of the descriptive frameworks (Carlson, 1999; Mentzas et al., 1998; Skyrme, 1999) and the hybrid framework (U.S. Army, 1999) do. This is in line with what other authors agree upon that a KM strategy should be closely aligned with the overall business strategy, and provide the organisation with a competitive and innovative edge (Duffy, 1999; Tiwana, 2000; Wiig, 1999).

Secondly, two of the descriptive frameworks (Carlson, 1999; Skyrme, 1999) and the hybrid framework (U.S. Army, 1999) also emphasise the importance of people and their contribution towards the KM effort, whereas only one of the prescriptive frameworks (Van Der Spek et al., 1994) looks at this aspect. Andrews (2000) and Tiwana (2000) also confirmed the similar findings.

Thirdly, in three of the frameworks (Macintosh, 1999; Mentzas et al., 1998; Van Der Spek et al., 1994) analysed, the focus on technology was distinctly disproportionate to the focus on the employees of the organisation. In the other three frameworks (Carlson, 1999; Skyrme, 1999; U.S. Army, 1999), the emphasis on both the technological and human factors was strong.

The literature also reveals that most Western managers and organisations have tended to choose an IT-Centric-Top-Down approach, but Takeuchi (1998) argued that what succeeds is a people-centric approach, from the bottom-up, but properly encouraged and supervised by top management.

Although each KM framework mentioned above addresses certain KM elements, not one addresses KM across the full spectrum of the organisation's needs (Calaberese, 2000), which applies to the educational environment.

2.6 Knowledge Management Framework for Education

The literature shows that the KM frameworks vary from one to another due to differences in the organisational environment or targeted outcomes (Rubenstein-Montano et al., 2001). The goal of this thesis is not to create yet another definition, but to define a KM framework to suit the objectives of KM in the educational environment, specifically, teaching database normalisation. The corresponding definition is to create efficient and effective way to discover, capture and utilise knowledge of teaching database normalisation, form a knowledge-sharing community in a related database normalisation area, and produce a flexible knowledge acquisition and maintenance process.

Certainly, the KM systems and other variations mentioned above are extremely valuable contributions to the KM society, but this thesis argues that problem solving is a motivation for learning. KM practices should be applied to the process of problem solving, as problem solving is essentially the same activity as understanding the nature of the problem (Popper, 1972). Further, the real challenge in KM is less in the 'sending' and more in the 'receiving', particularly the processes of sense making, understanding, and being able to act upon the information available (Denning, 2001).

In the light of this thesis, it is proposed that both teachers and learners must get involved in order to obtain a better understanding of the current teaching and learning situation by recognising and resolving problems and recognising opportunities. Therefore, knowledge transformation occurs dynamically based on problem solving processes and the ability to reconfigure and reuse knowledge to satisfy a variety of learning uses. The process is initially triggered by the learners. Figure 2.2 depicts the KM framework in the educational environment.

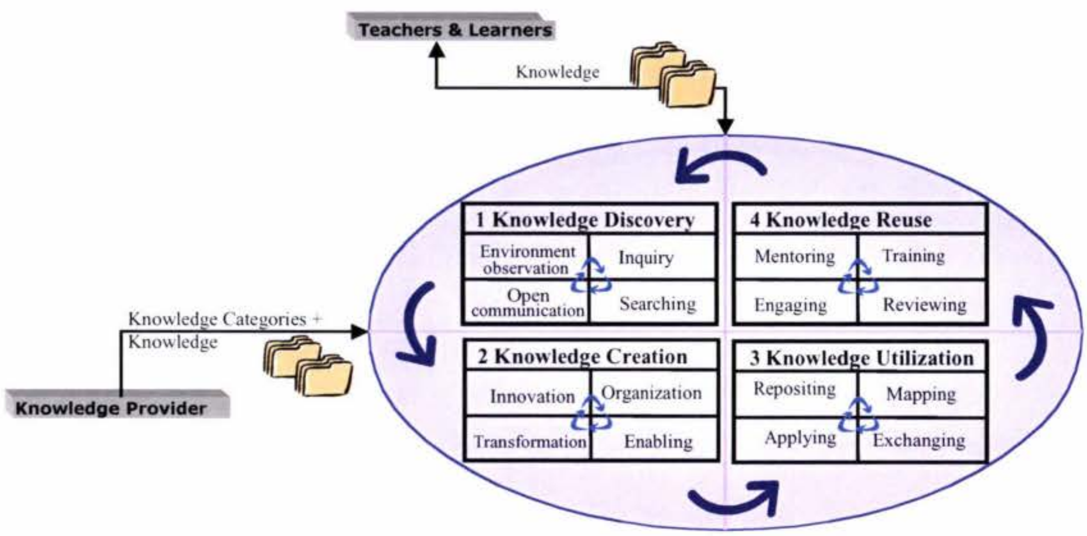

Figure 2. 2 Educational knowledge management framework

According to Figure 2.2, this KM framework consists of three parts: teachers and learners, knowledge provider and knowledge process, presented as an oval shape.

Teachers and learners fire the trigger to start this knowledge process by sending the knowledge request. They send the request based on different kinds of educational scenarios, such as scenarios on gaining practice on the 3rd normal form. Knowledge providers are the source of knowledge. They maintain the amount of knowledge used by the users.

The knowledge creation process is the abstract view of the series of learning actions evoked along the corresponding teaching scenario. Based on the previous argument, this learning process is divided into four integrated phases: knowledge discovery, knowledge creation, knowledge utilisation and knowledge reuse. Each phase contains several activities which are based on natural human learning behaviours, for example: problem discovery consists of the activities such as environment observation, open communication, searching and inquiry. The four phases mentioned above are integrated with each other. They form a rolling cycle which starts with knowledge discovery and this rotation does not terminate until learners are satisfied with the required knowledge. The sub-components of each phase self-rotate along the learning process. The rotation of inner activities of each phase terminates when the learning process shifts from one phase to another phase.

To view horizontally the central oval, knowledge discovery (cell 1) and knowledge utilisation (cell 4) are focusing on practices that help learners find out problems, while knowledge creation (cell 2) and knowledge capture (cell 3) are focusing on the problem solving. If the central box is viewed vertically, cell 1 and cell 2 are the process of knowledge generation along which learners discover and solve new problems. Cell 3 and cell 4 combine knowledge sharing practice and emphasise the re-adoption of the knowledge about previously solved problems or issues.

In short, this framework has an advantage over other frameworks, because the tangible knowledge assets from both teachers and learners, like their 'external' interaction[1] with their environment (information), and / or an individual's 'internal'

1 External Interaction means the degree to which human input influences (changes) the messages presented from external media.

interaction[2] between new and previously existing information and experiences are captured and stored.

Thus, valuable knowledge can be further enhanced by other teachers and learners so as to generate further knowledge based on the original knowledge, and reuse what was achieved. Applying this KM framework guarantees that knowledge is sharable and reusable. New knowledge can be created at the end of each knowledge life cycle. Further, KM may also encourage the learning and feedback loops to continue.

2.7 Summary

Most organisations realise that 'Knowledge' is a strategic resource that gives them sustainable competitive advantages (Drucker, 1993). In order to effectively manage the knowledge assets with the educational environment, and understand the impact of students' learning patterns on teaching, in this chapter knowledge was first defined, then the concepts of KM and the importance and benefits of applying KM in education were explained. Based on the reviews of six different existing KM frameworks, a KM framework is set up in an educational environment. Four sub-processes – knowledge discovery, knowledge creation, knowledge utilisation, and knowledge reuse – are shown interacting with each other which encourages new knowledge to be generated and thus it is stored and continues the interchange within the knowledge life cycle. This frame work lays the foundation of this thesis.

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2 Internal Interaction = Changes in cognitive knowledge structures and processes resulting from the interchange between new information (received via media) and previously-existing information/knowledge structures.

CHAPTER 3

Knowledge Discovery via Web Mining

Enter the World Wide Web...much more interest in lifelong learning, just in time learning, and what do we have? A shattering of industrial age methods, models, and ideas about education...

– Poley, 2001

3.1 Introduction

Many tertiary education institutions have invested heavily in information technology to help them manage their teaching resources more effectively and gain a competitive edge. Over the last three decades, increasing amounts of critical teaching and learning resources have been stored electronically and this volume is expected to continue to grow considerably in the near future.

Yet despite this wealth of data, many institutions have been unable to fully capitalise on its value. Thus, the intention of managing these online data brings forward the concept of knowledge discovery, an incorporated part of KM processes.

This chapter focuses on the concepts of knowledge discovery and its functions and benefits to teachers and students. In addition, it explores the techniques for knowledge discovery, which involve its contents, functions, and benefits. At the end of this chapter, the educational KM framework which integrates knowledge discovery as part of the knowledge process will be re-emphasised.

3.2 Knowledge Discovery Review

The field of knowledge discovery is getting to be very popular and has grown recently. The large amounts of data collected and stored might contain knowledge which could be useful, but it is not obvious to recognise, or trivial to obtain it (Fayyad, 1996). There is no human capable to sift through such amounts of information and even some existing algorithms are inefficient when trying to perform this task. Knowledge discovery systems incorporate techniques from a large variety of related fields to utilise their strengths in the process of discovering knowledge.

In order to achieve a thorough understanding of the knowledge discovery techniques and apply them in the educational environment, the following two subsections concentrate on the definition, components with their functionality and processes of knowledge discovery in database.

3.2.1 Knowledge Discovery in Database VS Data Mining

Quite often, literature on the topic of knowledge discovery uses terms like *data mining* and *knowledge discovery in database* (KDD). In Frawley et al. (1999), a clear distinction between data mining and knowledge discovery is drawn. Under the conventions, the knowledge discovery process takes the raw results from data mining (the process of extracting trends or patterns from data) and carefully and accurately transforms them into useful and understandable information. This information is not typically retrievable by standard techniques but is uncovered through the use of Artificial Intelligence techniques.

Data mining is defined as the process of data exploration to extract consistent patterns and relations among variables that can be used to make valid predictions. Data mining is a modern data analysis approach that does not replace traditional statistical techniques; rather it combines statistical methods with increasing computing power to process huge volumes of available data (Berry & Gordon, 2000).

Fayyad et al. (1996a) state that knowledge discovery in databases is the process of identifying valid, novel, potentially useful, and ultimately understandable patterns / models in data. Data mining is a step in the knowledge discovery process consisting of particular data mining algorithms that, under some acceptable computational efficiency limitations, find patterns or models in data.

To further explain the above KDD definition (Dalkilic et al., 1997), the pattern, traditionally, refers to the models or structure in data, but now places more emphasis on the expression in some language describing a subset of the data or a model applicable to that subset (data comprises a set of facts).

Validity and novelty speak to how potentially useful the information is. Validity is a real concern, since there is not any means of verifying the newly discovered information. The novelty aspect means that the information most likely could not be obtained by other means. For example, 'the algorithm to define the fifth normal form' is obvious information, but to emphasise that 'a database in the third normal form is definitely in the first normal form' should be avoided, because it is trivial. Lastly, process is more of an apologia about the current state of affairs than anything else is. Knowledge discovery is a process, loosely coupled to some sequence of events leading to knowledge, but this rarely, if ever, runs linearly. Figure 3.1 (Fayyad et al., 1996b) illustrates the significant steps in the process of KDD: nearly 4/5 of the time is spent in pre-process and transformation and somewhat less than 1/5 of the time is spent in data mining. Data brought from the data warehouse typically are clean and therefore, do not need pre-processing.

An important notion, called interestingness[3] (Piatetsky-Shapiro & Matheus 1994), is usually taken as an overall measure of pattern value, combining validity, novelty, usefulness, and simplicity. Interestingness can be explicitly defined or can be manifested implicitly via an ordering placed by the KDD system on the discovery patterns or models. Note that all the terminologies used here are derived from relational database theory and database systems.

[3] This word *interestingness* is directly from the literature and no claim is made as to its lexical legitimacy.

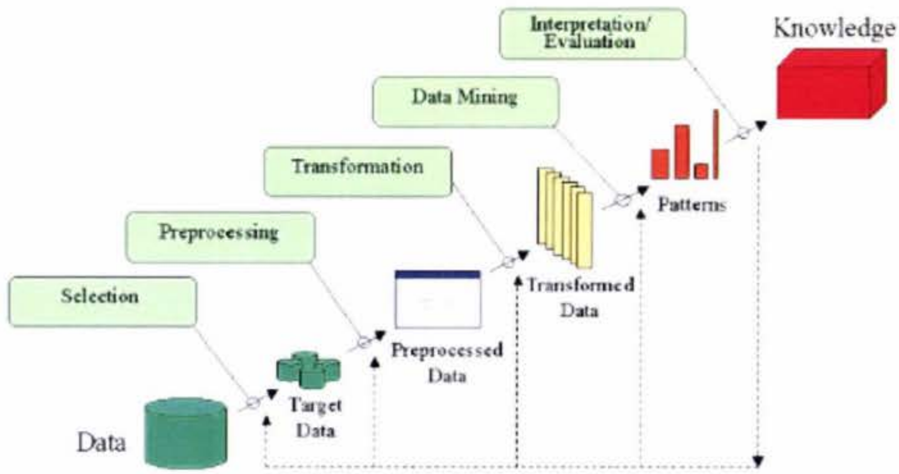

Figure 3. 1 Significant steps in the process of knowledge discovery in databases (from Fayyad et al., 1996b)

3.2.2 Steps of Knowledge Discovery Process

According to the definition above, KDD is an interactive and iterative process, which means that the possibility of changes in status are possible and a better quality of the search result can be obtained by repeating the KDD steps.

In order to adapt a suitable KDD process in this thesis, four known and commonly accepted literatures were chosen as the comparison base in Table 3.1.

Simoudis (1997)	Mannila (1996)	Fayyad et al. (1996a)	Brachman & Anand (1996)
	understanding the domain	learning the application domain	task discovery
data selection		creating a target dataset	data discovery
data transformation	preparing the data set	data cleaning and pre-processing	data cleaning
		data reduction and projection	model development
		choosing the function of data mining	
data mining	discovering patterns (data mining)	choosing the data mining algorithm(s)	data analysis
		data mining	
result interpretation	post processing of discovered patterns	Interpretation	output generation
	putting the results into use	Using discovered knowledge	

Table 3. 1 The process of knowledge discovery – list of steps

Data mining (the dark grey coloured row) gets the most attention in research, therefore in publications as well. Those are mostly focused on learning algorithms; some methods combine data mining with previous data preparation (light grey coloured row), which is usually dataset reduction.

Thus from the above comparison, the KDD processes can be encapsulated into a smaller number of higher level stages to more simply identify the whole process, which consists of data selection, data analysis / pre-process, mining and evaluation. Figure 3.2 illustrates the KDD process in graphic presentation.

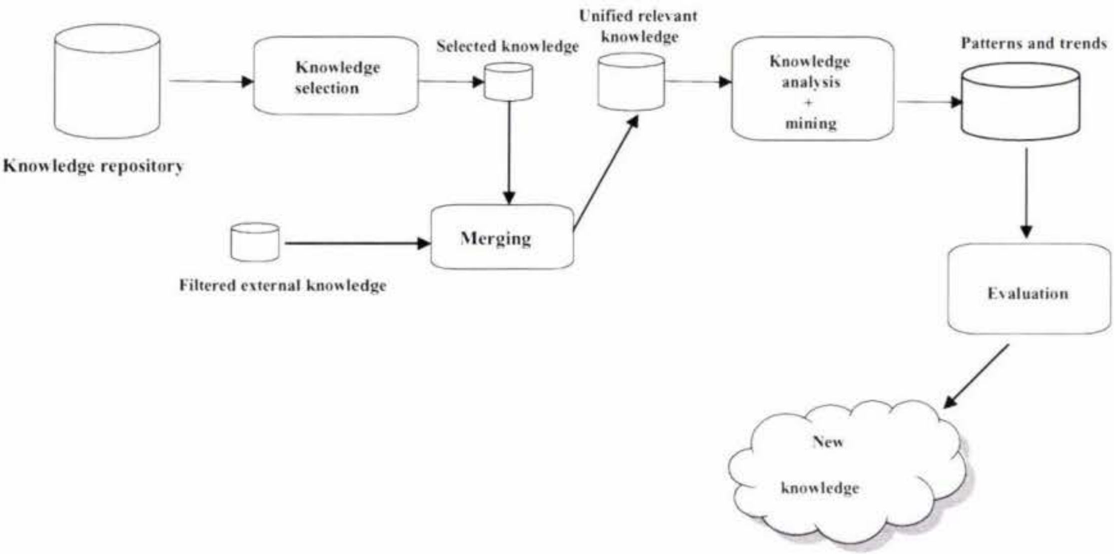

Figure 3. 2 The four steps (selection, merging, analysis and evaluation) of the knowledge discovery process

In most cases, knowledge discovery starts with the data-sets in the knowledge repository, usually developed for tasks other than KDD. After due consideration (and this can require some initial exploratory runs through the KDD process to gain better insights into what is required from the knowledge repository.) an appropriate collection of selected data is extracted from the knowledge repository. These selected data, along with external data extracted from sources such as web searches, form the basis for the rest of the KDD process.

The knowledge selected via knowledge selection activity is merged with knowledge obtained from external sources in knowledge merging activity. The knowledge analysis and mining activity result in patterns and trends that lead to the creation of new knowledge after evaluation.

Evaluation is a vital task, because using a variety of tools and even tuning a single tool in a variety of ways leads to the discovery of many different patterns that have to be evaluated on relevance.

In short, data mining and KDD are concerned with extracting interesting and useful patterns, information, or knowledge from the local knowledge repository and from the external data. Based on the comparison of four common KDD processes, a four-step KDD process is formed and should be considered as an iterative process where earlier stages often need to be refined to add 'discoveries' made in later stages. Further, to recall the educational KM framework (Figure 2.2 in Chapter 2), knowledge discovery is the beginning of the knowledge life cycle. Thus, this four-step KDD process is used to discover the knowledge which is incorporated as the first stage of the KM framework, which plays a vital role in the integrity for the KM system to be constructed.

3.3 Importance of Knowledge Discovery in Education

For the last decade, education reform has been high on the agenda of school sectors (Carroll et al, 2003). The basic premise is to provide the most favourable environment for teaching and learning, so that students can fully realise their potential and teachers can have more room to help students learn more effectively.

Teaching should be in favour of learning. On one hand, it is clear that education aims to provide a better teaching and learning environment for both teachers and students. Thus, from the teacher's point of view, the knowledge to be delivered should be more specific and targeted in accordance with different groups of knowledge receivers. This means that teachers should customise the teaching curricula, teaching materials, and teaching resources based on the course levels and students' understanding level, which is the major task for teachers in order to meet students' learning requirements and achieve educational goals.

On the other hand, the media for knowledge delivery no longer relies on the traditional style. As the web continues to evolve and expand, the information technology – the Internet – has gradually changed our ways of studying, living and working. Educational institutions are continually undergoing change as they respond to the demands of their internal and external environments (Kearsley & Moore, 1996).

Recently, advances in the high-speed networks and the Internet technologies have led to new types of teaching and learning.

An advantage of web-based material in general is accessibility, which means that it can be used by any student in any country who has the required linguistic and computing skills and appropriate hardware (Huckvale et al., 1997). Web-based teaching makes the distance between teachers and students shorter and ensures that teaching and learning can take place any time and anywhere. Teachers can answer the student's questions immediately by making use of the tutorial system established. Students can learn through the web-based courseware. The powerful knowledge acquisition and processing ability can establish a learning feedback system so that a student's learning process can be tracked. The active and varied forms of presentation of multimedia technology and web can make some abstract concepts easier to understand (Daugherty & Funke, 1998). Further, web-based teaching has reduced the operational cost of knowledge delivering.

Thus based on the situation as described above, Knowledge Discovery of student learning patterns plays a vital part for teachers in producing quality teaching material to fulfil the educational purpose. Good teaching resources benefit students' future development which - in turn - will encourage teachers' own professional development.

In order to apply knowledge discovery techniques, this thesis positioned the teaching channel as web-based teaching, because of its flexibility and adaptivity in teaching database normalisation. Further, in the next section gives close consideration to the dynamic nature of knowledge discovery related with the students' learning patterns in web-based education via web mining.

3.4 Knowledge Discovery in Web-based Education

Currently, many universities have set up their own intranet, which is able to access public domains as well. Different teachers and students have different teaching styles and learning interests. Determining the composition of user interest on the web is a daunting task. Given the massive size of the web, along with the time and resource costs involved in the traditional techniques - such as contextual inquiry, user surveys, and so on, - they are unable to determine the user browsing patterns which best represent the high level composition of user activity on a site. This leaves students with the need to browse through different web sites until a seemingly acceptable choice is reached. Thus in this section, the technique of web-based knowledge discovery – web mining is discussed in detail.

3.4.1 Web Mining in General

Web mining is the extraction of interesting and potentially useful patterns and implicit information from artefacts or activity related to the World Wide Web. There are roughly three knowledge discovery domains that pertain to web mining (Kosala & Blockeel, 2000): web content mining, web structure mining, and web usage mining.

Web content mining is the process of extracting knowledge from the content of documents or their descriptions. It focuses on techniques for searching the web for documents whose content meets web user queries. Web document text mining, resource discovery based on concepts indexing or agent-based technology may also fall into this category. *Web structure mining* is the process of inferring knowledge from the World Wide Web organisation and links between references and referents in the Web. It is related to the analysis of the link structure of the Web, in order to identify relevant documents. Finally, *web usage mining*, also known as web log mining, is the process of extracting interesting patterns in web access logs. It is defined as the process of applying data mining techniques to the discovery of usage patterns from web logs data, to identify web user behaviours (Srivastava et al., 2000). Figure 3.3 illustrates the taxonomy of web mining.

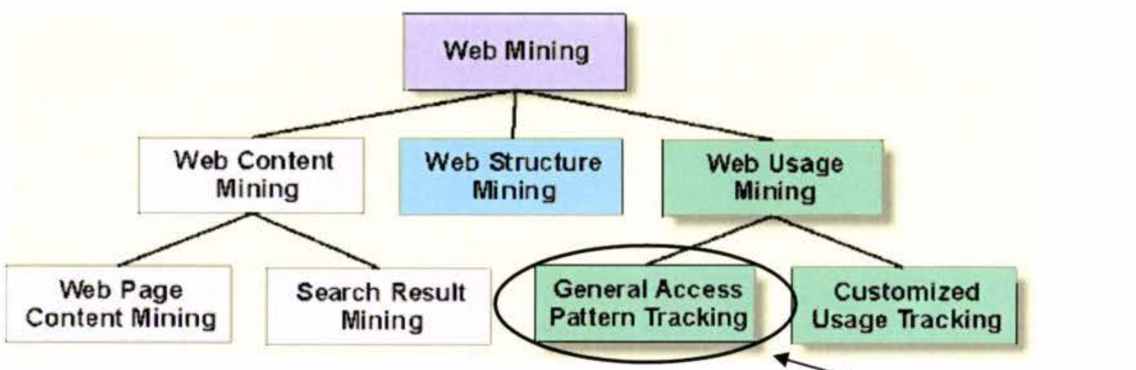

Figure 3. 3 Taxonomy of web mining (adapted from Srivastava et al., 2000)

In general, web mining and personalisation require modelling of an unknown number of overlapping sets in the presence of significant noise and outliers. Moreover, the data sets in web mining are extremely large. Therefore, this thesis concentrates on inquiring into web usage mining which mines and clusters web access logs, because categorising students' learning patterns based on their interactions with the course website is the key in web usage mining. The click streams generated by various students often follow distinct patterns, knowledge of which may help the teachers customise their teaching materials.

3.4.2 Knowledge Discovery via Web Usage Mining

As mentioned before, the flexibility of the web-based teaching and learning environment has been the driving force in the rapid growth of e-education. The ability to track learners' browsing behaviour down to individual mouse clicks has brought the teachers / educational researchers and students closer together than ever before.

The scenario described above is one of many possible applications of web usage mining, which is the process of applying data mining techniques to discovery usage patterns for web data, targeted towards various applications in order to understand and serve better the needs of web-based applications, such as the web-based teaching and learning environment. Web usage mining consists of three phases, namely pre-processing, pattern discovery, and pattern analysis.

It is possible to use this in conjunction with standard approaches to personalisation, such as collaborative filtering, which can help address some of the shortcomings of these techniques, including reliance on subjective user ratings, the lack of scalability and poor performance in the face of high-dimensional and sparse data (Mobasher et al., 2001).

In web mining, data can be collected at the server-side, client-side, proxy servers, or a consolidated business database. In (Srivastava et al., 2000), the authors present a more detailed description of these data sources. To summarise, (i) web server logs explicitly record the browsing behaviour of site visitors, (ii) client-side data collection can be implemented by using a remote agent or by modifying the source code of an existing browser, and (iii) web proxies act as an intermediate level of caching between client browsers and web servers.

3.4.3 Web Usage Mining Process

The information provided by the data sources described above can be used to construct several data abstractions, namely users, page-views, click-streams, and server sessions (from WWW Committee Web Usage Characterization Activity). A user is defined as a single individual that is accessing file web servers through a browser. In practice, it is very difficult to uniquely and repeatedly identify users. A user may access the Web through different machines, or use more than one browser at one time. A page-view consists of every file that contributes to the display on a user's browser at one time and is usually associated with a single user action such as a mouse-click. A click-stream is a sequential series of page-views requests. Note that any page view accessed through a client or proxy-level cache will not be recorded on the server side. A server session (or visit) is the click-stream for a single user for a particular website. The end of a server session is defined as the point when the user's browsing session at that site has ended.

The process of web usage mining can be divided into three phases: pre-processing, pattern discovery, and pattern analysis (Srivastava et al., 2000).

Pre-processing consists of converting usage information contained in the various available data sources into the data abstractions necessary for pattern discovery. Another task is the treatment of outliers, errors, and incomplete data that can easily occur due to reasons inherent in web browsing. The data recorded in server logs reflects the (possibly concurrent) access of a website by multiple users, and only the IP address, agent, and server side click-stream are available to identify users and server sessions. However, it is important to notice that the data collected by server logs may not be entirely reliable because some page views may be cached by the user's browser or by a proxy server. In a web server log, all requests from a proxy server have the same identifier, even though the requests potentially represent more than one user. In addition, due to proxy server level caching, multiple users throughout an extended period could actually view a single request from the server. The web server can also store other kinds of usage information such as cookies, which are markers generated by the web server for individual client browsers to automatically track the site visitors.

After each user has been identified (through cookies, logins, or IP / agent analysis), the click-stream for each user must be divided into sessions. As often it is not know when the user has left the website, a timeout is often used as the default method of breaking a user's click-stream into sessions.

The next phase is the pattern discovery phase. Methods and algorithms used in this phase have been developed from several fields such as statistics, machine learning, and databases. This phase of web usage mining has three main operations of interest: association (i.e. which pages tend to be accessed together), clustering (i.e. finding groups of users, transactions, pages, etc.), and sequential analysis (the order in which web pages tend to be accessed). As in most real-world problems, the clusters and associations in web mining do not have crisp boundaries, and often overlap considerably.

Pattern analysis is the last phase in the overall process of web usage mining. In this phase, the motivation is to filter out uninteresting rules or patterns found in the previous phase. Visualisation techniques are useful to help the application domains expert analyse the discovered patterns.

3.4.4 Access Logs Processing Architecture

In order to apply the web mining techniques to assist teaching and learning, a general architecture for web access mining is adapted using the site's web server logs as data source (refer to Figure 3.5). The pre-processing phase includes initial preparation tasks that are included in a processing agent system (Marín et al., 1998). This system performs the following tasks: noise filtering (i.e. removing irrelevant data like access errors or images requests), session's identification, and storage in a repository. Session identification consists of grouping all page-view records from a given IP address collected during user activity periods (inactivity is defined as a period of 30 minutes or higher for which no registered accesses are sent to the web server). For each valid page-view, the processing agent assigns the corresponding knowledge section based on site structure information present on the page's URL. Each webpage is associated to one section and user accesses one or more web pages during a session.

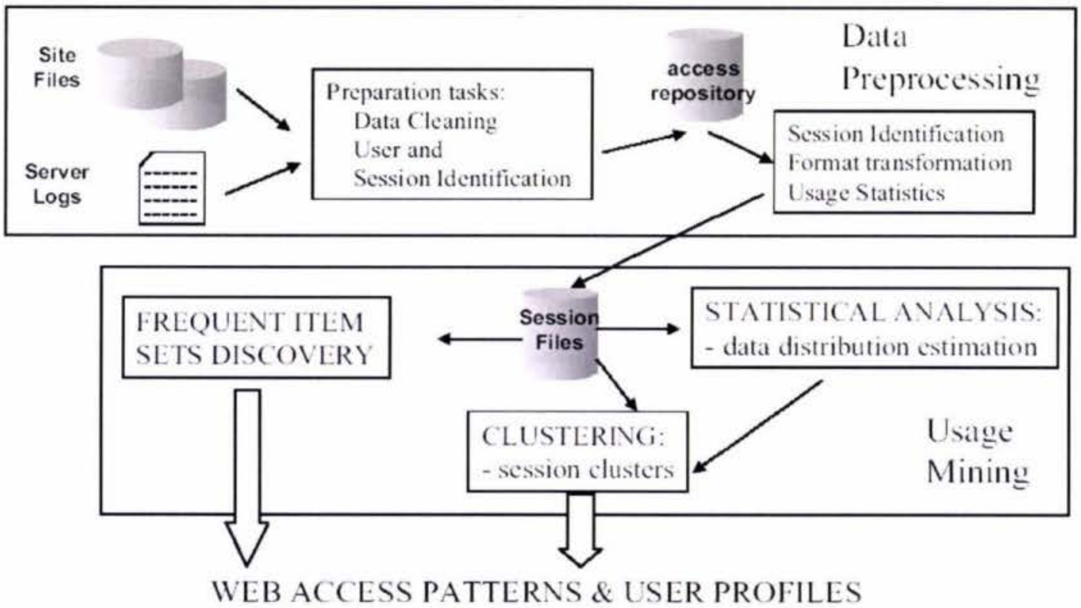

Figure 3. 4 Overview of a general architecture for web access mining (from Batista & Silva, 2002)

The sessions identified by the processing agent as described above are called *short sessions.* When a user inputs / accepts the requests for identification, the web server also registers a cookie that is accepted by that user. *Long sessions* are defined as the set of short sessions that share the same cookie (accumulation of the user access transactions grouped by cookie).

To adapt these data to the data structures of the data mining algorithms used, log access tables are transformed into numerical and Boolean matrices, where each column corresponds to a newspaper section and each row represents a session. In numerical matrices, each matrix cell contains the quantity of articles accessed on each pair (session, section); in Boolean matrices a cell is True when at least one article is accessed in that (session, section) pair.

The aggregated data matrices are examined through a set of basic statistical functions that help in obtaining a preliminary view about the data. For numeric variables, the maximum, minimum, mean, and standard deviation are observed; for Boolean variables the frequencies are obtained.

3.5 Summary

In this chapter, knowledge discovery is emphasised, since it is the beginning of the KM process. The application of data mining and knowledge discovery techniques is explained and compared.

With the vast usage of web-based education, it becomes vital to understand students' learning patterns to prepare the teaching curricula in a professional manner. Thus knowledge discovery on the Web web usage mining as the focus of this thesis, is further illustrated in detail. The benefits of using web usage mining will help and improve the teachers' knowledge of students' learning behaviours so that they can customise the teaching materials on the web basis. All these activities will finally provide an active teaching and learning environment, encourage students' learning attitude and knowledge re-utilisation.

CHAPTER 4

Knowledge Capturing on Teaching Database Normalization

Learning can and often does take place without the benefit of teaching – and sometimes even in spite of it – but there is no such thing as effective teaching in the absence of learning. Teaching without learning is just talking.

-- Angelo & Cross, 1993

4.1 Introduction

Teaching supports and guides learning. After defining the KM framework and identifying the knowledge discovery techniques of student learning pattern discovery, this chapter concerns from the teaching point of view how knowledge can be captured while teaching database normalisation. This knowledge capturing of the teaching related knowledge includes different teaching methodologies in teaching database normalisation, the contents and scope of database normalisation, common practice in teaching this subject, and limitations to be aware of while delivering the knowledge to the students.

The knowledge mentioned above is tacit knowledge, which will be used as the knowledge input in the knowledge repository, from which students can obtain the knowledge on database normalisation. Thus, the approach to the knowledge capturing of this type of intangible knowledge should differ from the knowledge discovery techniques – web usage mining mentioned in Chapter 3.

By reviewing, comparing and analysing the different techniques of knowledge gathering, a survey approach is brought up to complete the task because it is seen to be preferable in comparison with other approaches, as it gives more benefits while handling the soft knowledge 'recording'. Based on this result, a survey on teaching database normalisation is conducted and the survey results are analysed and illustrated to be used as the input of the knowledge base.

4.2 Common Techniques for Collecting Explicit Knowledge

In the field of KM, the term explicit knowledge is usually accepted as documented information. Thus the tasks of discovering explicit knowledge can be conducted by the techniques used in information collection. In general, collecting information is carried out mainly through asking questions of various types, but also through observation. The process of collecting information, however, involves much more than listing a few questions and then asking them in the field.

For many years, scientific techniques have been set up for collecting information. These techniques seek to establish cause-effect relationships, produce generalised results and provide quantitative data through structured data collection procedures. These techniques have gained recognition over past years as being favoured for understanding complex social or scientific conditions. Techniques such as observation and open-ended interviews seek to explore situations in depth. Some of the common techniques are introduced as the following (Bickman & Rog, 1998; Hemmer et al., 2000; Hentschel, 1998; McNamara, 1999; Pretty et al., 1995; White, 1998).

The most publicly used and accepted technique is *survey*, in which standardised information is collected through structured questionnaires to generate quantitative data. Surveys may be mailed (surface and electronic), completed on site or through interviews, either face-to-face or by telephone. Another known method is to design a *case study*, which examines a particular case in depth (programme, group of participants, single individual, site / location). It uses multiple sources of information and methods to provide as complete a picture as possible. *Interviews*, a face-to-face information gathering technique, collects information by talking with, and listening to, people either face-to-face or over the telephone. Interviews range on a continuum from those which are tightly structured (as in a survey) to free flowing and conversational interviews. *Observation*, on the other hand, collects information through 'seeing' and 'listening'. Techniques, such as group assessment, expert or peer review, and portfolio review use group processes to collect evaluation information. Some approaches used for particular purposes include testimonials, tests, photographs, slides, videos, diaries, journals, logs, and document analysis. Very occasionally, techniques like action cards[4] are used and applied for information gathering.

These information-collecting techniques include traditional measurement approaches such as tests and ratings, as well as more investigative procedures such as observation, interviews, case studies, and literature reviews. Each method has its advantages and disadvantages. For example, an interview requires time, replies to a questionnaire might not be truthful, with observation you might not get to see what you need to see and letters might not be answered. Whatever methods are used in the investigation, a number of different steps are involved. All these steps are important for the reliability, relevance and cost effectiveness of the investigation.

4.3 Techniques for Capturing Tacit Knowledge

Knowledge can take various shapes and forms. Tacit knowledge needs to be formalised and made explicit to be shared more easily. Further, Information Collecting does not necessarily convey that knowledge is definitely captured. Tangible knowledge can be captured relatively easily, but intangible knowledge which is embedded in individual's mind is rather abstract and hard to capture.

In the teaching environment, there is general recognition that educational institutions need to pay more attention to how to manage the intangible knowledge provided by the academic faculty. They may undervalue the creation and capture of knowledge, they may lose or give away what they possess, they may deter or inhibit knowledge sharing, and they may underestimate in both using and reusing the knowledge they have (Earl & Scott, 2001). On the contrary, recognising the potential of knowledge in value creation and reuse would encourage managing knowledge as a

[4] Action cards use of index cards on which participants record what they did – the 'action' – and when they reach their goal; primarily used in self-assessment.

resource, to discover and to release knowledge that is not known (Resatscha & Faisstb, 2004).

Different educational institutions compete with each other in terms of effectively demonstrating knowledge leadership and consistently delivering better knowledge to their students. These questions require more attention, such as what knowledge is crucial to successfully deliver the knowledge to the students? What knowledge is to be stored and reused? How well do teachers and students manage, develop and exploit this knowledge? Who is responsible for maximising its value to the students?

The questions mentioned above are very important, but before providing the answers to these questions, the initial knowledge has to be first effectively captured, then KM can carry on the processing of the knowledge in the knowledge repository to create new knowledge (Vat, 2003).

Many existing techniques which have evolved from the cognitive psychology and artificial intelligence fields have been developed over the years. Within these common data collecting technologies, various techniques have been also applied over the years to capture knowledge. The following are the most common methods used for programme evaluation, some of which are applied along with the social science research methodologies, which are geared toward qualitative knowledge. In comparison, similar approaches are also mentioned in De Long & Davenport (2003), Friedman-Hill (2003) and Talisayon (2001).

Interviewing, the most typical method for capturing knowledge, may be conducted using either structured or unstructured interviews. Structured interviews follow a sequence of questions prepared in advance with some flexibility for deviation; while unstructured interviews use typically open-ended questions and are not planned in advance. The skill of the interviewer is a key ingredient in getting at the deeper knowledge as opposed to the shallow knowledge of the expert. Used usually as a supplement to interviews, the *survey / questionnaire* is another of the important techniques for capturing knowledge. Lessons learned, best practices and heuristic knowledge (rules of thumb) could be described on these forms which express tacit knowledge explicitly.

Observation / simulation, another common method, refers to the fact that some knowledge can perhaps be gained through observing an expert solving a problem in his / her work environment. In this technique, the knowledge engineer is a casual observer, watching the actions of the expert, firsthand, in the workplace. Computer simulation may also trigger the application of knowledge by the expert in running through a simulation. Further, protocol analysis, another common way, deals with verbal walkthroughs in which the expert reasons aloud with his / her decision-making process without the intervention of the interviewer. The expert describes the dead-end paths, as well as those that follow a positive direction, in reaching a decision. Besides these methods, learning by doing utilises the fact that some knowledge and insights used by an expert can be picked up through apprenticeship, mentoring or on-the-job training. This master-apprentice relationship may uncover some of the knowledge that the expert applies.

In order to facilitate KM processes, it is essential to provide ubiquitous ways of capturing knowledge at the explicit level and then directing it to specific roles for processing. The goal will be to capture reasons for actions as well as the actions themselves to be able to see their relevance in context.

4.4 Justification for Choosing the Survey Approach

'... Tools (such as surveys) are created by toolmakers who invest their devices with a certain sphere of knowledge. These tools are then employed to generate information which typically re-enters the tool maker's sphere of knowledge to confirm, deny or embellish what s/he believes s/he already knows...(Chauvel & Despres, 2002)'.

A survey is most appropriate when the evaluation questions and information needs are best answered by the people themselves (Thorn, 2001). Often individuals own reports of their opinions and behaviours needs tracking down for further usage. Further, there are things which can not be seen directly, such as attitudes and beliefs. Or it is really hard to observe people's actions, such as students' preferences level of in a given topic. Therefore, the solutions to these situations are to ask them and find out the answer.

The use of surveys based on the production of data by means of a questionnaire, is perhaps the most common tool of extracting knowledge. Several factors explain the appeal of surveys to researchers. First, this analytical tool allows the researcher directly to focus on her / his subject of interest, by just questioning people about it. In this way, scientific investigations can have content as specific as intended, and can gather homogeneous data supplied, in principle at least, by exactly the kind of people who are the target of the research. Second, the scores produced by the survey are amenable to statistical description and analysis, through the use of correlation and regression techniques. Third, by relating the surveyed sample to the corresponding population, the set of data provided by the survey can be the basis of statistical inferences. Fourth, it can not be ignored that survey methodology is fast and straightforward compared to many other research methods. This allows researchers, research centres and practitioners to act in a relatively quick and intellectually respectable manner. These four main reasons would explain the widespread use of surveys in scientific research.

On the other hand, we have to note that tacit knowledge, however, is not best collected through a survey. It may be more direct and useful to use other methods. A variety of alternatives exist such as, existing data, records, documentation, tests of abilities, case study. For example, it may be more useful to actually observe course management practices than to ask a teacher if s/he is using the systems. Alternatively, it may be difficult for teachers to know how many times students access the web-based course sites over the past term. An analysis of the tracking records of students browsing behaviours would be better sources of knowledge.

It is very important to be first clear about the knowledge that is highly wanted and needs collecting, and then comes the decision of the proper methods. The purpose of this thesis is to use KM techniques to capture the teaching knowledge on database normalisation so that the knowledge can be stored, reused for the academic staff, which can lead to creation of new knowledge related with teaching methods. Based on the review of different techniques on explicit and tacit knowledge capturing, a survey on teaching database normalisation is considered suitable and proper to capture the knowledge related with database normalisation teaching and learning.

4.5 The Nature of the Survey

A survey is a way to collect information directly from people in a systematic, standardised way (Saluja et al., 2000). Surveys use questionnaires that ask the same question in the same way of all respondents. Data collected this way can then be used to make inferences about the population of interest (e.g. students' learning style). Knowledge can be collected about people's opinions, thoughts, attitudes, beliefs, behaviours, experiences and backgrounds.

In this thesis, a broad distinction is made between two schools of thoughts in this regard: the classical (positivist) perspective and the interpretive (postpositivist) perspective on survey research (Hamilton, 2002). The classical perspective is closely associated with the scientific method as it was refined during the twentieth century, while interpretivism arose as a serious response to the classical perspective (in the field of business management) during the 1980s (Rose, 2000).

4.5.1 The Classical Approach

The classical school holds that survey research generates a 'detailed and quantified description, a precise map and / or a precise measurement of potential' (Kuhn, 1970). This is accomplished by the following well established methods (Fisher, 1998): (i) developing the research plan, which fixes certain attention on some topic and defines this topic properly which presents characteristics or facets of the phenomenon; (ii) raising the survey questions around the variables; (iii) attaching metrics to the survey questions; (iv) laying out the survey formation, launching a pilot test and sending it to a predetermined sample of respondents; (v) analysing the surveys that are returned, providing the raw material for research reports, survey-feedback programmes, and publications and so on; and (vi) finally, reporting the survey results.

The approach outlined in these six steps encapsulates most of the survey research reported in the business literature dating from 1950 to the present day (Peterson, 2000). The reasons why this approach is so popular are that its benefits can be expressed in the following three aspects.

Reality. The classical school assumes that a reality exists 'out there', that this reality is singular, and that the phenomena circulating within it are knowable to the point of defining all their characteristics and causal relations with other phenomena (Diaz-Martinez & Navarro, 1996).

Objectivity. If reality is made up of knowable phenomena, and the researcher's job is to study these phenomena, the researcher and the phenomena are in no way connected and, hence, the researcher can be objective (from Webster's Dictionary).

Common meanings. Since the researcher is studying phenomena which are observable to all circulating in a reality common to all, the meanings of the words assigned to the phenomena are (in the ideal) perfectly shared by the researcher and all others.

4.5.2 The Interpretive Approach

Interpretivists, the counter approach to the classical school, hold that realities are multiple rather than singular, objectivity is a myth, that action arises from interactions in circumscribed situations, and that the meanings ascribed to the words we use are imperfectly shared, at best (Conroy, 2001).

Indeed, these two schools of thought represent two different bases. The classical approach is to define, measure, codify and eventually control a phenomenon, whereas interpretivists are focused on how individuals conceptualise their world and make sense of it. Because it is rather complex for interpretivists to stress the fundamentally interpretive nature of social reality (Pozzebon, 2003), the forms of interpretive survey methodology are more likely to employ particular methods, such as cognitive mapping, case histories, focus groups, Delphi techniques and so on (Díaz-Martínez & Navarro, 1996).

4.5.3 Justification for Selecting the Classical Survey Approach

The researcher must choose a survey method that best suits the research topic, respondent characteristics, time line, experience and resources available. The goal of the survey is to obtain the trustworthy, authentic and responsible evidence that will be used.

When choosing a method, the following statements need to be considered, such as: What is the purpose of the evaluation? Who are the users of the evaluation, the respondents from whom the survey will be conducted? What resources are available (time, money, volunteers, etc)? What will be the degree of intrusiveness, the advantages and disadvantages of each method? (Gillham, 2000; Harkness et al., 2003; Munn & Drever, 1999; Peterson, 2000).

Moreover, the interpretive approach shows its advantage over the classic approach in certain perspectives, however, the classic approach is considered more practical in capturing both explicit and tacit knowledge. The reason is that the classic approach permits the researchers to generate a 'thick description' of their view of reality. This feature is consistent with the aim of this thesis – to discover the deeper insight of the underlying knowledge in teaching database normalisation. Hence, the appropriate survey method in this thesis is – conduct a survey of a particular group of people to question in detail.

Based on the general strategies of the classical survey construction, a survey on knowledge collection is accomplished through 5 stages: (i) survey planning, this includes draft survey design, pre-survey evaluation and finalisation of the survey; (ii) invitation for survey participation, that is, contact the academic staff who teach database design in relation to database normalisation in the Department of Information Systems, Massey University, Palmerston North campus; (iii) conduct the survey that is, ask lecturers to fill out the survey forms and obtain feedback from the academic staff. This stage is to capture knowledge of teaching database normalisation, particularly targeted on tacit knowledge; (iv) survey collection and organisation, that is, prepare for the survey analysis; (v) extract the knowledge and analyse the outcomes for further use. This stage is particularly interested in assessing lecturers' attitudes and understanding of their own teaching behaviours, determining different teaching methodologies or strategies applied in database normalisation teaching, and determining the content of knowledge on database normalisation which should be taught with the awareness of the levels of study during normal semester time.

One further remark on the survey design: a survey should be developed in such a way that the lecturers' tacit knowledge should be able to be captured first and then be 'interpreted' into explicit knowledge. This requires that the survey must enable the lecturers to express what their approaches in teaching database normalisation are and how they apply their knowledge to the real teaching situations. In addition, the researcher should be aware of the constraints / influence factors related to the teaching objectives and tasks within the department.

4.6 Survey Development

With the review of different knowledge capture strategies and further justification of the classic survey approach, the following factors are detailed and explained, simultaneously with the conducting of a meaningful survey.

4.6.1 Survey Participants Selection

Involving intended users in the survey leads to greater commitment and helps to ensure the survey is relevant and is used. Key people might be involved in the planning, questionnaire construction, data collection or analysis and interpretation. They can serve in an advisory role, be involved in, or manage one aspect of the survey or be fully involved throughout the survey implementation.

Since the intention is to capture the knowledge of the existing academic staff in the Department of Information Systems, the vested interests in this survey concern how to finally target knowledge of teaching methods in database normalisation. Hence, most of the academic staff whose teaching activity relates to database normalisation theory were asked to participate in this survey.

To smooth the survey process, the staff were notified about the coming survey by an invitation for participation. In this way, staff could be reassured that they could actually answer the questionnaire, and some possible suggestions could be raised before distributing the survey so that improvements could be made within the survey.

4.6.2 Survey Content Outline

Clarifying the specific content and topics of the survey is difficult but necessary; otherwise it is possible to include a lot of questions that do not answer the needs. Defining the survey content means setting boundaries so you can write the correct questions.

Further, the survey should focus on the priority information needs. It is important to make a distinction between what would be nice to know and what is necessary to know. In order to collect all sorts of valuable teaching resources related with database normalisation knowledge and make the best use of them, capturing knowledge starts with understanding the lecturer's educational background, teaching roles and the allocations of teaching activities in the department. All these help analyse the teacher's educational intention, that is, identify whether they focus on research or they focus on real life practices. Next, questions are raised in terms of the preferred teaching methodologies in teaching normalisation, which reflects a range and diversity of experiences, that is, an in-depth story of each individual teacher. Based on the knowledge obtained from the previous stages, questions on the next section are designed to capture the deep thoughts of teaching activities and methods in database normalisation theory, such as what should be taught in normalisation theory

Moreover, the survey is also designed to focus on the role of Information Technologies in teaching since in the thesis KM techniques will be applied to capture the knowledge.

4.6.3 Questionnaire Development

One of the most common forms of human communication is asking questions. Asking questions is perhaps second only to observation as the way people acquire knowledge (Kipling, 1903). Technically, a question communicates an inquiry.

Research questions seldom appear in isolation. It is rare for a single research question to be asked in an empirical research project. Rather, several research questions tend to be included in a questionnaire, whether it is called that or an interview schedule, a measurement instrument, or simply a list of questions. An effective questionnaire is carefully structured to provide valid and reliable information at a reasonable cost. It provides just the 'right' amount of information to meet the needs of a research projects, no more and no less (Peterson, 2000).

A questionnaire provides a tool for extracting information which can be organised and discussed. However, the number and type of questions, the format of questions and the layout of the questionnaire depend on the type of survey. Based on the survey objectives and content, several aspects are mentioned in constructing a questionnaire.

Kind of Information. There are four different types of information which need to be distinguished. Knowledge (what people know, how well they understand something); Beliefs / opinions (the perceptions people hold); behaviour (what people do); personal attributes (a person's personal characteristic – age, educational background, and so on.)

Wording of the Questionnaire. This ensures that questions in the questionnaire are understandable by the respondents so the intended results can be obtained.

Formatting the Questionnaire. The appearance, length, and the order in which the questions appear can directly impact the survey outcomes. The questionnaire designed in this thesis is pleasing to the eyes and easy to complete.

Pre-testing the Questionnaire. Pre-testing is an indispensable part of questionnaire design. This gives a chance to examine individual questions, as well as the whole questionnaire, very carefully. A time frame for this action is considered during the survey development.

4.6.4 Survey Plan Schedule

Survey milestones help structure time, resources and responsibilities. Good planning ensures that the resources will be used more thoughtfully and effectively. In regard to this survey, a Gantt chart is set up to clarify each milestone, please refer to Appendix II.

4.7 Survey Analysis and Interpretation

4.7.1 Brief Summary of Survey Results

Following Invitation of Survey Participation (ref. to Appendix I), a survey on teaching database normalisation was conducted within the Department of Information Systems, Massey University. The initial timetable for the Survey is shown in Appendix II. In outline it involved planning the survey, drafting the questionnaire, several-round discussion on the development of the format of the survey and questionnaire, on the implementation of the survey and on the eventual successful implementation of the findings.

On the wider basis, support was involved at all stage including a pre-survey testing. The questionnaire was delivered to all the staff who teaches database design courses with database normalisation as part of the teaching tasks. The wide range of survey participation has generated a great deal of interest, which lays the success to the research work.

4.7.2 Main Survey Findings

The questionnaire (please refer to Appendix III) was designed in consultation with my supervisors and pre-survey testing participants. It consisted of closed and open questions which were grouped into four sections.

Section 1 – General information about the questionnaire participants.

Section 2 – General views on teaching – the respondent's views as a teacher and general teaching objectives, and so on.

Section 3 – Teaching methods and content on database normalisation – respondent's knowledge on how to conduct effective teaching in this area based on different teaching levels.

Section 4 – Use of technology in teaching – respondent's comments about Information Technology influence on teaching.

The overall level of response was very high at ninety-seven percent of the lecturers in the Department of Information Systems, Massey University. The response was higher from lecturers (54%) than Tutors (23%) and Graduate Assistants (23%).This is testimony to the success of the effort to involve most of the teaching staff in the department. In addition, the level of response to the open questions was very high demonstrating enhanced commitments from staff in terms of time and their desire to be involved to assist students' research. The open questions, besides reinforcing the main issues, further the understanding of teaching database normalisation which would merit further investigation.

Section 1 – General Information about Participants

In this section, respondents are asked to specify the level(s) of course(s) in which database normalisation theory forms part of the teaching task. Fifty-four percent of the respondents responded that database normalisation is regarded as part of teaching task in 300 level and 200 level papers, respectively, while another fifteen percent responses indicated that it features in 100 level courses.

At this stage, in the department, there is no distinctive outline or scope that database normalisation is scheduled as part of the curricula at either the Masters level or the PhD level. One reason to support this is that in these two levels students are supposed to apply what they have learned to further and deepen the knowledge understanding level. For example, one of the survey participants is currently undertaking his PhD in advanced normalisation theory, which is pure research oriented individual development and requires independent research throughout a 3 to 4 year period. Further, based on these figures, the average teaching hours assigned to corresponding course levels are illustrated in the following Figure 4.1. This implies that database normalisation is largely taken as part of the teaching task in the 300 level, 200 level and 100 level. The teaching hours have quite significant weights in these levels with 21 hours per semester, 9 hours per semester and 2 hours per semester, respectively.

In short, this section evaluates the current teaching tasks, showing that focusing on database normalisation is mostly at the 100 level, 200 level and 300 level, which requires the thesis to place more emphasis on the normalisation teaching at these levels.

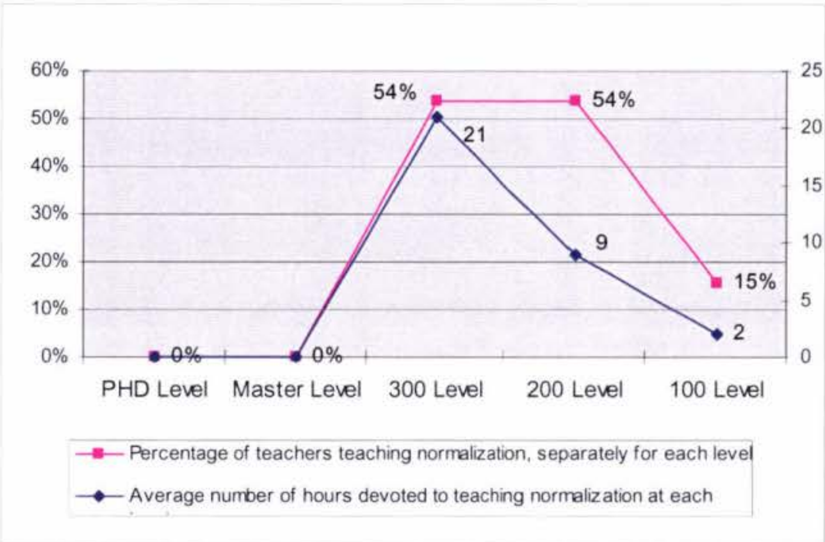

Figure 4. 1 Teaching resources allocated to teaching database normalisation

Section 2 – General Views on Teaching

In this section, participants are asked to identify the responses which best reflect their level of agreement on 7 different statements regarding effective teaching. The level of agreements are designed based on a five-point ***Likert scale***[5] (ScienceDaily encyclopaedia), that is, *5 = strongly agree, 4 = somewhat agree, 3 = not sure, 2 = somewhat disagree and 1 = strongly disagree*. The responses to this section for the whole group are quite positive about the 7 listed statements. As teachers, they would like to provide students with an environment conducive to learning new knowledge, to understand and to master what they have learned. Figure 4.2 below show the comparison based on Likert five-point scales. Teachers feel more comfortable with agreements on Question 3, Question 5, Question 6 and Question 7.

5 Likert scale is a rating scale measuring the strength of agreement with a clear statement. It is often administered in the form of a questionnaire used to gauge attitudes or reactions.

Many discussions surrounded Question 4, Question 8 and Question 9. Regarding Question 4, agreements and disagreements share similar weights, which reflect two main teaching focuses: research-oriented teaching versus practice-oriented teaching. In Question 8 and Question 9, different teachers have different definitions of what up-to-date materials and interesting materials are in terms of effective teaching and learning. Thus the up-to-date materials referred to in this thesis are the latest research, thoughts or discussion on certain topics, wherein these materials are guided and first filtered by the teachers, rather than blindly passed on to the students. The interesting materials considered in the thesis are those which can encourage and guide students to further their learning journey.

Generally, the responses in this section identified that two main teaching focuses currently exist in the tertiary education environment. One is the research oriented – in which there is more or less theoretically based teaching, and the other is practice oriented which places more emphasis on applied science, how to apply what the students have learned in the real life situation.

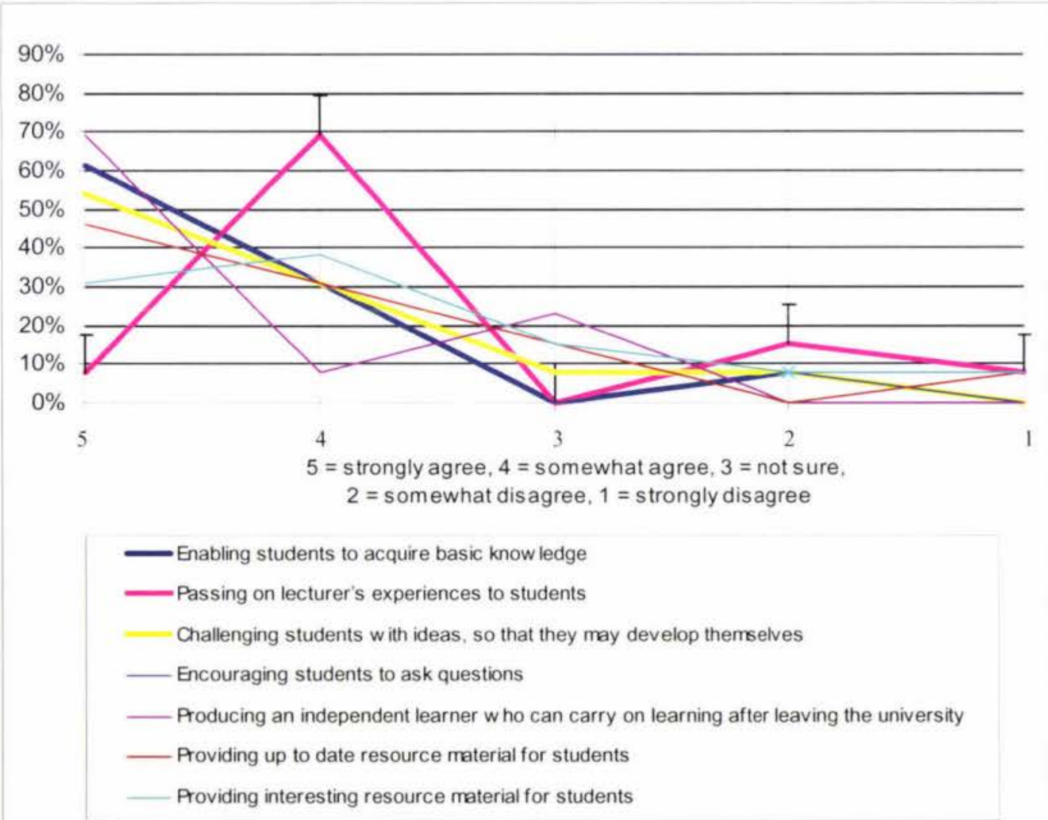

Figure 4. 2 Views on the overall teaching objectives and approaches

Section 3 – Teaching Methods and Teaching Contents

In this section, there are 11 questions in total which go deep to discuss the possible teaching methods in regard to database normalisation and the related teaching content in accordance with the respective course levels.

The first question in this section, Question 10, asked for comments on whether database normalisation is an important part of database design theory and whether it is possible to obtain a sound database schema without in-depth understanding of the normalisation theory. All (100%) participants agreed that normalisation is an important part of database design theory which can not be omitted from any learning on database design. It lets students understand that not all databases were sound and faithful when they were set up and that there are several points to be considered to achieve a well-defined database, that is, normalisation is one of the concerns.

Hence, it is worthy of further research and any research or efforts which can help teachers to teach efficiently and students to learn effectively will be absolutely welcomed and encouraged. In response to the second question under Question 10, quite diverse opinions were presented. Some teachers mentioned that in real life projects, it is quite common that normalisation theory is not applied for those experienced database developers, since they have sound knowledge or experience with database schema and structure. But in whatever case, the knowledge of database normalisation is essential to both novices and advanced database developers. For a detailed illustration of responses, please refer to Figure 4.3.

Question 11 asked respondents to specify the teaching methods they would like to use while teaching database normalisation. Forty-six percent of teachers prefer lecture-centre teaching. Thirty-eight percent of teachers are in favour of case-based teaching and problem-based teaching, respectively. Seminar style teaching and collaborative / cooperative teaching share another fifteen percent separately. The last eight percent goes to project-based teaching. All the answers reflect that there are fairly different ways concerning teaching database normalisation.

As mentioned before, 300 level, 200 level and 100 level teaching are the main foci of this thesis; this can easily explain the reason why the teachers are in favour of lecture-centred teaching and case-based / problem-based teaching, that is, learning is motivated by examples / cases from real life projects, while lectures are on general concepts, problems and further discussion. Further, several participants expressed the view that web-based teaching is another possibility to teach database normalisation. This adds another valuable research input on web-based KM. Please refer to Figure 4.4 for detail.

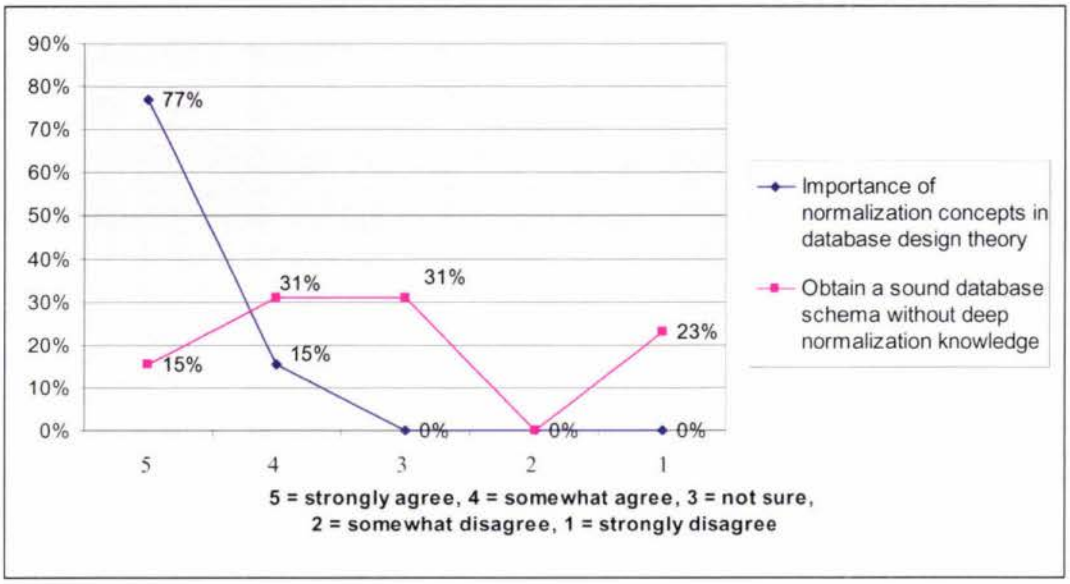

Figure 4. 3 Views on the objectives of teaching database normalisation

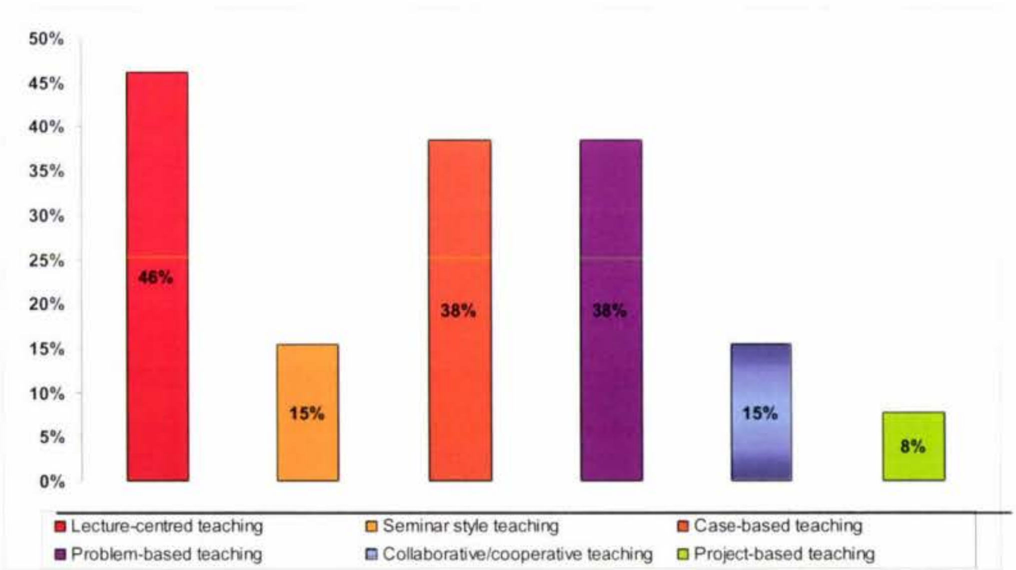

Figure 4. 4 Appropriate teaching method(s) utilized in teaching database normalisation theory (each respondent could select one or more methods)

Question 12 continues Question 1 with more specification on the teaching objectives in different course levels (refer to Figure 4.5). Figure 4.4 shows that the higher the course level is, the more independent and flexible teaching objectives are expected. In regard to the 100 level to 300 level, teaching objectives step from knowing the concepts to understanding, mastering and applying the theory in real life projects, which corresponds to practice-oriented teaching. On the other hand, the Masters level and PhD level have a more research-oriented basis.

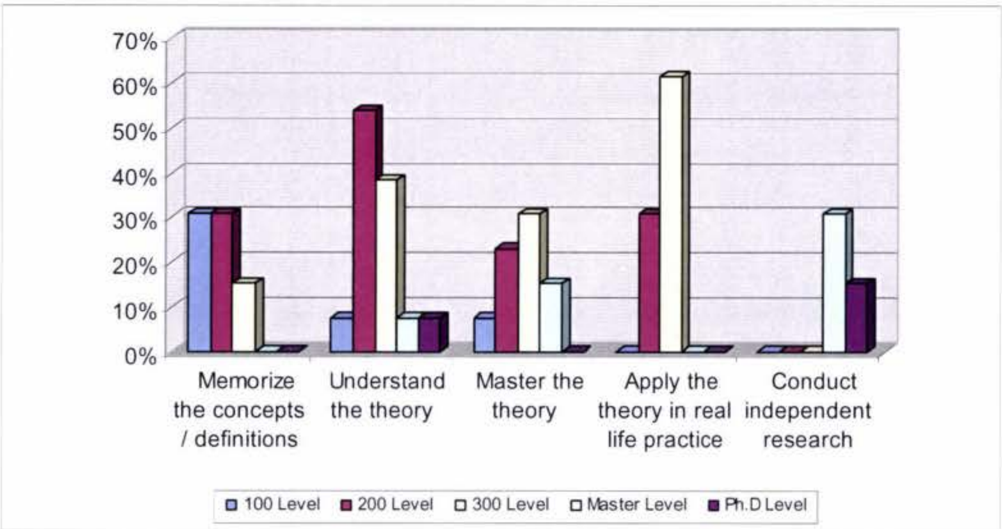

Figure 4. 5 Expecting teaching objectives in different course levels

Question 13 to Question 20 open the discussion more from the teaching content point of view. In response to Question 13, twenty-three percent of the respondents clearly identify the best approach to design a normalised database schema is to apply algorithms and follow the normalisation step by step, that is, a successful database is obtained by first modelling the information in 1st normal form, then successively adjusting it to the 2nd normal form, 3rd normal form, Boyce / Codd normal form, and so on. Another thirty-one percent prefers to attempt to come up with a normalised schema, that is, model the structure of the information directly in BCNF satisfying lossless-join and dependency preservation [6]. In contrast, thirty-eight percent of respondents choose the adaptive solution that is, based on a different situation, to apply the suitable approach.

An interesting finding during the survey interview is that teachers in lower level courses found that the inductive way of teaching facilitates the students' understanding process and students are encouraged to extend the learning / research,

[6] If we can not achieve this, we accept one of
– lack of dependency preservation (or use of more expensive inter-relational methods to preserve dependencies)
– data redundancy due to use of 3NF

while teachers in higher level courses prefer the deductive way to direct students' learning, since students have the ability to adapt the environment to learn by themselves. These findings give the evidences that effective teaching also needs to take students' knowledge levels into consideration.

When asked in Question 14 and Question 15 – *what knowledge should be delivered first to the students before learning database normalisation and what should be emphasised first to achieve a thorough understanding of the concepts of functional dependencies*, the following points are listed based on the rating, see Table 4.1 and Table 4.2. These show that relational schema, redundancy, anomalies, database tables, conceptual modelling and the ER model are the foundation of the entry of database normalisation theory, plus a better mathematics background will help the learning to occur smoothly.

Knowledge to Learn (Question 14)	
Intuitive understanding of the structure of database tables	15%
Quality aspects of relational schema: redundancy, anomalies, etc	54%
Mathematical rigor	54%
Concepts of soundness, completeness, faithfulness, etc	77%

Table 4. 1 Knowledge to be delivered to the students before learning database normalisation

Knowledge to Learn (Question 15)	
Prerequisite mathematical knowledge	54%
Database design process, such as conceptual database design and logical database design, etc	54%
Entities, relations, cardinality, and entity-relationship model	23%
Redundancy, anomalies, functional dependency and multi-value dependency	15%

Table 4. 2 Knowledge to achieve thorough understanding of the concepts of functional dependencies

In Question 16, the respondents are asked to identify the importance of algorithms in normalisation theory. About thirty-eight percent confirmed that it is extremely important, because it lays the foundation of the normalisation theory; twenty-three percent said it is important, but not critical to grasp. In contrast, eight percent said it is not important at all, and even twenty-three percent expressed the view that it can be omitted. In the question, the dramatic changes reflect that different course levels have quite different teaching and learning foci. At the lower level, algorithms do not play an important role at all and students can understand and use the database normalisation concepts by simply learning and applying some real life examples, but at the higher level, students are supposed to learn the algorithm first so as to apply it to the real life cases. The responses to this question are consistent with the previous finding, which will be applied in the thesis.

Question 17 is the last closed question in Section C. It asked the participants to specify up to which level of normal forms is sufficient for students to master. About sixty-two percent went to Third normal forms and another fifty-eight percent went to Boye / Codd normal form. Based on this finding, this research will also focus on the normal forms below the Boyce / Codd normal form.

In Section C, there are 3 open questions – Question 18, Question 19 and Question 20. A summary of statement made by individual teachers in response to these three questions is as follows:

Question 18. *Based on your teaching experience, what knowledge should be taught regarding the normalisation theory?*

Most the responses indicated that the following knowledge should be considered as part of the teaching task regarding database normalisation, including fundamental mathematical knowledge in algebra; related knowledge in database design process, entities, relations, cardinality, and entity relationship model; redundancy, anomalies, Armstrong Axioms, functional dependency, multi-value dependency; derivation tree; both normalisation concepts and table examples with more emphasis on table examples; norm forms with special emphasis on the third normal form and the Boyce / Codd normal form; and further explanation on redundancies caused by other dependencies which leads to the fourth normal form.

Question 19. *Normalisation theory also has its own limitations; please briefly describe the content that you would like students to know.*

The survey responses expressed the point that teachers consider that not only the positive side of database normalisation is important, but also knowledge in terms of limitations of normalisation theory helps students to understand the knowledge more thoroughly. Knowledge which, it is suggested, should be taught includes: comparison between the Boyce / Codd normal form and the 3rd normal form to illustrate the limitation of normalisation concepts; the number of join query determines the database performance; the concepts of loss of semantics should be further explained, also the concepts of normalisation for database not in the 1st normal form have not been well studied yet. This survey result shows that a good understanding of both the advantages and disadvantages of table structure, relationships, Entity-relationship model, anomalies and the range of different normal forms is essential for students to clearly understand this knowledge.

Question 20. *What knowledge on normalisation theory should be delivered so that students can determine when to apply normalisation principles and when not to apply them?*

The survey answers emphasised three aspects. Firstly, it should be able to distinguish between well and poorly designed database, that is, why they are or not well designed and basic knowledge on normal forms such as why they are useful and how to achieve them. Secondly, practical examples of where and how to apply second normal form, third normal form, and the Boyce / Codd normal form should be further illustrated. Thirdly, in the real project, de-normalisation may be required.

In short about the above three open questions, the responses gave more knowledge on the content level – what should be taught based on their own teaching experience in the department. This knowledge will be used as one source of knowledge inputs besides the textbooks.

Section 4 – Use of Technology in teaching

In section 4, there are 2 questions which further explore the possibility of applying Information Technology to assist teaching. Question 21 asked in what aspects Information Technology (such as WebCT) can help your students to learn the course content. The majority, seventy-seven percent goes for flexibility for distance learning, sixty-two percent said it provides instant feedback to teachers and learners, and thirty-eight percent considered that knowledge can be easily updated. The rest (23%) said it goes to enhance learning experience.

Possible Aspects with Information Technology Support (Question 21)	
Flexibility for distance learning	77%
Enhance learning via the use of multimedia	23%
Provide instant feedback to teachers and learners	62%
Knowledge can be constantly updated	38%

Table 4. 3 Benefits of Information Technology in education

The responses to this question show that modern teaching is inseparable from Information Technology. With the support of Information Technology, teaching can be treated more efficiently and effectively. Students also enjoy this learning experience which eventually helps them achieve better learning goals. Table 4.3 shows the percentage allocation.

The last question of this survey is designed as another Likert scale question but with three points, i.e. *3 = yes, 2 = not sure, 1 = no*. Question 22 asked participants to comment on the current Information Technology usage, the status and further application from 7 different aspects.

Information Technology (IT) Usage, Status and Future in Teaching		Yes	Not Sure	No
Currently use IT in my teaching	On line lectures / tutorials	**75%**	0%	25%
	On line reading materials	**75%**	0%	8%
	On line lab assignments	**75%**	0%	17%
	Tools to supporting teaching & learning	33%	8%	42%
	Simulation / interactive learning	17%	0%	**75%**
	Measure of student participation	25%	33%	25%
	Measure of the level of comprehension of the materials	25%	33%	25%
Is it working effectively?	On line lectures / tutorials	42%	42%	8%
	On line reading materials	33%	67%	0%
	On line lab assignments	**50%**	42%	0%
	Tools to supporting teaching & learning	33%	33%	0%
	Simulation / interactive learning	17%	33%	8%
	Measure of student participation	25%	42%	0%
	Measure of the level of comprehension of the materials	17%	50%	0%
Would like to use IT to enhance in future	On line lectures / tutorials	**58%**	0%	17%
	On line reading materials	**67%**	0%	8%
	On line lab assignments	**75%**	0%	8%
	Tools to supporting teaching & learning	**58%**	8%	8%
	Simulation / interactive learning	**55%**	20%	8%
	Measure of student participation	**50%**	8%	8%
	Measure of the level of comprehension of the materials	**50%**	17%	8%

Table 4. 4 Benefits of electronic tools in course content & course management

Table 4.4 illustrates the percentage under each scale. The corresponding figures are highlighted in bold type if they are greater than fifty percent (including fifty percent in the case). The analysis summarised that currently Information Technology is used only at the basic level of course content delivery which merely converts paper documents into an e-version, such as online lectures, tutorials, some extended reading materials and laboratory assignments and so on. Further potential can be investigated in these two areas: tools to support teaching and learning and simulation / interactive learning.

As highlighted for attention, it is quite distinctive that simulation / interactive learning is far behind the teaching expectation, and needs more effort to develop. Although the answers show quite uneven percentage allocation on whether Information Technology is working effectively, most of the survey participants would prefer a little bit longer time span to identify whether it is effective or not, that is one reason for this quite diverse feedback on this part. In this part of this question, all the aspects received over 50% positive responses. This shows that Information Technology has the potentiality to assist and support teaching. This finding supports the goal of this thesis to further the research in applying modern technology, in this case KM, for teaching database normalisation.

4.8 Summary

This chapter concentrates on transferring tacit knowledge to explicit. It starts with exploring different knowledge collection techniques in terms of explicit knowledge collection and tacit knowledge capturing. By comparing and contrasting different approaches, the classical survey approach is chosen as the suitable option for capturing knowledge on teaching database normalisation.

The major findings are (i) significantly more positive responses than negative ones; (ii) currently courses on database normalisation are designated in the 300 level, 200 level and 100 level, respectively; (iii) database normalisation theory is seen as an important part of the teaching task; (iv) there is a major demand for finding out better solutions on teaching database normalisation; (v) different teaching methods should be applied in accordance with different course levels; (vi) course content and the way of knowledge delivery varies from the 300 course level to the 100 level; (vii) details of course contents on different learning levels are recorded, which will be used in the system prototype implementation stage; and (viii) the role of Information Technology in teaching is encouraging, and is expected to be utilised even more in the near future.

CHAPTER 5

System Design and Implementation

Good system design is a balance of many factors, including reliability, scalability, maintainability, cost effectiveness and appropriate technologies.

- System planning corporation

5.1 Introduction

Modern information systems are usually based on the software development life cycle. The system design phase occurs right after the feasibility study phase and the requirements analysis and specifications phase. The perspectives of system design require an integrated approach to look at the system requirements and to outline the design models and architecture, after which system implementation can be carried out successfully. Three important benefits of an integrated system are improved decision-making capabilities, improved business processes, and increased productivity (Ransford, 2002).

KM systems are one type of information system. This technology support KM in organisations, specifically knowledge discovery, creation, utilization and reuse

(Ruggles, 1997). In this chapter, in order to develop a sound KM system, a number of KM systems and practices are classified. The related current system development methodologies, techniques and tools are also reviewed and discussed. An integrated design approach is then outlined in accordance with the scenario of this thesis. Based on the findings from the previous chapters, a KM system design architecture is developed and illustrated in detail. This serves as the guide for implementing the system prototype in the next stage. The web mining related logging system is described and embedded as part of the KM system in order to analyse the user learning patterns. Further, the system prototype is implemented. A brief description on the user interface and coding is illustrated at the end of the chapter.

5.2 Knowledge Management System Design Approaches

In modern system design, there are known methodologies, such as business process re-engineering (Hammer & Champy, 1993), expert system development methodologies (Prerau, 1990), and information system development methodologies. These three approaches all involve different type of developmental life cycle. Each respective life cycle begins with planning and analytical tasks (e.g. re-engineering process identification, expert system problem assessment, IS planning). Furthermore, each life cycle prescribes some physical and procedural changes through implementation and makes a transition (or moves) into a maintenance phase to complete the life cycle.

On the contrary, Mertins et al. (2003) argue that few approaches on KM systems have been widely published and acknowledged, and even fewer approaches have tried to develop a systematic method to integrate KM activities into educational practices. In order to outline education-based KM system design methodologies, in the following paragraphs some selected business based KM system design approaches are presented and discussed.

The **Business Knowledge Management Approach** (Bach et al. 1999) tries to relate KM activities to business objectives and business processes that are based on multimedia document processing. The approach distinguishes between business processes, the knowledge structure and knowledge repository. The knowledge structure represents the knowledge domains and content. The knowledge repository includes KM processes, roles and responsibilities as well as Information Technology systems and documents. In their second book (Bach et al. 2000), they present a few instruments to improve the use of tacit knowledge for business processes and an evaluation of these instruments with recommendations for their integration into business processes. With this enhancement, the KM system proposed has more emphasis on the potential and live knowledge within the employee's brain and experience.

The **Model-Based Knowledge Management Approach** (Allweyer, 1998) adds a new perspective to the modelling of existing business processes, especially of knowledge-intensive processes. Allweyer (1998) also affirms that knowledge-intensive processes are less structured, not exactly foreseeable and, in most cases, not repeatable. KM activities are considered as an integral part of existing business processes.

However, this approach is limited to the description of required and used knowledge as well as generated and documented knowledge. Knowledge is understood as information in connection with the value for the owner of the information, which allows people to act. This is explicit knowledge rather than tacit knowledge.

The **Building Block Approach** (Probst et al, 1998) is considered to be the most widespread KM approach in German speaking areas. It specifies eight building blocks to manage knowledge – knowledge goals, knowledge identification, acquisitions, development, sharing, utilization, retention and assessment. The idea of building blocks for KM has been proposed by Wiig (1995) with examples of building blocks for knowledge creation and dissemination. Knowledge as a resource is considered to be the only integrative pattern of their approach, which follows on external logic rather than the inherent logic of knowledge. Furthermore, categories such as leadership, culture and technology are not systematically included within the concept, which has already been criticized by practitioners as a deficit (Vogel, 1999). Figure 5.1 is one of case studies on KM, which can be adopted as building blocks into the selected area and process.

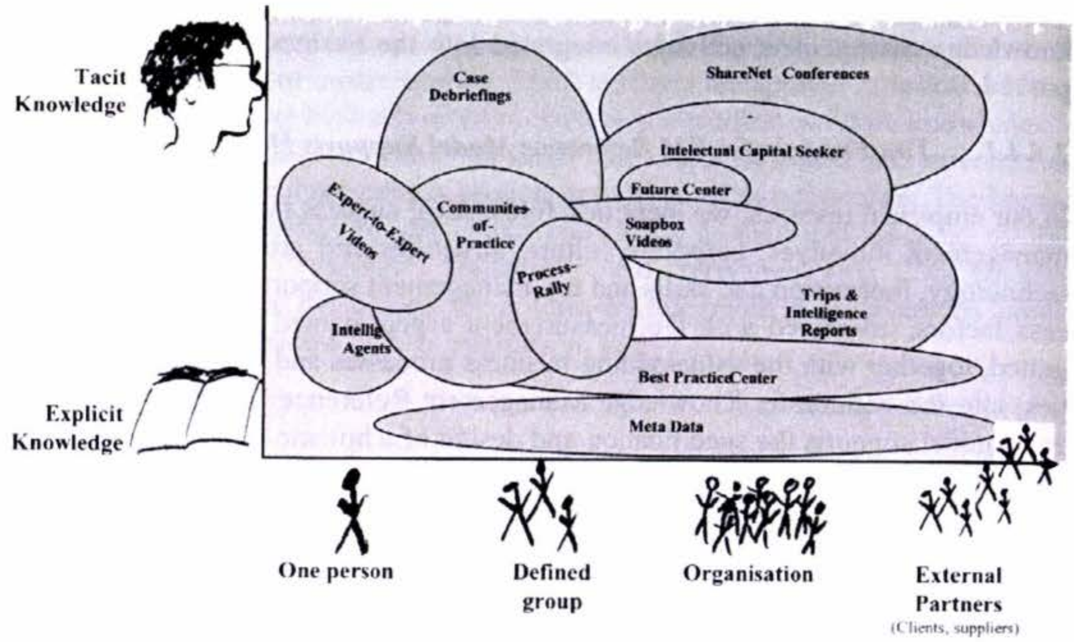

Figure 5. 1 Best practice methods as building blocks for knowledge management (from APQC, 1996, EFQM 1997, cf. Chapter 11)

Besides the above mentioned three approaches, there are other existing methodologies, such as PROMOTE Methodologies (Hinkelmann et al. 2002), CommonKADS Methodologies (Schreiber et al, 2000), etc. In terms of a business environment, whatever method is used, the improvement of the existing methods and development of new methods should be considered in relation to meeting business needs. In terms of an educational environment, the existing methods provide good direction and guidance, and an adapted approach to KM system design methodologies with an educational focus can be developed.

5.3 Educational Knowledge Management System Design Methodology

Based on the brief review of the existing KM system design methods, the proposed methodology defines lifecycle actions referring to knowledge and KM in an educational environment. The methodology tries to divide the whole design methodology of KM into three dimensions: KM system planning and evaluation, Knowledge Management Life Cycle (KMLC) and Software Development Life Cycle (SDLC) (refer to Figure 5.2).

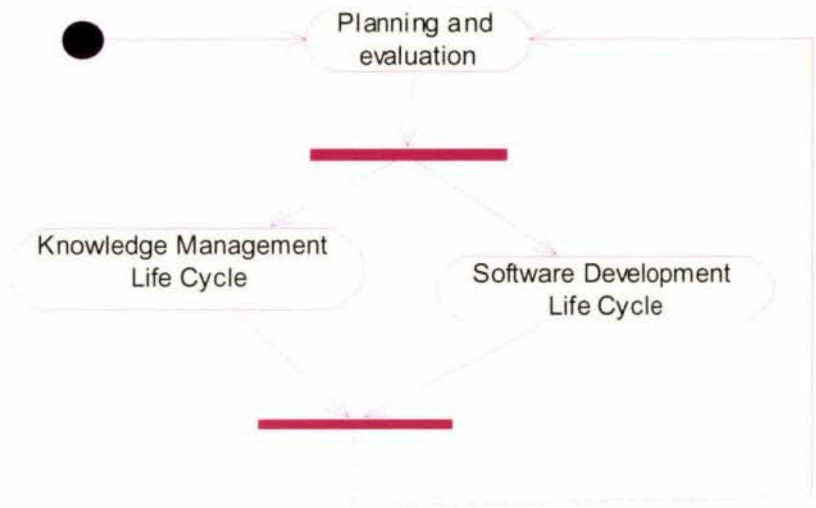

Figure 5. 2 Knowledge management system incremental design framework.

The KMLC is the most common activity in educational institutions. It has a significant impact on the academic staff and students. Through a feedback loop based on knowledge discovery, knowledge creation, knowledge utilization and knowledge reuse, both explicit knowledge and tacit knowledge are captured. Based on teaching and learning objectives, the KMLC captures all sorts of knowledge and allocates quality knowledge into the knowledge repository. The KMLC is not linear, which means that knowledge components are processed not necessarily in a sequential way. However, the sequence of operations while processing a single knowledge component is always the same: first knowledge creation after problem solving request (discovery knowledge), then utilization, and reuse by the target students. Figure 5.3 illustrates how knowledge flows in an educational KM system.

Students initialize the trigger of problem solving and look for the solutions which are the actions of knowledge discovery. Knowledge is created based on teachers' exchanging of knowledge and students' giving feedback on the corresponding knowledge. Newly updated knowledge is stored in the knowledge repository. Teachers and experts with different teaching curricula are other sources of knowledge input to the knowledge repository. Other knowledge input sources can be provided from external sources and educational communities. For example, communities may generate knowledge products in terms of FAQ, best practices and white papers. The knowledge repository may be enriched further by external sources like Internet or knowledge vendors. Thus the users of this knowledge repository, teachers and student who are the beneficiaries of the database, are able to keep this knowledge repository updated and sharable which - in turn - encourages the knowledge circulation within this knowledge life cycle.

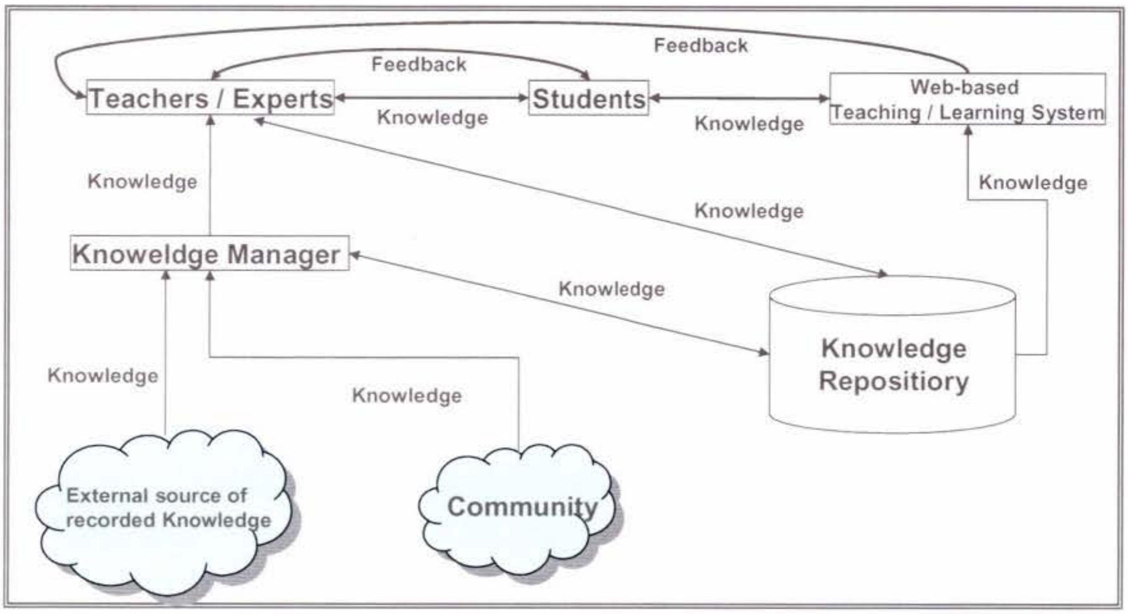

Figure 5. 3 Knowledge flows in an educational knowledge management system

The KM action manages the knowledge life cycle and software life cycle. It is iterative and incremental. Management in this thesis involves making decisions on teaching structure and adjusting the teaching and learning objectives which - in turn - impact on the knowledge life cycle. KM actions consist of stages: verification, design, implementation, and change management. Figure 5.4 snapshots the KM actions over knowledge life cycle.

A software life cycle can be defined as a set of activities, methods practices and transformations used to develop the software and associated procedures. It lays the base for KM system implementation.

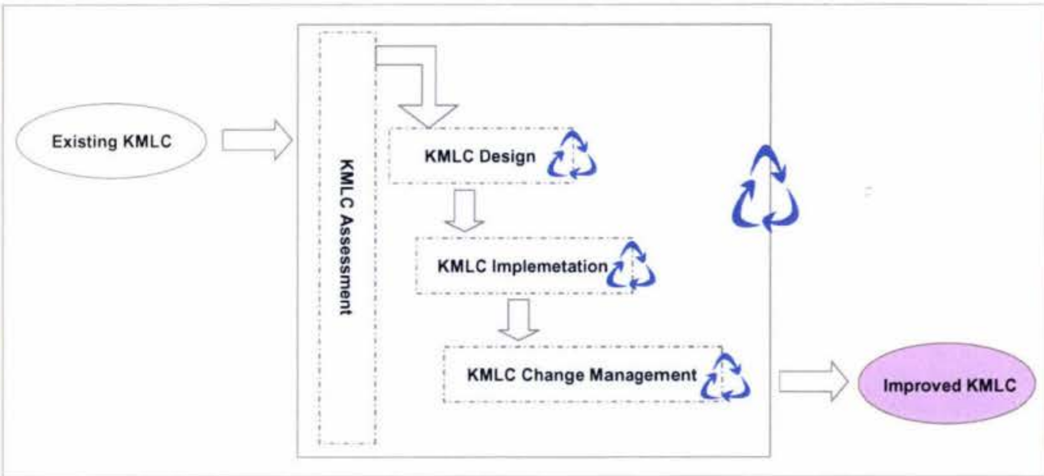

Figure 5. 4 Knowledge management actions over knowledge management life cycle

In summary, the major innovation of this methodology is to consider a KM system as not being a pure information system. A KM system needs extra consideration in the knowledge life cycle and KM activities, because the knowledge itself, especially the tacit knowledge is continually updated and changed. Therefore, KM actions guarantee that both explicit knowledge and tacit knowledge within the knowledge life cycle are captured, utilized and re-used, while the software life cycle is the process which provides the technology environment to make all this action happen.

5.4 Knowledge Management System Platform Architecture

The principal functional area of the KM system platform architecture in this thesis should provide an overview of system features. The target of this system design is to help teachers share teaching resources in database normalisation related knowledge and to help students learn and grasp database normalisation concepts better. Figure 5.5 illustrates the KM system platform architecture in details.

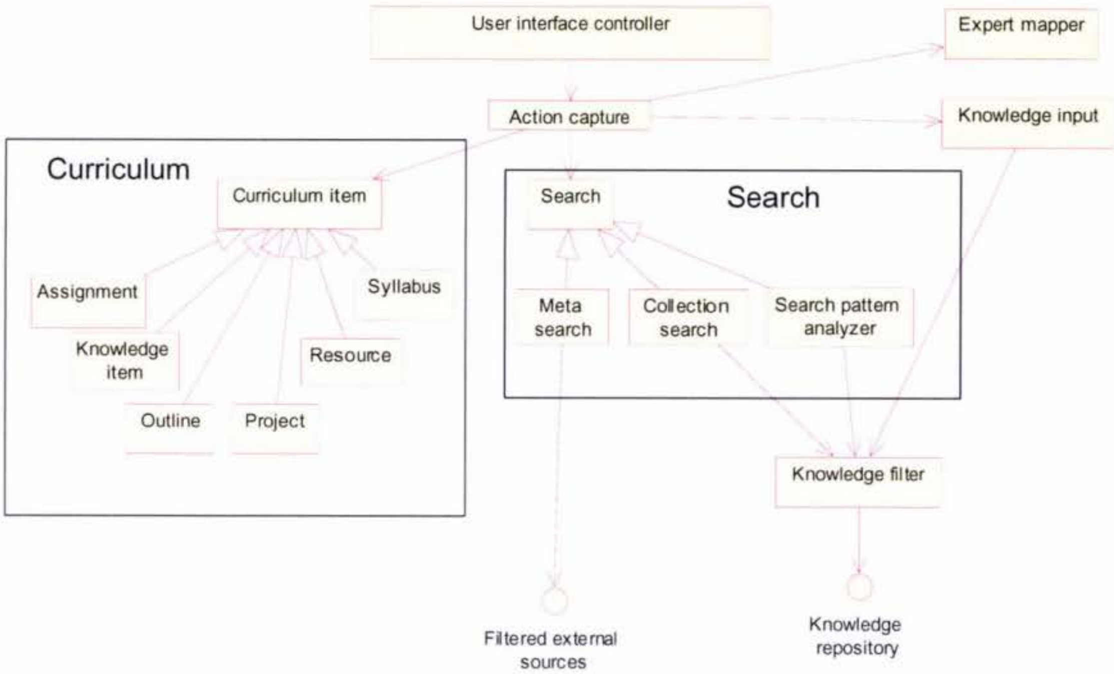

Figure 5. 5 Educational knowledge management system architecture

The KM system architecture's central feature is the knowledge repository supported by associated management functions which enable knowledge creating, sharing and re-utilization. Access to the knowledge repository and the related data-manipulation actions is effective via the end-user graphic interface. The goals of this architecture are listed below:

- Provide web based education on database normalisation
- Encourage teaching & learning resource storing, sharing and updating
- Support effective learning strategies
- Help students to understand the database normalisation concepts easily
- Track student learning preferences and patterns
- Support student evaluation
- Support access to external resources
- Support students' direct discussion with suitable database experts on certain database related topics.

The major components of this architecture are: curriculum components, search components, expert mapper, knowledge input, action capture and knowledge filter. These components are represented in Figure5.5.

Curriculum components: Curriculum components provide access to official class information, including announcements, the syllabus, a course outline, assignment information, project information, and class resources. These categories are similar to the categories used in WebCT.

Search components: Searching components are based on a meta-search framework and support queries on external source and local database and browsing pattern analysis. Meta search is based on the Google search engine. Regarding the user click stream tracking and analysis, it is recorded by the [action capture] logging mechanisms sitting behind the user interface. This is explained in detail in the next section.

The expert mapper component allows students to direct queries to domain experts, and the knowledge input component enables students to share knowledge with each other.

The action capture component acts as an intercepting filter, logging user actions for subsequent usage mining. Finally, the knowledge filter acts to guarantee the quality of knowledge made available via the knowledge repository.

In short, this KM system architecture is the basis for prototype development in the next chapter. It explains the system functions to meet the teaching and learning requirements.

5.5 Learning Pattern Profiler Design

Researchers in the hypertext community have studied dynamic hypertext configuration. Stotts and Furuta (1991) mentioned that criteria for reconfiguration are supplied by the hypertext designer. Many research studies (AccessWatch.com; Cunha el at., 1995; Yan el at., 1996) and some commercial products such as: Interse Market Focus 3 and NetCount Service have looked at capturing user's web access patterns and storing them in log files for different purposes. Based on a user's accesses, these criteria are checked and if satisfied, the linkage among documents adapts in a predefined way. WebWatcher (Armstrong et al., 1995) proposes a learning approach to provide navigation hints. User feedback is used to improve the quality of the hints. Letizia (1995a) records what interests a user has shown, e.g., links followed and keyword searches performed. It then looks ahead in the associated pages that might be of interest and suggests them to the user.

In this thesis, as explained in Chapter 3, understanding students' learning patterns is vital to teachers in terms of setting up the teaching curricula and effectively organizing teaching resources which - in turn - help students to learn effectively. Further, as web mining is focusing on knowledge discovery which is the first task of the KM framework in this thesis, this is implemented as part of the KM system prototype. For the purpose of recording students' browsing patterns, a simple profiler is designed as a counter which counts the number of accesses to a web page and records the visit path. By referring to the approaches mentioned in Armstrong et al. (1995) and Letizia (1995b), Figure 5.6 below gives an overview of the learning pattern profiler with modification and adaptation to serve the purpose of this thesis.

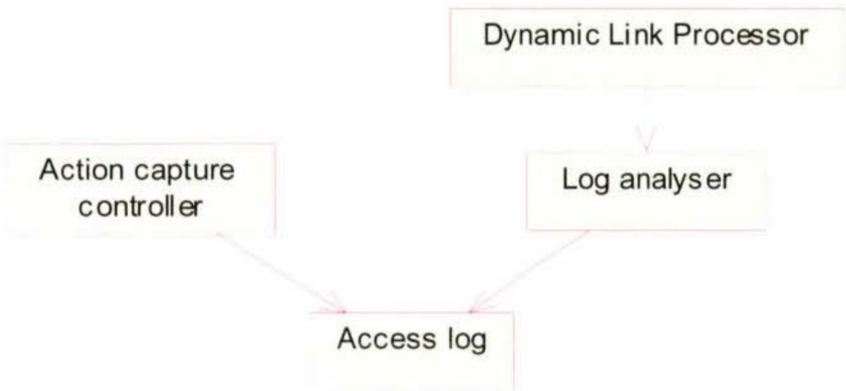

Figure 5. 6 Learning pattern profiler design

The architecture consists of four main components: action capture controller, access log, encapsulating the log data, the log analyser, performing log analysis and encapsulating the data obtained in the analysis, and the dynamic link processor.

The profiler is executed entirely on the server side. The web server is able to support HTTP and additionally supports the notion of a user session: i.e. an ongoing interaction between the user and the web server. As a user may have different information goal each time s/he accesses the web links, in order to better model student learning patterns, analysis should be set up as per session base. However, in HTTP, connections between a web client and a server are stateless and there is no notion of session at all. To overcome this difficulty, one of the common practices (e.g., Time Warner's Pathfinder, 1996) is to encode session identifiers in URLs. The first time a user accesses the server, a new session identifier is generated. In the HTML document returned, this identifier is encoded in all URLs referring to objects on the same web site. Thus, the next time the user clicks on these encoded URLs, the session identifier is passed back. This way, a session can be maintained across multiple URL requests. An identifier timeout mechanism can also be used to make sure different sessions from the same client are given different identifiers.

Log Analyser Module. This periodically (e.g., weekly) extracts information from user access logs to generate records of users sessions. One record is generated for each session in the logs. The record registers the access patterns exhibited by the user in that session. Records are then clustered into categories, with 'similar' sessions put into the same category.

During a session, students may show varying degrees of interest in these items. If there are *n* interest items in the web site, a user session is represented as an *n*-dimensional vector, the *i-th* element being the weight, or degree of interest, assigned to the *i-th* interest item. If an HTML page is viewed as an interest item, then it is assigned a weight equal to the number of times the page is accessed, or an estimate of the amount of time the user spends on the page (eg. normalized by the length of the page), or the number of links the user clicks on that page.

Once the sessions are represented in a vector format, a clustering algorithm is set up against them. The goal of this process is to discover session clusters that exhibit similar learning interests and patterns which - in turn - help teachers prepare the teaching curricula. When translated to the vector representation, the 'similar' clusters of session vectors are examined.

Similarity can be defined in a number of ways. Clustering (also known as unsupervised learning) is a well-studied area (Bezdek & Pal, 1992; Hartigan, 1975) and there are a number of well-known clustering algorithms; e.g., leader, k-means, hierarchical, and fuzzy set approaches. In some algorithms, a vector may belong to more than one cluster, and in that case, cluster membership can be crisp or fuzzy.

The algorithm used in this thesis applies a number of constraints desirable for performance (clustering time) reasons or for better clustering outcomes. The first is that only those sessions that access are more interesting than a certain number of pages, say *MinNumPages*. For example, it is not very useful to cluster users who just visit the home page and leave. With this constraint, the number of sessions can be reduced in this analysis. Secondly, constraining those clusters that are under a certain size, say *MinClusterSize,* removes insignificant clusters and may also improve performance.

Dynamic Link Processor Module. When a user requests a new page, this module tries to classify his current partial session record against one or more of the categories obtained offline by the log analyser. The top matching categories are identified, and links to unexplored pages contained in these categories are inserted at the top of the page shipped back to the user.

This section presents a learning pattern profiler design that facilitates the analysis of student's access patterns to discover common learning patterns, behaviours and interests. This information can be used by teachers to customize their teaching material in order to meet student learning needs.

5.6 Further Remarks on Knowledge Management System Design

Based on educational KM system design architecture and the associated learning pattern profiler design architecture, two additional aspects are concerned to support the KMS functionalities: (i) the network design to support sharing; and (ii) meta-knowledge (knowledge about the knowledge) to support organisational memory.

In terms of **Network Design**: Knowledge networks are intended to create links between individuals to facilitate knowledge sharing (Alavi, 2000). This thesis proposes that the network design can best support the socialization process by connecting knowledge seekers to knowledge sources, as opposed to the repository model – e.g. knowledge bases – that is not designed to encourage socialization.

In terms of **Meta-knowledge**: Meta knowledge can support effective management of organisational memory (Plant & Gamble, 1997; Schwartz, 1999). This is similar to maintaining meta-data about data stored in databases or maintaining information about items stored in physical inventories. An additional support for the use of meta-knowledge comes from epistemology literature (Lehrer, 1990) where information about the knowledge is required by users of the knowledge to justify its use. Meta-knowledge mainly supports the internalization and storage of knowledge but can also support socialization by providing users with information about knowledge and knowledge sources.

5.7 System Prototype Implementation

The system prototype offers in its GUI the concepts of KM. It is organized to help teachers and students develop knowledge.

5.7.1 Platform Requirements

The prototype is browser based so that both teachers and students can access it from a typical university computer lab. The main coding languages are HTML, JSP, PHP and MySQL.

JSP technologies are used in the middleware and run on a web server. Messages passed between client and server in HTML format which is compatible with different computer platforms.

At this stage, there is no usercode and password required before login on the system, thus it does not require high security authentication.

5.7.2 User Interface Components

The main user interface is composed of four panels: normalisation tasks panels, concepts display panel which is subdivided into further panels and Knowledge search panel.

The right-hand side of the screen is the display panel which is divided into one part for definition type of results, and one part for example type of results. This display panel corresponds with the normalisation tasks panel and the search panel. The curriculum components are provided with the course links which are displayed in the general course window. This is not considered the major part of this user interface.

On the left upper part are the listed normalisation tasks. The design is based on the Survey findings on teaching database normalisation. Each concept is presented as a folder, within which detailed normalisation knowledge is listed. This panel corresponds with the display panel, i.e. given one concept, the definition of this concept is described in the upper display window, while examples of related knowledge are illustrated in the lower part of the display window. This gives simple, clear visual effects, which - in turn - helps students enjoy the learning 'journey'.

The left lower part of the screen is the query panel which can search the results from both the local database and Google knowledge base. Once the query is entered, the search result will be displayed in the upper display window. Figure 5.7 is a snapshot of the main user interface.

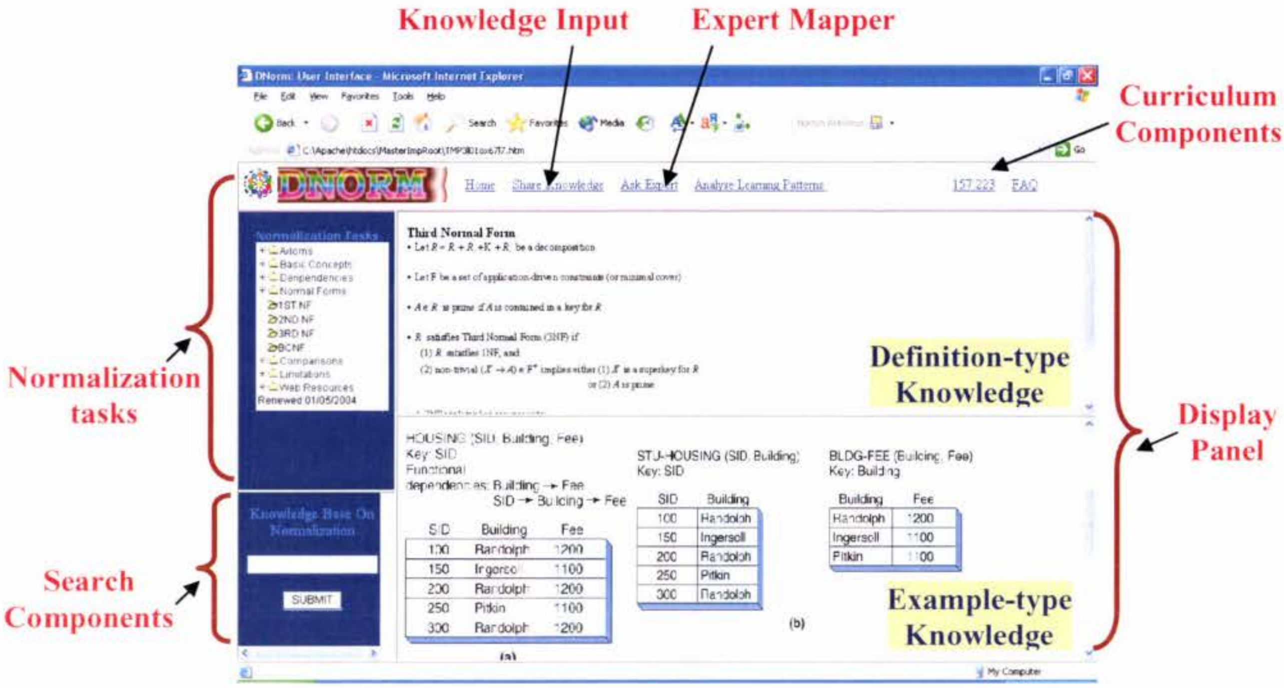

Figure 5. 7 Home page of the prototype system

Another feature of the system is its ability to provide a knowledge sharing function. For any users, teacher or students, who are interested in any topics and would like to share the knowledge with each other, this is a good place to upload the knowledge. However, note that all the submitted knowledge is first gone through by the course controller. This is one of the actions which ensures the knowledge uploaded to the system is indeed knowledge for the right level of the students. This is one of the procedures to avoid any frauds and guarantee that all the incoming knowledge is for the right purpose. A screen print of a knowledge sharing window is provided in Figure 5.8.

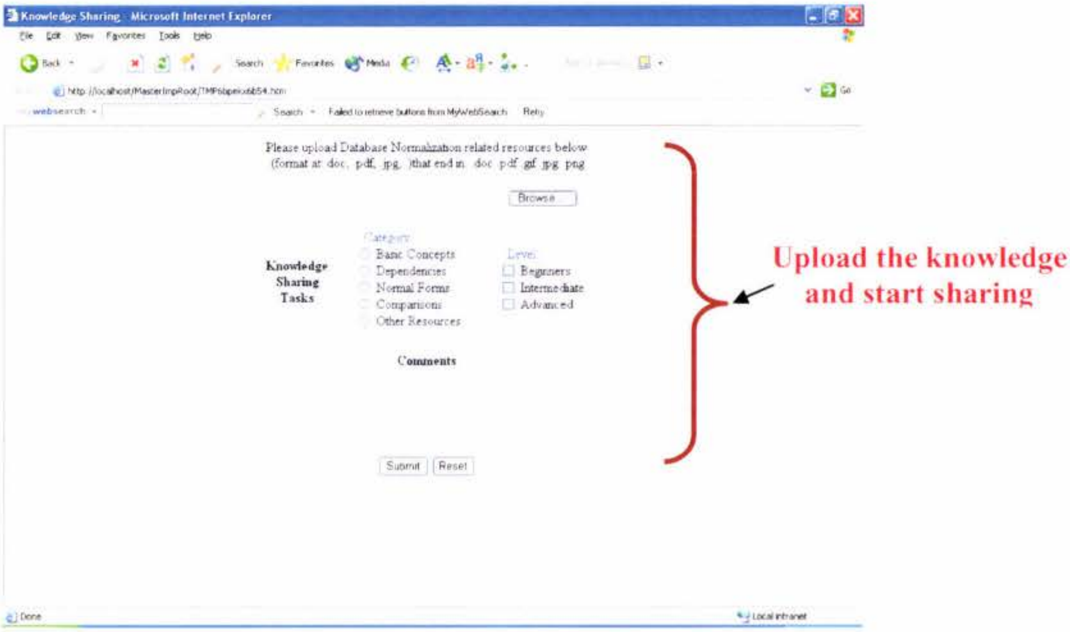

Figure 5. 8 Knowledge sharing portal

To further increase knowledge sharing, *Ask Experts* is another feature to provide sharing and exchange of knowledge. This opens the media for those who are seeking database experts for any sort of normalisation related problem solving actions. The benefit of this channel is that it is fast and confidential.

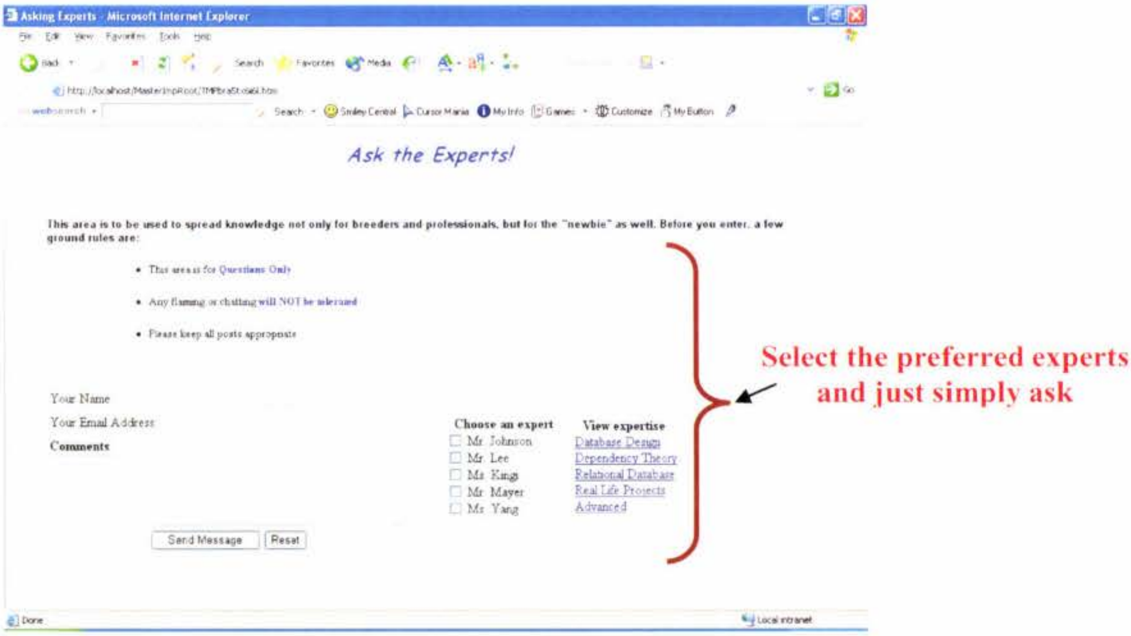

Figure 5. 9 Interface for contacting an expert

As discussed in previous chapters, the system also provides the report on students' learning pattern tracking, which is used by teachers to customize their teaching contents. At present, the prototype only analyses the learning pattern on the knowledge of general normalisation tasks, the knowledge requested via the search engine and the knowledge requested via contacting a specific expert. Although the system is capable of tracking and logging the user actions against the prototype, the fully functioned analysis profiler will be further improved.

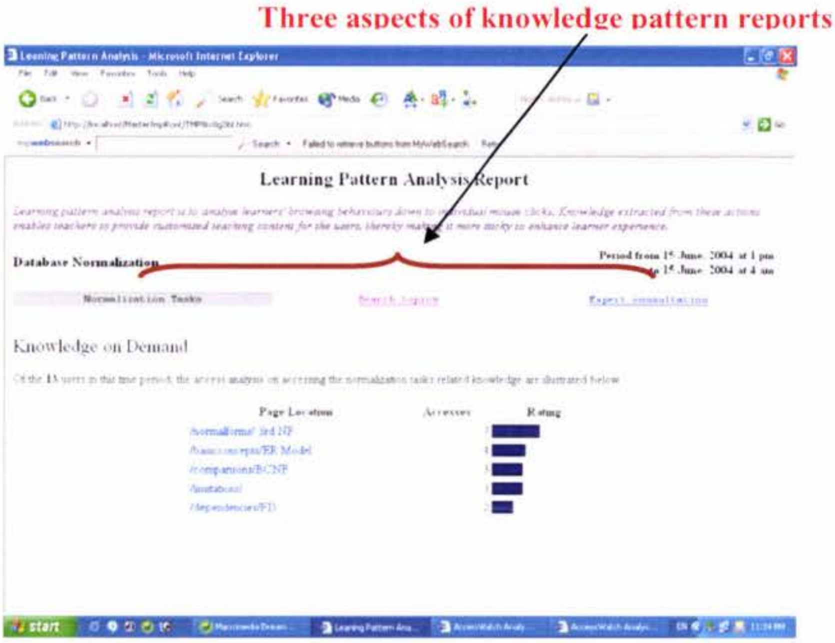

Figure 5. 10 Sample learning pattern analysis report – normalisation tasks

5.8 Summary

This chapter, compared with the first four chapters, shifts the focus from theoretical explanation to close practical system design. Based on the review of the different KM system methodologies, a specific KM system approach is set up to meet the requirements of serving educational based teaching and learning purposes. System design architecture is set up, which includes educational based KM system architecture embedded with learning pattern profiler design architecture. A system prototype is implemented and illustrated in this chapter.

CHAPTER 6

System Prototype Evaluation

A clear definition of what the software needs to do to be successful. Target users, target market, performance needed, level of skill of the users, areas of later expansion, etc. - these are all basic factors that have to be taken into account for an 'successful' system implementation.

-- Mortensen, 2003

6.1 Introduction

Educational technology is a tool that can facilitate new ways of teaching and learning. High quality software is a vital ingredient of teaching. Teachers are using technology to implement new instructional techniques, restructure their classrooms, and transform student and teacher roles. According to the Secretary's Conference on Educational Technology '95, technology makes it easier for teachers to individualize instruction and for students to engage in self-motivated learning. Technology can accommodate students with a variety of learning styles more flexibly than conventional materials and is well suited to collaborative instruction.

As the amount and variety of educational software grows, there is commensurate need for it to be assessed for suitability for its intended purpose, such as usability.

Lecturers and teachers need to know whether and how software can be used to improve their teaching and learners need to know how it might affect the learning experience (Golebiewski, 1997). Not least, software which is developed for educational purposes should be assessed against the initial system development requirements so as to reassure the system is capable of fulfilling the goal of assisting teaching and learning.

Different system evaluation methodologies are available to examine the overall system functionalities and judge the quality of academic software. Thus, in order to assess the KM system prototype, an evaluation method is chosen in comparison with the existing evaluative criteria. An evaluation survey is carried out, which focuses on whether the prototype is able to provide a KM environment. The survey results show that the prototype enables knowledge discovery, creation, sharing and reutilization potentials, which - in turn - encourage teaching and learning.

6.2 Existing System Evaluation Methods

With the vast improvement in computer technologies, different software is available for assisting our daily life in an easy format. This also applies to the educational environment, since education is more and more inseparable from modern information technology, to achieve better teaching and learning outcomes.

Although different educational software is available, not all the software meets educational objectives and educational context of use (Hammond et al., 1993). Thus, software evaluation becomes a more and more important process to determine whether a particular software meets educational requirements in supporting teachers to construct a more professional teaching environment and student to learn effectively and efficiently.

To fulfil the software assessment purpose, different system evaluation methods are available, which can be summarized into four categories according to evaluation characteristics, i.e. subjective evaluation methods, objective evaluation methods, expert evaluation methods and experimental evaluation methods.

6.2.1 Subjective Evaluation Methods

Subjective evaluation methods, known as survey methods (Macleod, 1992), are directly based on the users' feedback. These methods allow users independently to interact with a system via the user interface and collect the subjective view while using the system. In these methods, real users are involved, and information is gathered after the users use the system.

The first method in this category is *questionnaires*. They offer the advantage of providing the data about the end users' views of user interface quality, as opposed to an expert or theoretician's view, and can provide data about system usability in a real work setting (Norman & Shneiderman, 1989). It is essential to ensure that the group of people responding to the questionnaire match the actual and intended group of end users, and that they have used the software for intended purposes, performing the specific work tasks which helps determine whether the software is worth distributing or not.

Practical examples of using this method are applied in the 'ISONORM 9241 Questionnaire' designed by Prümper (1993) and the 'Questionnaire for User Interaction Satisfaction' (QUIS 5.0) developed by Norman and Shneiderman (1989).

Interviews also belong to this category, but are more time-consuming than questionnaires. They need careful pre-planning, and a good degree of expertise on the part of interviewers (Lindgaard, 1994). Since the interviewer can adjust the interview to the situation, interviews are well suited to exploratory studies in which the evaluation scope is not yet finally defined. Structured interviews with a pre-determined set of precisely phrased questions are required if data is to be analysed statistically. Unstructured or flexible interviews covering pre-specified topics but in a style and order shaped by the responses of the user can elicit more revealing information about the usability of a system. The results are more difficult to analyse, but can be highly informative (Fowler & Mangione, 1990).

6.2.2 Objective Evaluation Methods

Objective evaluation methods (also known as observational methods) involve real people using working systems (Macleod, 1992). They are based on observing users' interaction with the system and can range from being almost entirely informal to highly structured. Often, the interaction of the users is recorded in some way for later observation or analysis. Many software producers use a usability lab in which representatives of real users perform test tasks under the observation of experts. Observation or video records are often used to confront developers with usability problems of users. Wiklund (1994) stated that this approach seems to be more effective than a report generated by human factor experts.

Under this category, three common methods are highlighted, direct observation, video recording and interaction monitoring.

Direct observation is the simplest form of observation. It involves having a person familiar with usability issues observe individual users performing tasks with the system. If the system is fully implemented and in its natural work setting, then direct observation tells much about the use and usability of the system.

Video recording allows data to be separated form analysis. The evaluator is free from analysing the data during the observation. Any aspect that has been recorded can be analysed by the evaluator in details after the session. One of the major disadvantages of this method is the time required to analyse the data.

Interaction monitoring is to automatically gather data about how people interact with the system. With the help of monitoring facilities all user inputs (e.g., commands, mouse clicks, menu options) and system outputs (e.g. information displayed, changed states) can be recorded.

6.2.3 Expert Evaluation Methods

Expert evaluation methods ask for a person with expert knowledge to make judgements about the usability of the system for specific end users and tasks. These methods lie at the intermediate stage between subjective evaluation and objective ones (Blackmon et al., 2002). Although Hammond et al. (1985) reported the superiority of the expert judgement based on a comparison between expert judgement and user observation, expert evaluation could not really reflect the real user's interaction and feedback.

Expert methods can be expressed in the following ways: specialist reports and expert walkthrough, cognitive walkthrough, checklist, guidelines and principles.

6.2.4 Experimental Evaluation Methods

The last category is based on experiments asking scientific questions. This requires soundly designed empirical experiments in the testing of hypotheses about the usability effects of various factors in design. These methods are rather hard to define, because the methods involved in the determination of the dependent and independent variables, the selection of the proper environment for the study, and the underlying theory dealing with man-machine interaction (Vredenburg et al., 2002).

6.2.5 Summary of Evaluation Methods

From the above sections, each evaluation method has its advantages and disadvantages. The choice of a method for a specific evaluation depends upon the stage of the system development, the kind of user involvement, the type of data necessary for the kind of results required, the available expertise, the possible place of evaluation and the available resources (time and money).

Based on the Macleod (1992), the important characteristics of evaluation methods are illustrated in the table 6.1

Type of Method	Subjective	Objective	Expert	Experimental
Timing of use	prototype or later	prototype or later	any stage	any stage
User-based	yes	yes	no	yes
Scope	broad	broad	broad	very narrow
Place	in-house	in-house or laboratory	in-house or at the expert's workplace	laboratory
Costs: time, money	low / medium	Medium / high	low	high
Main advantages	Fairly quick User-based; really user's view; diagnostic	User-based and involves user performance on work tasks; Diagnostic	Low cost Quick; diagnostic	User-based Rigorous; can produce: results with validity and reliability
Main disadvantages	Less effective early in the design cycle	Less effective early in the design cycle	Not-user based Questionable reliability	Narrow scope High cost

Table 6. 1 Summary of important characteristics of evaluation methods

6.3 System Prototype Evaluation

In order to provide a basis for both effectiveness and analytic evaluation, 5 teachers who are involved in teaching database normalisation in 100 level, 200 level, 300 level, respectively, were chosen. The knowledge bases are first defined as 7 normalisation tasks, which can be expanded based on further teachers requirements after the evaluation. The evaluation is set up based on the consideration of the following processes.

6.3.1 Justification of Survey Approach on Prototype Evaluation

The purpose of the system prototype is to help teachers to better deliver the knowledge on database normalisation to the students, which - in turn - benefits the students in grasping the knowledge in professional manner. Thus, evaluating this system prototype requires the real end user to 'play' with it and provides the feedback upon the system interaction. Further, in the field of KM, it emphasizes the identification of the knowledge flow along the knowledge life cycle, thus it is rather important to reflect the real end user's understanding and actions on the prototype.

Based on the evaluation methods and their characteristic comparison described above, the survey approach shows its potentiality in evaluating the KM system prototype. This approach ensures that knowledge entered into the system reflects teaching and learning requirements, such as suitable teaching content in database normalisation, awareness of students' different knowledge levels, etc. It can also capture the teaching methods, background and knowledge differences since the teacher who controls different course levels is directly involved in the system evaluation. It might be possible to overcome the biases imposed by a particular domain, by having particular experts for example. Further, users can directly contribute new inputs while assessing the system.

In short, without significant time and money consumption, it is feasible to perform a survey evaluation on this KM system prototype.

6.3.2 The Survey Participants Study

The basic concerns in performing the participants study are: identify the right group of user to assure the right input of knowledge bases; instruction or training before the evaluation; perform any necessary enhancements to the system in order to accommodate their needs so as to smooth the evaluation; study the results of their knowledge based building efforts.

As a survey approach is applied in the prototype evaluation, academic staff who teach database normalisation or database design are suitable for the evaluation. Nevertheless, the selection should take into account the difference between course levels, thus evaluators should be chosen from different course levels.

In order to smooth the evaluation, a brief system user tutorial (refer to Appendix IV) is documented. This provides each participant with a better understanding of the system functionality and guides the participants through different parts of the prototype while doing the evaluation. Further, during the research period, the prototype remains active which means the system will be modified or improved from time to time based on any significant new feature requirements.

Since the prototype is a KM based system, knowledge bases are defined into 7 teaching tasks according on the Survey on Teaching Database Normalization (refer to Appendix III). These seven aspects are anomalies, basic concepts, dependencies, normal forms, comparisons, limitations, and web resources.

6.3.3 System Evaluation Questionnaire Development

The questionnaire contains four sections containing a total of 30 questions. The majority of the questions (28 out of 30 questions) are closed questions, which are 3-range Likert scale questions. It is expected for each participant to use 10-15 minutes to finish the questionnaire.

Section A of the questionnaire asks for general information on the course level in order to identify the differences of knowledge base. Section B deals with what the prototype has achieved in helping teaching and learning database normalisation. There are 11 questions in this section. In section C, 8 questions are asked in terms of what the prototype fails to achieve. Section D consists of 9 questions which are concerned with how to improve the prototype.

6.4 System Evaluation Questionnaire Analysis

Based on the responses from lecturer and tutors, the questionnaires are analyzed in order to identify whether the system prototype meets the objectives set in teaching database normalisation.

In Section A, the general information on course level is raised: *Please specify the level(s) of course(s) you currently teach, in which database normalisation is part of the teaching task.* This is a multiple-choice question which has four choices: Master Level, 300 level, 200 level and 100 level.

The survey participants fall into three different course levels, i.e. 300 level, 200 level and 100 level. This reflects that database normalisation remains at the knowledge delivery level rather than the higher research level within Massey University. Participants in higher levels expressed the need to enrich the content of database normalisation which means that teaching in 300 level should explore the deeper knowledge of this theory than the 200 level. Similarly, 200 level course requires more attention on this topic than 100 level. Figure 6.1 illustrates the percentage of participants of different course levels.

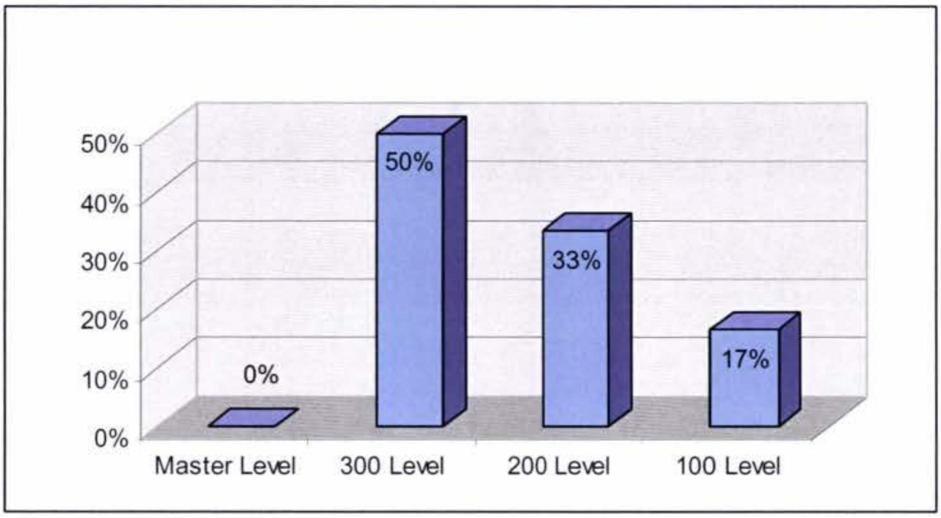

Figure 6. 1 System evaluation survey: percentage of participants teaching database normalisation, separately for each course level

Section B is to ascertain the success of the system prototype by collecting the comments of the overall system quality, that is, *is the system perceived to be useful in teaching database normalisation?*

In order to answer the above question, eleven sub-questions are posed to the participants of the study. These questions range from the knowledge scope on database normalisation, benefits of using the prototype, to knowledge life cycle. Answers were on a scale where 3 means 'achieved', 2 means 'partly achieved', 1 means 'not at all achieved'.

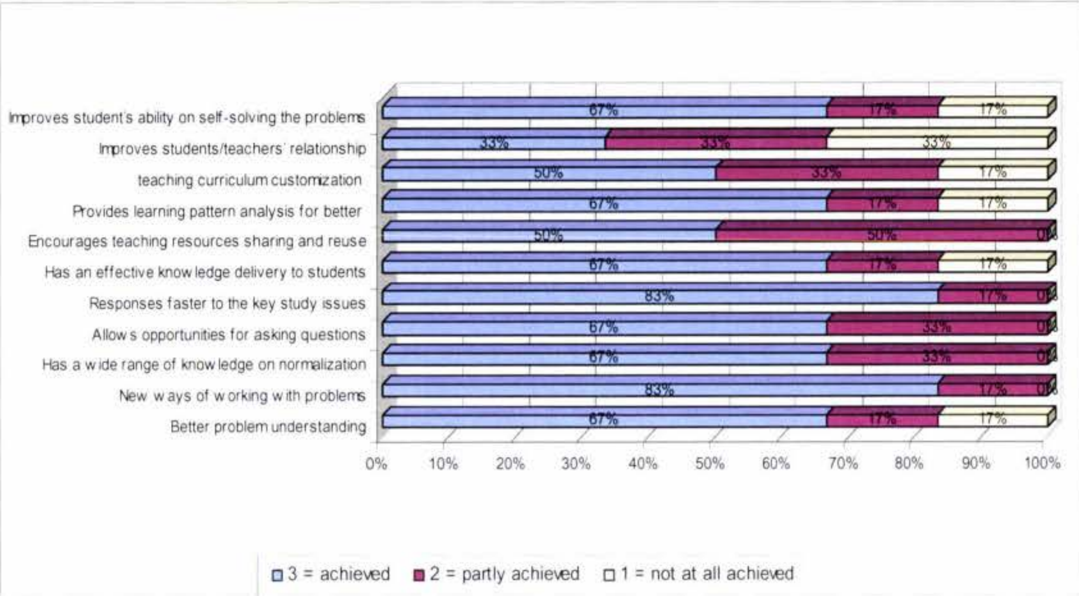

Figure 6. 2 Perceived potential benefits of the system

Ten questions out of eleven questions have received positive responses (please refer to Figure 6.2 above). This indicates a reasonable strong feeling that using the prototype is worthwhile. Participants gave a high score on 'prototype can respond faster to the key issues'. This suggests that the prototype is capable of capturing the student problems, which - in turn - encourages knowledge discovery within the knowledge life cycle.

Regarding the prototype as a new way working with problems, a high positive response was received, which expressed that the prototype helps both teachers in teaching database normalisation and students in learning this knowledge.

Moreover, the prototype has the potential to encourage sharing and reutilizing the teacher resources, which confirms it is rather important for teachers to communicate with each other in order to learn from one another. Since this question only received fifty percent agreement, the prototype evidently should deploy more efforts in this perspective.

Besides the positive responses, two aspects did not receive positive scores. The prototype does not seem to significantly contribute to improving students / teachers' relationship. Thus, a better solution to this aspect should be found, because a harmonious teacher & student environment can definitely increase motivation in both teaching and learning.

By identifying the prototype's benefits, Section C looks at different aspects which the prototype fails to realize. The main reason for this section is to discover the prototype's weakness as a KM system. This will definitely help improve the system functionality in the next version of the prototype. There are 8 questions addressing different concerns in this section. As in Section B, a three-range Likert scale is used: 3 stands for 'strongly agree', 2 refers to 'agree', and 1 equals to 'disagree'.

To recall the response in Section B, it shows that the prototype, as an example of educational KM system, has the potentials to help teaching and learning database normalisation. It has the advantages over traditional teaching methods on this topic. However, in certain aspects, the prototype has not fully achieved the set target. Figure 6.3 illustrates the weakness by contrasting with the strength.

Generally speaking, there are two aspects which show the system prototype needs further development. On one hand, more efforts should be deployed on the system functionality perspective so as to overcome the drawbacks, such as: insufficient knowledge in the knowledge base and insufficient output for pattern analysis. On the other hand, some non-technical issues are highlighted. High negative response rates explained that the KM system is still not known by the teachers and students, and is still in the infant development period. Therefore, more information on which KM system can really help teachers and students, and how KM system will help them should be emphasized while distributing any KM based systems. Moreover, all the participants expressed that it is a good idea to use web mining on tracking and analysing student click-streams, as this is good for teachers to understand student learning patterns so as to customise the teaching resources based on the course level and student understanding level.

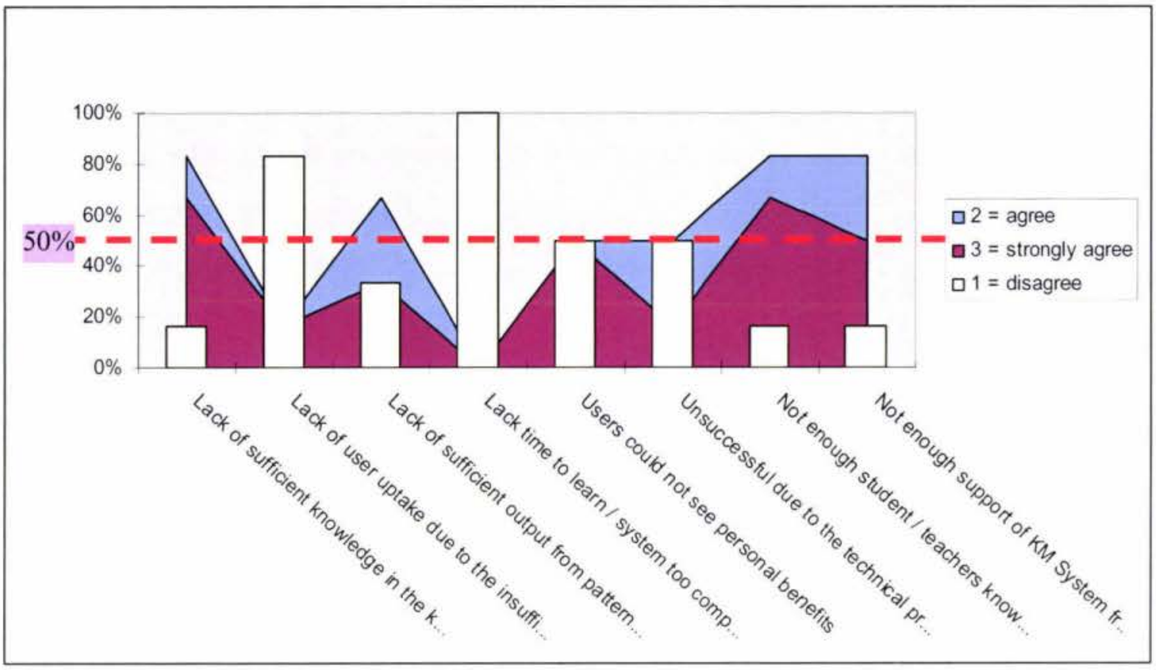

Figure 6. 3 Perceived potential drawbacks of the system

In short, the system evaluation on what the prototype fails to realize, to some extent, conveys a positive response that the idea of applying KM in teaching database normalisation is a good practise. However, this educational KM prototype still needs more efforts in terms of improving system functionality and user navigation.

Section D concentrates on what should be implemented next in the prototype. Nine questions are designed for this section, focusing on the following aspects: more knowledge inputs and more common practices; better pattern analysis to achieve deep understanding of student learning interests; a full-functional search engine; a discussion form, more information on applying KM in teaching database normalisation; training and help etc. All these questions serve the purpose to develop a fully functioned KM system to support teaching database normalisation. Figure 6.4 gives the general weights on question 21 to question 29. Three scales are: 3 = done, 2 = next 3 months, and 1 = later. Designing three scales based on the time constraints, on one hand, confirmed the status of the current prototype functionality; on the other hand raise the priority concerns as to what should be implemented next.

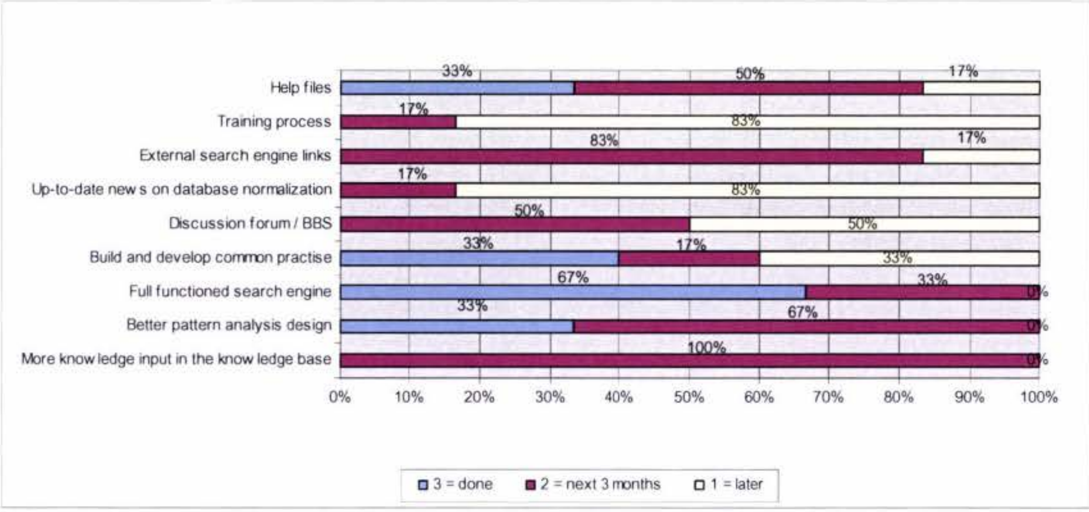

Figure 6. 4 Evaluation of the possible new features

To simplify the chart list above, it is divided into two independent charts: one is on what is to be implemented in 3 months (refer to Figure 6.5), and the other one is on things to be developed later (refer to Figure 6.6).

The responses to these nine questions in Section C show the participants are happy with what has been done relating to the search engine. This functionality enables effective knowledge retrieval and knowledge sharing. The top priorities of system amendments focus on more knowledge inputs which all the participants emphasized should be done as soon as possible, so that the teachers can start more serious knowledge sharing and knowledge re-utilization on database normalisation related theory, and students can fully use the system and grasp the knowledge better. This - in turn - gives evidence that the prototype encourages knowledge flow between teachers and students. Further, regarding the student learning pattern tracking, more development work should be prepared and designed in order to capture more student click stream action on the website, and provide a detailed tracking analysis report. More efforts should be deployed on discussion forums, external search links, and system help files / manual etc. Improving these aspects can influence the knowledge environment and knowledge discovering, knowledge sharing and knowledge re-use can be processed in a more professional manner.

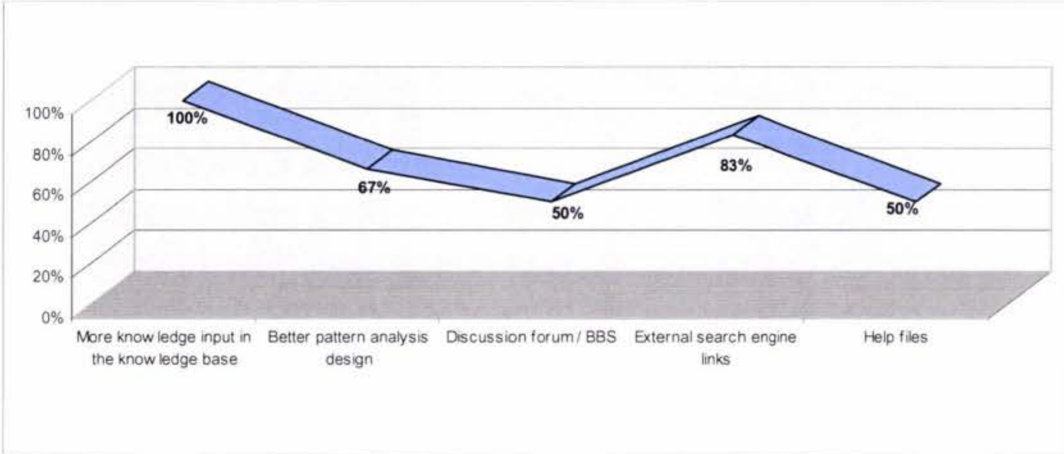

Figure 6. 5 Priority rating for the proposed new features – high priority features.

Although training and KM system news updates are listed in the second priority group, these two aspects reflect that KM system supports are vital to KM system success. Without pushing system supports related development, a KM system can not be fully developed, and can not attract users to 'play' with the system, which - in turn - will block the knowledge flow within the knowledge life cycle.

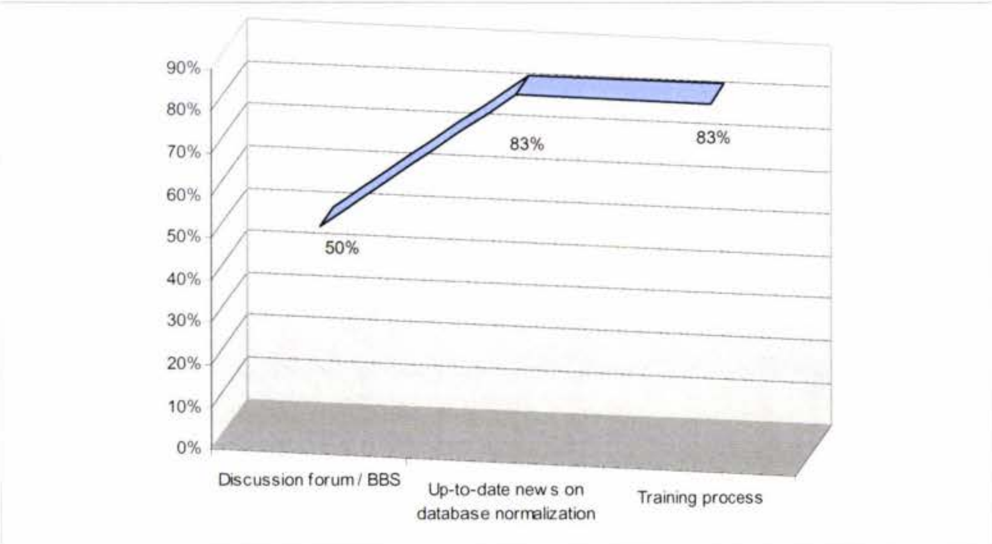

Figure 6. 6 Priority rating for the proposed new features – low priority features.

6.5 Executive Summary of Evaluation Findings

The prototype has the KM characteristic of encouraging the iteration of the knowledge flow along knowledge processes: knowledge discovery, creation, sharing, use and reutilization. It deploys the efforts in applying KM techniques in teaching database normalisation theory. Meanwhile, with the application of web mining techniques, it enriches the knowledge discovery process which provides teachers with more knowledge on students learning patterns and interests.

To look closely at the system, the prototype addresses the tacit knowledge and explicit knowledge on normalisation theory in a different manner. Explicit knowledge is defined as normalisation tasks, which are generated from the teachers' survey on teaching database normalisation. On the other hand, it deals with the tacit knowledge by directly linking the student with the database normalisation experts. This makes the communication more friendly and efficient. Moreover, all the knowledge inputs are evaluated by the teacher before they are put into the knowledge base. This guarantees that knowledge is suitable for the right group of students based on the knowledge gathered from the student learning pattern analysis.

The search functionalities of the system also provide students with another source of learning database normalisation.

All these aspects mentioned above attest to the prototype's success. But on the other hand, the evaluation also reveals the weakness of this system implementation. Two major aspects are highlighted in the survey analysis. One is that more diverse normalisation knowledge should be captured and added to the knowledge base, which enriches the knowledge pool for both teachers and students. The other concern is that the learning pattern analysis is still in the infant period and more functionality features should be designed or re-designed to meet the educational purpose. Both of the issues are in the top priorities which should be sorted out in the next three months.

The survey analysis also indicates that KM system support is also a vital part, because KM system is still a vague 'term' in the educational environment. Most of the teachers and students are not sure how a KM system can really help users to achieve better teaching and learning outcomes. Hence, extra efforts should be deployed, including: related news on KM systems in an educational environment to achieve better acceptance by the end users; help files and training sessions should be provided for a better user friendly system.

6.6 Summary

In abstracting thesis, several key questions emerged. The questions revolved around how to effectively share and utilize teaching resources on database normalisation, and how to discover the student learning interest and customize the educational materials to meet students' learning needs.

Surrounding these two key questions, the system prototype is designed and implemented. In order to evaluate whether the system prototype meets the original system requirements, the survey evaluation method is chosen in comparison with other existing methods.

In short, based on the analysis of the survey responses, the prototype appears an important KM contribution to the education in database normalisation. Several important features explained its potential in assisting teaching database normalisation, but extended system improvements should be considered to meet the ever changing teaching and learning requirements.

Conclusions and Future Implications

...Knowledge management can thus cause motivation for a long – lasting change of the previous way of dealing with knowledge, i.e. a sustainable change of behaviour...

-- Tazari et al., 2003

This thesis has involved conducting three pieces of new research: (i) apply KM in teaching database normalisation; (ii) capture tacit knowledge on teaching database normalisation; and (iii) adopt web-mining techniques in a KM system to analyse the students' learning patterns and assist teaching-content customization.

This chapter summarises the findings from the new research conducted for this thesis. The collective findings are then considered as a whole in terms of their implications for future research, the application of KM in education, KM performance evaluation and system design and evaluation more generally.

7.1 Summary of Major Findings

Knowledge Management Perspective. In a business context, many organisations apply KM to improve their efficiency and effectiveness, and to encourage the creation and sharing of knowledge among people in the organisation. Thus KM should have a resonance in education, as one major function of education is the impartment of knowledge. This implies that just as businesses attempt to improve the efficiency and effectiveness of their operations through KM, so do educational institutions use the potential of KM to enhance teaching and learning.

This thesis explores the KM potentials in a particular educational environment: teaching database normalisation. Teaching and learning requirements are identified. The KM framework for educational purposes is developed and the KM system architecture is then defined. These laid the foundation for the implementation of the final system prototype. Until the evaluation of the prototype was conducted, the available evidence indicated that: (i) KM utilises both explicit knowledge and tacit knowledge; (ii) KM promotes knowledge creation, sharing and reutilization at all levels; (iii) KM overcomes the space and time constraints; and (iv) KM encourages the trust between teachers and students.

These findings prove that KM encourages both teachers in organizing the resources on database normalisation, and students to get motivated via this learning channel. Above all, the application of KM concepts can be extended to other teaching tasks.

Tacit Knowledge Perspective. For effective knowledge sharing, the knowledge has to first be captured. Tacit knowledge which is described as personal and deeply rooted in an individual's experience, values and culture, thus is difficult to computerise, codify, store and share with others (Murray & Myers, 1999; Polanyi, 1996).

This thesis reviewed the different strategies in knowledge capturing and developed the survey on teaching database normalisation, aimed at capturing teaching experience, judgement and further thoughts relation to database normalisation. The questionnaire received fully positive responses and teachers' personal knowledge could be gathered and conveyed into the knowledge base for sharing and generating new knowledge.

During the prototype evaluation, evaluators were satisfied with the categorized knowledge tasks which were derived from the tacit knowledge captured through the survey mentioned above. This positive response confirms that tacit knowledge in an educational environment can be captured and should be captured for better sharing and distribution. Note that further enrichments of the knowledge base are required during the prototype's evaluation.

Web Mining Perspective. The individual's visit to the public web pages can be a good source for inferring user's expertise in particular fields and the quality and quantity of web pages s/he has visited may be a good reflection of her / his expertise in the area (Srivastava et al., 2000). This leads to further research in analysing student learning patterns to achieve better customization of the teaching resources. The general knowledge discovery techniques were reviewed, and can be linked and used within the first process of an educational KM framework: knowledge discovery, knowledge creation, knowledge utilization and knowledge reuse.

In the scenario of teaching database normalisation, web mining techniques were identified as the right tool in terms of usage pattern discovery from the web data. According to the system requirements, web mining techniques, incorporated as part of system prototype, mainly concentrate on tracking students' browsing behaviours down to individual mouse clicks.

From the prototype evaluation results, this feature becomes an important part of the educational KM system, because teaching and learning are inseparable – they interact and influence each other. The more understanding of student learning interest obtained, the better teaching resources on the corresponding subjects can be utilized.

Although the pattern analysis was implemented as part of the system functionality, yet it is still in the preliminary stage and more efforts should be allocated to developing a learning pattern analyser with a fully functional tracking mechanism

7.2 Future Implications

There are a number of areas to consider for future research as a result of this thesis. More systematic research should be undertaken in the application of KM. A KM system shows its advantages in an educational environment, but how to measure the KM system performance will lead to other intensive field of research. Further, the system prototype should be developed further to meet teaching and learning requirements. Optional system evaluation methods may discover more issues and raise suggestions on advanced system implementation.

Educational Knowledge Management Implications. This thesis only deployed the concept of KM in a rather narrow scope: teaching database normalisation. Its success on this particular scenario should lead to extended investigation on applying KM in other educational scenarios.

In the thesis, a survey method is used to make tacit knowledge explicit. Since this method needs rather a large number of survey participants to assure knowledge diversity, it is comparatively time consuming. Further research input is encouraged to identify better methodologies on making tacit knowledge explicit.

Knowledge Management Performance Implications. This thesis so far has not addressed any measurement issues on KM performance. Thus, allocation of KM performance indicators along the entire knowledge life cycle could be taken as another research direction. This would mean that questions such as how effective students learn can be answered.

System Design Implications. As more expectations are expressed on a fully functioned knowledge base, further research such as developing an ontological base to provide a shared language, or meta-knowledge base (knowledge about the knowledge) to support organisational memory might bring out more benefits for knowledge sharing and knowledge acquisition. Furthermore, more research efforts should be placed on developing a more reliable and more analytical pattern analysis profiler.

System Evaluation Implications. The initial prototype evaluation results indicate that the prototype affects teaching and learning database normalisation in a positive manner. However, it is only a study with very basic pilot KM modules and the number of survey participants is comparatively a rather small group. Hence, more study is recommended in this perspective. This research should occur over a longer period of time so that the system can be enhanced with more features.

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Appendix I

Survey Participation Invitation

Dear all:

In the tertiary educational environment, learning is still closely attached to teaching, that is, what teachers teach will, to some extent, guide the students on how to learn effectively.

This survey is intended to give immediate, qualitative feedback on how the academic staff, who teach database design in the Department of Information System, Massey University, apply different teaching methods to guide and assist student learning. The summary of this study based on the data provided by survey respondents will be published / distributed at the end of this year.

Further, the results of this survey will be used in my master thesis as one source of knowledge input in the knowledge repository. On top of this knowledge base, a knowledge management system will be implemented for better knowledge sharing and reuse.

Your responses will be strictly confidential. Only summary data from all survey participants will be included in the final thesis.

Please return the completed questionnaire in the envelope provided to the pigeonhole for postgraduate students in the main office on or before 18 December 2003. If you have any questions about this study, you can contact the person(s) below:

Lei Zhang
Dept. of Information Systems
Massey University
L.L.Zhang@massey.ac.nz

Thank you very much for taking the time to provide me with this important information.

Sincerely Yours,

Lei Zhang
Master Student
Department of Information Systems
Massey University

Appendix II

Survey Milestones

Project Start: Mon 1/12/03
Project Finish: Fri 13/02/04

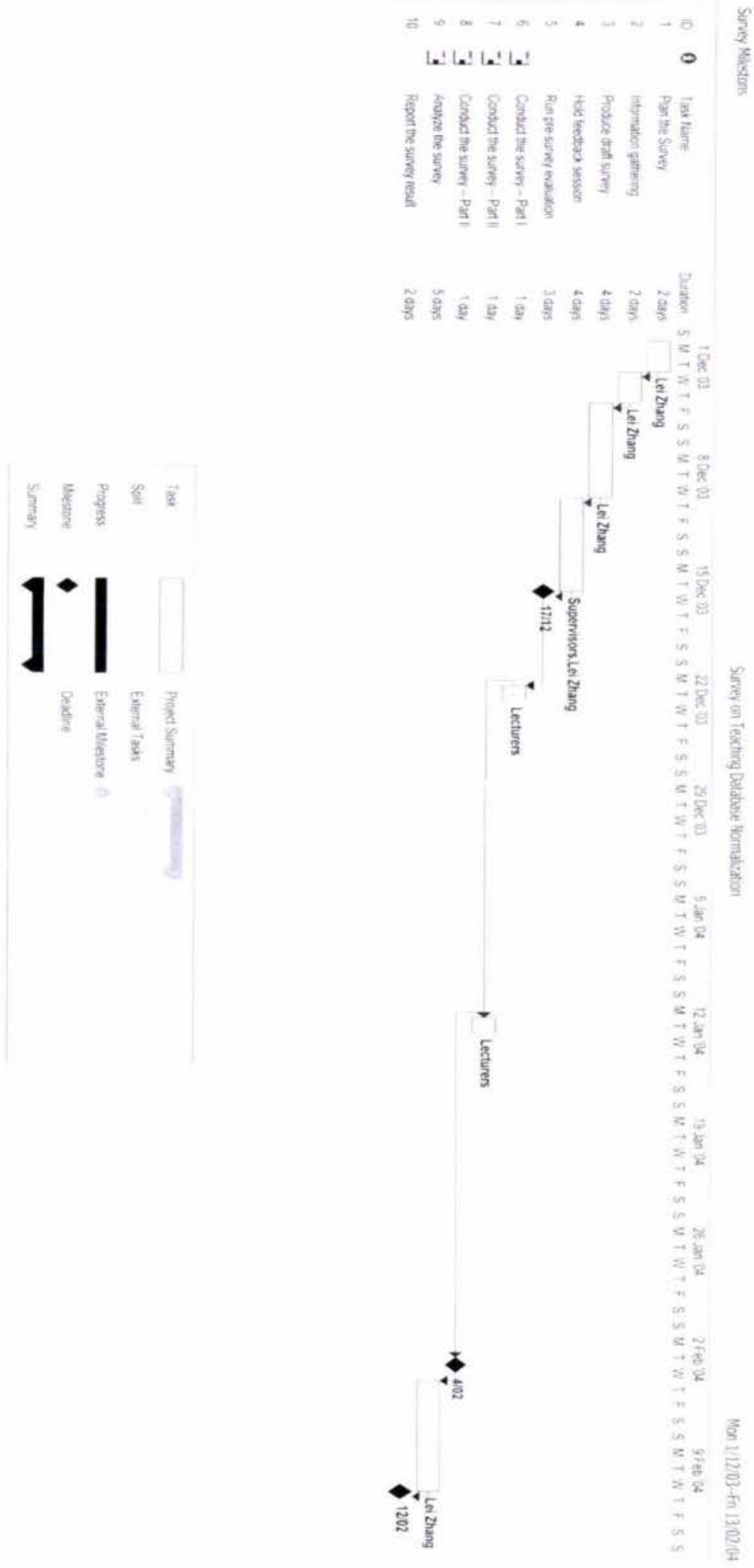
Tasks

ID	Task Name	Duration	Start	Finish	Resource Names
1	Plan the Survey	2 days	Mon 1/12/03	Tue 2/12/03	Lei Zhang
2	Information gathering	2 days	Wed 3/12/03	Thu 4/12/03	Lei Zhang
3	Produce draft survey	4 days	Fri 5/12/03	Wed 10/12/03	Lei Zhang
4	Hold feedback session	4 days	Thu 11/12/03	Tue 16/12/03	Supervisors,Lei Zhang
5	Run pre-survey evaluation	3 days	Wed 17/12/03	Fri 19/12/03	Lecturers,Lei Zhang
6	Conduct the survey -- Part I	1 day	Tue 23/12/03	Tue 23/12/03	Lecturers
7	Conduct the survey -- Part II	1 day	Tue 13/01/04	Tue 13/01/04	Lecturers
8	Conduct the survey -- Part II	1 day	Wed 4/02/04	Wed 4/02/04	Lecturers
9	Analyze the survey	5 days	Thu 5/02/04	Wed 11/02/04	Lei Zhang
10	Report the survey result	2 days	Thu 12/02/04	Fri 13/02/04	Lei Zhang

Resources

ID	Name	Group	Max Units	Peak Units
1	Lei Zhang	Student	100%	100%
2	Bhavani Sridharan	Lecturer	100%	0%
3	Alexei Tretiakov	Lecturer	100%	0%
4	Lecturers	Participants	100%	100%

Survey Milestones
The Gantt Chart View



Appendix III

QUESTIONNAIRE

Survey on Teaching Database Normalization

Department of Information System
Massey University

Completing the Questionnaire

Please answer the questions in the order given. Mark the choice which corresponds to your answer. For each question choose only one answer unless otherwise instructed.

Please answer all the questions, doing so as precisely as possible. If no answer fits, please choose the answer which comes closest to your views.

Unless otherwise specified, in this questionnaire the word teaching covers the following activities:

- **Preparing, originating, or giving courses;**
- **Updating course material;**
- **Preparing educational material such as learning modules, computer software packages;**
- **Assessing / grading student learning;**
- **Advising students;**
- **Supervising student during research, practical work or other work.**

Your responses will be strictly confidential. Only summary data from all survey participants will be included in the final thesis.

Section A

This section includes general questions about you.

1. Please specify the level(s) of course(s) you teach, in which database normalisation theory is part of the teaching task. (Choose more than one if appropriate).
   - ☐ PhD level
   - ☐ Master level
   - ☐ 300 level
   - ☐ 200 level
   - ☐ 100 level
2. How many hours, on average, do you ASSIGN to teaching activities related with database normalisation theory during the database design course (i.e. teaching material preparation, delivery, curricula enrichment, projects, research, etc)? Please fill in:

Section B

This section includes questions about your views on teaching.

To what extent do you agree with each of the following statement regarding effective teaching? Circle the response which best reflects your level of agreement.

5 = strongly agree, 4 = somewhat agree, 3 = not sure,
2 = somewhat disagree, 1 = strongly disagree

3. Enabling students to acquire basic knowledge	5	4	3	2	1
4. Passing on lecturer's experiences to students	5	4	3	2	1
5. Challenging students with ideas, so that they may develop themselves	5	4	3	2	1
6. Encouraging students to ask questions	5	4	3	2	1
7. Producing an independent learner who can carry on learning after leaving the university	5	4	3	2	1
8. Providing up to date resource material for students	5	4	3	2	1
9. Providing interesting resource material for students	5	4	3	2	1

Section C

This section includes questions related with teaching methods and content on database normalisation.

Present your opinion on the following statements regarding database normalisation.

5 = strongly agree, 4 = somewhat agree, 3 = not sure,
2 = somewhat disagree, 1 = strongly disagree

10. Is it important to teach normalisation theory as part of the database design theory?	5	4	3	2	1
Is it possible to obtain a sound database schema without an in-depth understanding of normalisation theory?	5	4	3	2	1

11. While teaching database normalisation theory, which teaching method(s) would you like to utilize? (Please select the most appropriate choice only).
    - ☐ Lecture-centred teaching
    - ☐ Seminar style teaching
    - ☐ Case-based teaching

☐ Problem-based teaching
☐ Collaborative/cooperative teaching
☐ Project-based teaching
☐ Others, please specify ______________________________

12. What are your expected teaching objectives at each level? (Put circles around as many levels as appropriate).

Teaching Objectives	Course levels				
Memorize the concepts / definitions	PhD level	Master level	300 level	200 level	100 level
Understand the theory	PhD level	Master level	300 level	200 level	100 level
Master the theory	PhD level	Master level	300 level	200 level	100 level
Apply the theory in real life practice	PhD level	Master level	300 level	200 level	100 level
Conduct independent research	PhD level	Master level	300 level	200 level	100 level

13. What is the best approach to design a normalized database schema?
☐ Apply algorithms and follow the normalisation procedure step by stepAttempt to come up with a normalized schema Both approaches are legitimately dependent on the situation
☐ Others, please specify ______________________________

14. What knowledge should be delivered first to the students before learning database normalisation? (Choose more than one if appropriate).
☐ Prerequisite mathematical knowledge
☐ Database design process, such as conceptual database design and logical database design, etc
☐ Entities, relations, cardinality, and entity-relationship model
☐ Redundancy, anomalies, functional dependency and multi-value dependency
☐ More, please specify ______________________________

15. What should be emphasized first to achieve thorough understanding of the concepts of Functional Dependencies? (Choose more than one if appropriate).
☐ Intuitive understanding of the structure of database tables
☐ Quality aspects of relational schema: redundancy, anomalies, etc
☐ Mathematical rigor
☐ Concepts of soundness, completeness, faithfulness, etc
☐ More, please specify ______________________________

16. Do normalisation algorithms play an important role in normalisation theory?
☐ Extremely important
☐ Important, not critical to grasp
☐ Not important at all
☐ Can be omitted
☐ Not sure

17. Up to which level of normal forms do you think it is sufficient for students to master?
☐ Second normal form
☐ Third normal form
☐ Boyce/Codd normal form
☐ Fourth normal form
☐ Fifth normal form

18. Based on your teaching experience, what knowledge should be taught regarding the normalisation theory?

19. Normalization theory also has its own limitations; please briefly describe the content that you would like students to know.

20. What knowledge on normalisation theory should be delivered so that students can determine when to apply normalisation principles and when not to apply them?

Section D

This section includes questions related with the use of technology in teaching.

21. In what aspects can Information Technology (such as WebCT) help your students to learn the course content? (Choose more than one if appropriate).
    - ☐ Flexibility for distance learning
    - ☐ Enhance learning via the use of multimedia, such as sounds, graphics, animation etc.
    - ☐ Provide instant feedback to teachers and learners
    - ☐ Knowledge can be constantly updated
    - ☐ More, please specify ______________________________

22. The following refer to electronic tools that assist in the delivery of course content and in course management. Circle the appropriate numbers.

3 = yes, 2 = not sure, 1 = no

Activities	Currently use IT in my teaching			Is it working effectively?			Would like to use IT to enhance in future		
Delivery of Course Content									
On line lectures / tutorials	3	2	1	3	2	1	3	2	1
On line reading materials	3	2	1	3	2	1	3	2	1
On line lab assignments	3	2	1	3	2	1	3	2	1
Tools to supporting teaching & learning	3	2	1	3	2	1	3	2	1
Simulation / interactive learning	3	2	1	3	2	1	3	2	1
Course Management									
Measure of student participation	3	2	1	3	2	1	3	2	1
Measure of the level of comprehension of the materials	3	2	1	3	2	1	3	2	1

23. Please write any comments or suggestion you may have. Use overleaf or add page(s) if necessary.

Appendix IV

The System Prototype: Quick Start Tutorial

This User Guide is designed to be very easy to use and to get you up and running as quickly as possible. For people who want to dive right into using the prototype, the following Quick Start Tutorial is created.

Current Features

1. **Access to the home page** using the URL that was given to you. No user name and password are required at this stage.

2. **The main home page** consists four panels: Normalization Tasks panels, Concepts Display panel which is subdivided into two further panels and Knowledge Search panel.

3. **Normalization Tasks Panel**
   7 main normalisation related concepts are defined. Under each major task, there are some further sub-knowledge areas. To view the corresponding knowledge you are looking for, simply click the corresponding link. The related information will be displayed in the Display panel. Note that the upper display panel deals with the definition and the lower display illustrates the concepts by using examples.

4. **Knowledge Search Panel**
   Enter your query in the text field and then click Submit. The result will show up in the upper Display panel.

5. **Ask Expert**
   If the suitable answer to your queries is not provided, then you can go to the Ask Expert page and directly exchange knowledge with the available experts.

5. **Learning Pattern Analysis**
   The target user for this link is the teaching staff. The main function is to analyse student learning patterns by recording and analysing students' click streams.

Appendix V

QUESTIONNAIRE

KM System Prototype

Testing Survey

Department of Information System
Massey University

Completing the Questionnaire

Please answer the questions in the order given. Mark the choice which corresponds to your answer. For each question choose only one answer unless otherwise instructed.

Please answer all the questions, doing so as precisely as possible. If no answer fits, please choose the answer which comes closest to your views.

Unless otherwise specified, in this questionnaire the word teaching covers the following activities:

- **Preparing, originating, or giving courses;**
- **Updating course material;**
- **Preparing educational material such as learning modules, computer software packages;**
- **Assessing / grading student learning;**
- **Advising students;**
- **Supervising student during research, practical work or other work.**

Your responses will be strictly confidential. Only summary data from all survey participants will be included in the final thesis.

Section A

General information on the course level(s).

1. Please specify the level(s) of course(s) you currently teach, in which database normalisation is part of the teaching task. (Choose more than one if appropriate).
   - ☐ Master level
   - ☐ 300 level
   - ☐ 200 level
   - ☐ 100 level

Section B

System Prototype: best achieved

To what extent do you agree with each of the following statement regarding the overall quality after using the prototype? Circle the response which best reflects your level of agreement.

3 = achieved, 2 = partly achieved, 1 = not at all achieved

2. Better problem understanding	3	2	1
3. New ways of working with problems	3	2	1
4. Has a wide range of knowledge on normalisation	3	2	1
5. Allows opportunities for asking questions	3	2	1
6. Responses faster to the key study issues	3	2	1
7. Has an effective knowledge delivery to students	3	2	1
8. Encourages teaching resources sharing and reuse	3	2	1
9. Provides learning pattern analysis for better teaching curricula customization	3	2	1
10. Improves students/teachers' relationship	3	2	1
11. Improves student's ability on self-solving the problems	3	2	1
12. Is approachable, friendly and respectful to students	3	2	1

Section C

System Prototype: failed to realise.

Present your opinion on the following statements regarding what fails to achieve by using the prototype.

3 = strongly agree, 2 = agree, 1 = disagree

13. Lack of sufficient knowledge in the knowledge base	3	2	1
14. Lack of user uptake due to the insufficient communication	3	2	1
15. Lack of sufficient output from pattern analysis	3	2	1
16. Lack time to learn / system too complicated	3	2	1
17. Users could not see personal benefits	3	2	1
18. Unsuccessful due to the technical problems	3	2	1
19. Not enough student / teachers know about it	3	2	1
20. Not enough support of KM System from teachers and students	3	2	1

Section D

System Prototype: to be implemented.

Present your opinion on the following statements regarding what should be implemented next by using the prototype.

3 = done, 2 = next 3 month, 1 = later

21. More knowledge input in the knowledge base	3	2	1
22. Better pattern analysis design	3	2	1
23. Full functioned search engine	3	2	1
24. Build and develop common practise	3	2	1
25. Discussion forum / BBS	3	2	1
26. Up-to-date news on database normalisation	3	2	1
27. External search engine links	3	2	1
28. Training process	3	2	1
29. Help files	3	2	1

30. Please write any comments or suggestion you may have. Use overleaf or add page(s) if necessary.

____

____

Appendix V

Sample Coding – Knowledge Sharing

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>
<head>
<title>Knowledge Sharing</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<SCRIPT LANGUAGE="JavaScript">
<!-- Begin
extArray = new Array(".doc", ".pdf",".gif", ".jpg", ".png");
function LimitAttach(form, file) {
allowSubmit = false;
if (!file) return;
while (file.indexOf("\\") != -1)
file = file.slice(file.indexOf("\\") + 1);
ext = file.slice(file.indexOf(".")).toLowerCase();
for (var i = 0; i < extArray.length; i++) {
if (extArray[i] == ext) { allowSubmit = true; break; }
}
if (allowSubmit) form.submit();
else
alert("Please only upload files that end in types:  "
+ (extArray.join("  ")) + "\nPlease select a new "
+ "file to upload and submit again.");
}
// End -->
</script>
</head>

<body>
<center>
 Please upload Database Normalization related resources below:<br>
 (format at:.doc, .pdf, .jpg, .)that end in:
<script>
document.write(extArray.join("  "));
</script>
<p>

<form method=post name=upform action="mailto:l.l.zhang@massey.ac.nz"
enctype="multipart/form-data">
        <table width = "434">
         <tr>
                <td><div align="center">
       <input size= "40"type=file name=uploadfile>
     </div></td>
         </tr>
        </table>
<p></p>

<!--Use tables to line stuff up nice-->
```

```html
<!--Radio Buttons-->
  <table width="434">
   <tr>
    <td width="119" height="108" valign="middle">
     <p align="center"><font color="Black"> <b>Knowledge Sharing <br>
      Tasks</b></font></p>
     </td>
  <td width="167">
        <fieldset>
        <legend align= "top"> Category </legend>
   <font color="black">
    <input type="radio" name="topic" value="BasicConcepts">
     Basic Concepts<br>
    <input type="radio" name="topic" value="Dependencies">
     Dependencies<br>
    <input type="radio" name="topic" value="NormalForms">
     Normal Forms<br>
               <input type="radio" name="topic" value="Comparisons">
     Comparisons<br>
              <input type="radio" name="topic" value="OtherResources">
     Other Resources</font>
               </fieldset>
               </td>
          <td width="132">
              <fieldset>
              <legend align= "top"> Level </legend>
     <input type="checkbox" name="Beginners">
     Beginners<br>
    <input type="checkbox" name="Intermediate">
     Intermediate<br>
    <input type="checkbox" name="Advanced">
     Advanced
               </fieldset>
               </td>
 </tr>
</table>
<p></p>
  <b>Comments</b><br>
<textarea name="question" rows="5" cols="70"></textarea>
<br><br>

<!-- Hidden field, good for passing descrete values (maintain state) -->
<input type="hidden" name="Snap" value="Admin">

<!-- Submit and Reset buttons are needed in most all forms -->

<input type=button name="Submit" value="Submit" onclick="LimitAttach(this.form,
this.form.uploadfile.value)">

<input type="reset" value="Reset">

</form>
</center>
</body>
</html>
```