A Design Experiment on Students' Perceptions of a Knowledge Management System

By

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A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Applied Science
in
Management Sciences

Waterloo, Ontario, Canada, 2002

AUTHOR'S DECLARATION FOR ELECTRONIC SUBMISSION OF A THESIS

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Although there is a large body of literature exploring the topic of knowledge management, most of the focus is on its application to industry. Seldom has a research priority been placed on the use of knowledge management in a university setting. This research investigated the impact of applying a knowledge management system- Knowledge Net - to the students in a course about designing learning activities with interactive multimedia at the University of Waterloo. A design experiment method was employed. Eight students were engaged in the study. The purpose of the design experiment was to investigate the students' response towards Knowledge Net, their ability to absorb and apply the knowledge gained from Knowledge Net, and the incentives that encouraged them to share and retrieve knowledge from the system. The findings will be helpful for the people who want to practice knowledge management in a university setting.

The study results revealed that initially students had a positive attitude towards the potential value of the information in Knowledge Net. However, at the end of their design experiment, they reported a low expectation that students could learn from and apply the information in Knowledge Net. The reasons varied. It may be that they failed to truly understand the knowledge or to trust the source of information. Many students habitually prefer face-to-face contact with their counterparts to computers. As a result, the study suggested a few ways to improve the absorption of knowledge and to enhance the behavior of knowledge sharing. These new directions include: arranging personal meetings between the providers and recipients of knowledge, playing videos of other students sharing knowledge on Knowledge Net, increasing the level of encouragement and guidance from the instructor on use of the system, and applying situated learning and case studies. In addition, grading students on their use of Knowledge Net may be a useful incentive to help students make more effective use of Knowledge Net.

ACKNOWLEDGEMENTS

First of all, I would like to express my sincerest thanks to my supervisor, Professor Tom Carey and the support from the Centre of Learning and Teaching through Technology (LT3) at the University of Waterloo. Through frequent meetings with Professor Tom Carey, I have developed skills of how to independently conduct research and how to view things differently from a variety of angles. The staff at the LT3 have rendered me hearty support. I would especially like to thank Tracy Penny Light for her cooperation for conducting the design experiment in her course – the IS303a. And my thanks go to all the students participating in my design experiment. Without their support, my thesis would not be accomplished. Moreover, I owed much to Professor Liwana Bringleson and Professor Kevin Harrigon for their careful reading of my thesis. Their comments have helped me to realize some deficiencies of my thesis and to make it a more readable one.

In addition, I would like to thank all the professors, staff and the students at the department of Management Sciences at the University of Waterloo. I had a very enjoyable time working with all the people in the department.

Furthermore, my gratitude goes to all my friends, including Nuke Shim's couple, the friends from the campus bible study group and the Grandview Baptist Church. Their prayers and true friendship have greatly encouraged me in my hard times. In addition, I especially want to thank my friends, Instructor Zhou and Greg Larsen for taking time to carefully read through my thesis and try to correct every little mistake.

Last but not the least, I would like to thank my husband Steve for his love and care all the time. He has taken care of most of the housework in the period towards the completion of my thesis. I would like to thank my parents, my parents-in-law and my brother's family. The thesis is dedicated to my whole family, which continues to provide me enormous love and encouragement at the highs and the lows in my life.

To My Parents – Liang Youji and Peng Nianhe

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Chapter 1 Introduction

In this chapter, we introduce the subject matter and the goals of the thesis. The first two sections look at the importance of knowledge in contemporary organizations and at why knowledge management is an organizational competency. Section three describes the background of knowledge transfer within organizations. The knowledge itself consists of the types of knowledge, the forms of transfer, the transfer process and the incentives for knowledge sharing. Section four presents the context, focus, and significance of our study. In addition, it also points out the organization of the thesis.

1.1 The Importance of Knowledge in Contemporary Organizations

In the new economy era, competitors emerge and expand quickly. New products are launched frequently. New technologies develop quickly. Under such circumstances, the possession of capital or natural resources is no longer the decisive element driving economy forward. Instead, knowledge plays a more important role and has become an essential resource (Drucker, 1998; Wijetunge, 2002). The organizations, which can consistently produce and circulate knowledge within their workforce, have a much better chance to survive than those, which do not (Nonaka, 1998). In addition to academics, many people in industry have noticed this irreversible trend. Arie de Geus, head of planning for Shell Canada argues that the ability to learn faster than the competitors is the only sustainable advantage in corporate competition (Garvin, 2002). The capability for learning relies mainly on how well the organization uses the existing insights or knowledge to produce new insights or knowledge (Garvin 1998; Ahmed et al, 2002).

According to Davenport and Prusak (1998), knowledge is a mix of framed experience, values, and information that can facilitate evaluating and incorporating new experiences and information. Material assets such as capital and natural resources decrease as used. In contrast, knowledge assets increase with use (Davenport & Prusak, 1998). In addition, knowledge is hard to imitate, hard to substitute, and can be transferred within an organization (Ahmed et al, 2002). Therefore, it can provide a sustainable advantage and

its management can be a core competence for corporations (Davenport & Prusak, 1998;Brooking, 1999; Nonaka, 1998; Skyrme 1997; Wijetunge, 2002).

1.2 Knowledge Management as an Organizational Competency

The mere existence of knowledge somewhere in an organization is of little benefit. It may exist in some documents or in the heads of some people. However, unless someone seeks out the documents or the owners of the knowledge particularly articulate in regards to it, the knowledge is not exposed, nor is it shared by others. Therefore, the value of the knowledge cannot be leveraged. In addition, when documents disappear or a person leaves the company, the knowledge will vanish. As a result, the awareness of this knowledge is invaluable - systematically documenting and managing it in organizations is essential to the effective application of this knowledge.

Knowledge management is the systematic management of vital knowledge and its associated processes of creating, gathering, organizing, diffusion, use, and exploitation (Skyrme, 1997). It helps organizations to create, store, share, and disseminate knowledge effectively (Rowley, 2001). It aims at raising the level of individual knowledge to the organizational level by capturing and sharing individual knowledge and turning it into organizational knowledge (Rus & Lindvall, 2002).

Numerous experiences have proven that knowledge management is effective in many situations. It has been proven to save costs and to increase productivity and revenues in many companies. For example, Buckman Laboratories' knowledge management systems helped push new product-related revenues up 10 percent points and sales of new products up about 50 percent. Texas Instruments generated $1.5 billion in annual increased fabrication capacity by using knowledge management systems (O'Dell & Grayson, 1998). Firms such as Dow Chemical and Skandia and consultants such as McKinsey, Ernst&Young, and IBM Consulting have appointed "chief knowledge officers" and "directors of intellectual capital" to oversee the knowledge resources of their firms (Davenport & Prusak, 1998). Knowledge management implementation and use has

rapidly increased since the 1990s: 80% of the largest global corporations now have knowledge management projects (Rus & Lindvall, 2002).

1.3 How Knowledge is Transferred within Organizations

Knowledge management involves a knowledge evolution cycle. The knowledge evolution cycle includes five phases. They are originating /creating knowledge, capturing/organizing knowledge, transforming/organizing knowledge, deploying/ accessing knowledge and applying knowledge (Rus & Lindvall, 2002) as in Figure 1.1.

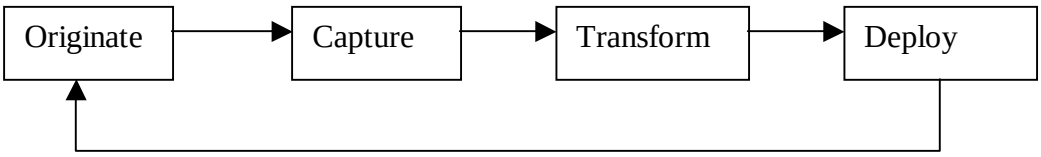


Figure 1.1 Knowledge Evolution Cycle

We group the latter three into the category of knowledge transfer. Knowledge transfer is a very important part of knowledge management. Apart from the companies that have successfully launched knowledge management products, there are also many suffering from the failure of it. One major reason derives from ineffective knowledge transfer. That is why it is the focus of our study.

Under some circumstances, people do not like to share knowledge or to retrieve knowledge, considering it a waste of time. Furthermore, people have been overwhelmed by a large amount of knowledge and were unable to identify the useful pieces. Under other circumstances, although some people have access to the right knowledge, they may not be able to understand it. Despite the large amount of money and efforts invested in knowledge management projects, knowledge in many organizations still cannot be effectively transferred from individual to individual and thus it cannot become an organization-wide asset.

What are the main things affecting knowledge transfer? How can these companies improve in their efforts? To answer these questions, we must first realize, as is shown in Figure 1.2, that knowledge management is a process of capturing the right knowledge, codifying it in appropriate forms, and delivering it to the right people (O'Dell & Grayson, 1998). Only after the right people find the right knowledge, absorb it, and use it can we say that knowledge transfer has been completed. The above process can be visualized from the following figure.

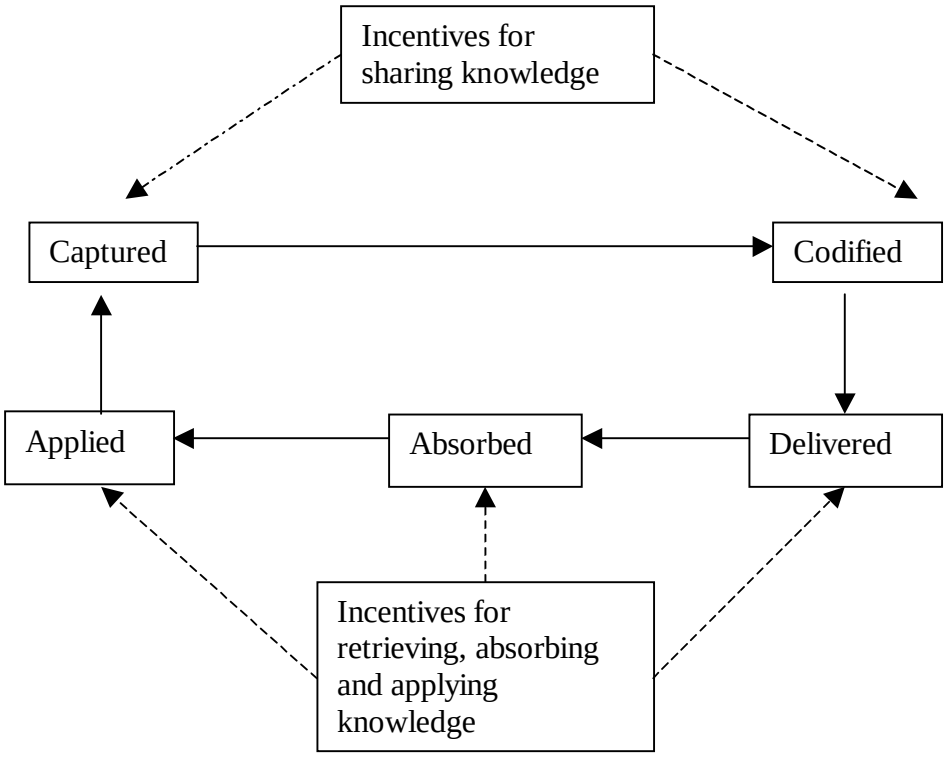


Figure 1.2 Knowledge Transfer Process

In summary, the nature of knowledge, its format, its availability to the right people at the right time, its absorption, and its application are strongly connected through the knowledge transfer process. Lack of any of the above steps may lead to knowledge management failure. In addition, the attitudes of people towards knowledge sharing and knowledge retrieval also play an important role. Many documents attribute these incentives to a knowledge sharing culture. In this section, why and how the above factors

play important roles in knowledge transfer is discussed. This discussion forms the background and basis for our research.

1.3.1 Categories of Knowledge

The types of knowledge make a difference in regards to which methods best support transfer (Dixon, 2000). To explore the effectiveness of knowledge transfer, it helps to distinguish between different kinds of knowledge. Different people categorize knowledge into different types.

Nonaka(1998) divides knowledge into ***explicit knowledge*** and ***tacit knowledge***. Explicit knowledge is also known as formal and codified knowledge. Tacit knowledge is also known as informal and uncodified knowledge. Explicit knowledge can be expressed in formal language and then transmitted between individuals formally and easily. Examples include product specifications and scientific formula. Tacit knowledge is highly personal. It is hard to formalize and difficult to communicate to others (Nonaka, 1998). Polany (1966) points out that the only way to learn tacit knowledge is through apprenticeship and experience.

Other than explicit and tacit knowledge, some software engineering experts divide knowledge into the categories of ***product knowledge*** and ***process knowledge***. Product knowledge is about the features and attributes of products. It directly influences the design of features and attributes. For example, product knowledge indicates why a certain design is performed and what has been taken into considerations as features of the product. Process knowledge is any knowledge about the activities, steps, and procedures used to accomplish the design goals (Ramesh, 2002). It directly influences how one carries out work and therefore only indirectly affects the features and the attributes of products. For example, process knowledge includes how to come up with some design ideas and how to communicate more effectively with team members. Some people have also called product knowledge ***"know-what"*** and process knowledge ***"know-how"*** (Dixon, 2000).

The two categories of knowledge are interrelated into each other. Product knowledge mostly contains explicit knowledge. Process knowledge normally contains both tacit and explicit knowledge.

Since the types of knowledge are significantly different, their forms of transfer are different too. Explicit knowledge is more readily expressed by language. Therefore, it is mostly documented and put in documents or databases. Tacit knowledge requires a transfer of more personal contacts such as observation, experiential study, or discussion (Rus & Lindvall, 2002).

1.3.2 Transmission + Absorption + Use = Transfer

Knowledge transfer consists of transmission, absorption and use. Lack of any of the above components will result in ineffective transfer (Davenport & Prusak, 1998).

Transmission means that the right information is delivered to the right users at the right time. Under different circumstances, different methods are used to achieve this goal. Some knowledge management teams use the "push" method to send relevant information directly to users. For example, the Best Practice Replication team in the Vehicle Operation Division in Ford sends five or eight best practices to the production engineers in each plant each week. In this way, it saves the production engineers the effort of searching the computer database to find the right practices. Other knowledge management teams use the "pull" method, which requires users to search for the information. For example, Ernst & Young developed PowerPacks, which collected documents bundled by topic, such as mergers, utilities, information technology, and banking. A consultant can search PowerPacks to download the necessary document to facilitate his work (Dixon, 2000).

Once information is presented and delivered to the right users, it must be absorbed and understood before it can be applied. The absorption of information depends on two

factors. One is the information. Is the information clearly stated in an appropriate form that can be easily understood by people? The other is the people dimension. People's absorptive ability is strongly related to whether they can understand the information. Prerequisite knowledge and skills are needed for understanding certain content. Do people have this knowledge and these skills? Research evidence shows that a lack of absorptive capability in the receiving team is a significant barrier to knowledge transfer (Szulanski, 1994).

However, does one apply the knowledge once one absorbs it? According to findings by Peffer and Sutton (1999), application of the knowledge may not necessarily occur. For example, at Mobil Oil, some engineers at one drilling operation developed some applicable techniques of determining how much steam is required to drill under various conditions. They embedded the techniques in a system and sent a memo to other Mobil drilling operations describing the techniques and their benefits. However, the techniques were neither adopted nor applied in other operations (Davenport & Prusak, 1998). The example showed that there are many barriers to applying knowledge. Such barriers include: lack of respect or trust for the source of the knowledge, pride, stubbornness, lack of time, lack of opportunities, and a fear of trying new things (Davenport & Prusak, 1998). However, knowledge application is a very key part of knowledge transfer. According to Davenport & Prusak (1998), knowledge delivery and absorption has no use if the new knowledge does not lead to some change in behaviour.

1.3.3 Incentives for Knowledge Sharing

Incentives are important for knowledge transfer. If people do not like to share knowledge or to apply knowledge from others, a knowledge evolution cycle cannot form in the organization. This means that the company cannot reach its goal of leveraging internal knowledge. Different organizations carry out different incentive systems for sharing knowledge. Some companies, such as Infosys (Ramasubramanian & Jagadeesan, 2002), use financial motivators. Some embed knowledge-sharing in their promotion plan. For example, Price Waterhouse has included knowledge sharing in its performance appraisal

system. Consultants must be able to produce "evidence" of actual sharing such as tutoring or training, development of methodology, and coaching for promotions (O'Dell & Grayson, 1998). However, which is the best motivator for knowledge sharing is not well understood. It depends on the context of knowledge-sharing and on the people involved.

In summary, the nature of information, its forms of presentation, its transmission, its absorption, and its application, in addition to incentives for knowledge-sharing, are important components of effective knowledge transfer. Each supports the others in the knowledge transfer process. Lack of any one will lead to the failure of knowledge transfer.

1.4 Our Study: A Knowledge Management Experience for Undergraduate Students

Although there are many studies about knowledge management, most of them focus on the industrial sector. Few of them draw attention to academic fields (Corrall, 1998). Although universities are considered to be the source of new knowledge and the knowledge generators (Agrawal, 2001; Wijetunge, 2002), ironically, there seems to be little concern about how to manage and distribute knowledge among different generations of students in universities. Instead, most literature about knowledge management in universities focuses on how to transfer knowledge from university to industry. Issues such as patents and commercializing products are currently hot topics. Therefore, we strongly feel that both investigating how knowledge can be passed among different generations of students and understanding the students' attitudes towards knowledge management are very significant. The investigation can benefit both the instructors and the students. It also helps to develop more expertise in knowledge management in universities. In this section, we are going to explain what our research questions are, why they are significant, and the actual organization of our study.

1.4.1 Context of Our Study: Knowledge Transfer across Successive Student Cohorts

Regardless of how little research has been directed to the students in knowledge management research, there is a significant amount of knowledge generated within and transferred among students. For example, a variety of courses are offered on campus each semester. Many students register in the same courses each year or each semester. From the start until the end of a course, they must have travelled on a learning curve and accumulated a significant amount of useful knowledge, including knowledge from the course domain (both know-what and know-how) and other know-how knowledge from outside the course subject, such as tips for learning and shortcuts for assignments. Some tips may be passed on to the next generation of student through informal contact such as conversation or unofficial channels such as course files. However, most of the knowledge is lost as time goes by due to the lack of systematic management. In addition, there is no place for new students to access the lessons learned or other useful knowledge from their predecessors. Therefore, new students in a course always have to start almost "from scratch" without knowing most of the valuable knowledge gained by their predecessors. As a result, the progress of new students is slowed down for the learning curve cannot be passed from previous students.

On the opposite side, if new students had access to previous students' knowledge, they could possibly build up their own knowledge on top of this previous knowledge and thus perform better than their predecessors. In addition to the enhancement of individual learning, effective organizational learning may also be obtained. That is, different generations of students in the same course may be viewed as a learning organization, which facilitates creating, acquiring, and transferring knowledge among them. As a result, later generations of students should out-perform the earlier ones. In addition, the students who have used the knowledge management systems at school can sooner and better adjust to the knowledge-sharing environment at companies that implement knowledge management.

Some people may challenge the ideas that students may want to learn how to learn through their own efforts, not through referencing previous students' works. However, we think that the ability to learn quickly from others' experiences is an important attribute of the learning process.

1.4.2 Focus of Our Study: "Lessons Learned" in a Multimedia Design Course

Our study will focus on the application of knowledge management in universities. It investigates how knowledge from previous students can be passed on to future students.

We conducted our study on the IS303a course - *Designing Learning Activities With Interactive Multimedia* at the University of Waterloo. It is a project-based course, in which both product knowledge and process knowledge are generated. Our study focuses on making explicit the knowledge, which can be articulated and documented, for future student cohorts. We interviewed past students from IS303a, recorded their valuable experience and lessons learned from their projects and presented it in the form of their comments in Knowledge Net, a web-based system for information retrieval. The comments include both product knowledge and process knowledge.

A good way to know whether this information from previous students can be transferred to a new cohort of students is to design a prototype knowledge management system and to test it. Our test was performed on the students of IS303a course in the Winter 2002 cohort.

Our research concentrates on knowledge transfer and the motivations for the students to share knowledge. The process of knowledge transfer consists of transmission, absorption, and application. Transmission determines whether the students can find the right information they need. Absorption ensures that the students understand the information. Application means that the students can use the information. However, even though the students can find, understand, and use the information, they must also be willing to do so.

Therefore, motivation for knowledge sharing behaviour is key. Our research questions are summarized as follows:

Given that the knowledge to be transferred is process and product knowledge about projects from past students in the IS303a course and that it is presented by their comments in Knowledge Net,

1. Can the new students easily find the information they need?
2. Can they understand it?
3. Can they apply it?
4. What motivates them to access the information and apply it?

Both a questionnaire survey and a qualitative interview are conducted to measure the results. The questionnaire survey quantitatively records the students' attitudes towards Knowledge Net. The qualitative interview encouraged the students to share their lessons learned and provided them a chance to articulate their attitudes towards Knowledge Net and knowledge sharing and the associated reasons

1.4.3 Significance of Our Study: Its Implications for Academics, Practitioners, Students and Companies

Our research will add to the existing knowledge management literature new insights about how knowledge can be transferred effectively at universities and the motivations for students to access and apply knowledge. It will provide ideas for researchers and practitioners about what kind of knowledge management systems facilitate knowledge transfer at universities. A key point to remember is that knowledge management systems refer to not only the technology systems but also to the social systems.

For academics and practitioners, our work will aid them to develop a better understanding of whether the process and product knowledge embedded in comments from previous experience can be easily understood and applied. In addition, the design of Knowledge

Net will provide recommendations and future directions for implementing knowledge management experiences in an undergraduate program.

Our study may facilitate students to develop the habits of sharing knowledge and of using knowledge management systems in universities. According to Davenport (1998), the students who seek and apply knowledge in school will continue to do so at work. This behavior at work will be a great benefit for their companies.

Our study results will have great implications for implementation of knowledge management within companies. Even though a company and a university have totally different settings, from the perspective of sharing knowledge, they are similar. For example, the students who register in one course in one semester can be viewed as employees who rotate or change jobs every four months. Our study of how to pass the knowledge on from one student generation to the next is very similar to that of how to retain useful knowledge in those companies. Therefore, our study results will provide ideas of what works and what does not work in knowledge management implementation for companies, especially those with a high turn over rate.

1.4.4 Organization of Our Study

Our study is organized as follows:

Chapter 1 has introduced the subject matter and the goals of this work. First of all, we introduced the definition and significance of knowledge and knowledge management. Second, we presented the key process of knowledge transfer as the basis of our study. Third, we have illustrated briefly our research questions accompanied by the context and significance of our research.

Chapter 2 reviews some of the relevant literature on knowledge management in industry and university of particular help in shaping our work. We studied works of Ruggle (1998) and of O'Dell and Grayson (1998) about the most common knowledge transfer methods

in companies and the barriers for transfer and their possible solutions. Van Aalst's (2001) study on a knowledge management system and its effect for multimedia development provides significant suggestions for the design of Knowledge Net. Giordano's (1998) findings about how a shared design memory system affects students' individual and organizational learning shed light on our study. In addition, the difference between our study and their past works will also be highlighted: our research investigates knowledge transfer across student cohorts (as did Giordanos's), in the domain of multimedia design (as in Van Aalst) , with the intent of developing experience in the processes described by Ruggle (1998), O'Dell, and Grayson (1998).

Chapter 3 presents the research model. It first introduces the design experiment followed by the design of Knowledge Net, our experimental artifact. The design process for Knowledge Net consists of a user scenario-design, an initial design, a pre-test, and finally a revision of the design.

Chapter 4 presents the design experiment and the results from the questionnaire survey and the qualitative interview. Discussions follow. We also compare the results from the questionnaire survey and the qualitative interview.

Chapter 5 points out a possible future revision for Knowledge Net. We also report the limitations of our study and bring forward a future research agenda. In addition, we reflect on our design experiment and propose future revisions.

Chapter 2 Literature Review

In this Chapter, we will review key works about knowledge management applications in industry and university. Four works from Ruggles (1998), O'Dell and Grayson(1998), Van Aalst(2001), and Giordano (1998) are reviewed. Additional information from overall studies of knowledge management has been summarized in the previous chapter. Readers seeking a broader review of knowledge management will find the book, *Working Knowledge* by Davenport and Prusak(1998) particularly useful.

Ruggles (1998) examined the results of studies of 431 U.S. and European organizations conducted in 1997 by the Ernst & Young Center for Business Innovation. He described what the companies were doing to manage knowledge, what they thought they should do, and the lessons they learned. O'Dell and Grayson (1998) summarized issues for companies to transfer best practices and the biggest barriers in doing so. In addition, they proposed possible solutions. Performer (Van Aalst, 2001), a knowledge management system used to facilitate educational multimedia development, shed light on the design of Knowledge Net, which is in the same domain. Finally, Giordano's (1998) study of how a shared memory affected individual and organizational learning in a course in a university enlightened our study. It was the key building block on which our study was constructed.

2.1 The State of the Notion: Knowledge Management in Practice

Ruggles' (1998) study has pointed out the most common techniques of carrying out knowledge management by some companies and the lessons learned.

2.1.1 The Four Most Popular Knowledge Management Project Types

Intranet, data warehousing, decision support tools, and collaboration tools are all used for knowledge management. An intranet can be used to support the exchange of information within or outside of organizations. A data warehouse stores the explicit knowledge within organization and makes it available to employees. Decision support tools store best

practices in the organization, with expertise generalized into rules and guidelines to support the performance of employees. Collaboration tools help people to generate more ideas.

Interestingly, the above four mostly commonly used tools all concentrate on technology. However, can pure technology bring in the ideal result of knowledge management? The following are what the companies felt they "should do" in terms of knowledge management policy.

2.1.2 The Three "Should Do"s of Knowledge Management

After companies employed the above methods of knowledge management for some time, they realized that there were a few additional policy initiatives they should do to facilitate knowledge transfer within their organizations. The following is their list.

Mapping Sources of Internal Expertise

As previously mentioned, a data warehouse which can only store explicit knowledge is not able to transfer tacit knowledge, which is very important in business process. The only way to get tacit knowledge is to interact with knowledge owners by talking or observing.

As a result, the idea of a knowledge map emerged. It is a "Yellow Page" catalog of relevant people, grouped according to expertise, questions, and issues. It can point the knowledge seekers to the right knowledge owners. By interacting with each other, the knowledge seekers may be able to grasp some of the tacit knowledge embedded in the minds of knowledge owners, which cannot easily be codified.

Creating Networks of Knowledge Workers

Knowledge maps and other searching-means used to identify knowledge experts are suitable for people for finding expertise when they need to. However, the Institute for Research on Learning says the informal, socially constructed communities of practice within an organization work as the true mechanism through which people learn and through which work gets done (Wenger, 1998). For example, Chrysler has built Tech Club to bring expertise together to exchange and build collective knowledge in many specialty areas.

Establishing New Knowledge Roles

Many companies feel that there is a need for a Chief Knowledge Officer (CKO) i n their organizations. The CKOs can leverage knowledge, enable it (training/technology), and make it visible (identifying gaps/establishing priorities).

In summary**,** the four most commonly used tools of knowledge management focus on technology. But the three policy initiatives concentrate on people. Generally speaking, what most companies initially did was to implement some technological projects. However, after trials and errors, they felt that in addition to technology, humans play more important roles in enabling knowledge transfer. Indeed, knowledge sharing, in its nature is much more about the interrelationship of content, context, and the people who put the pieces together. As a result, these companies turned their focus to linking the people who need knowledge with the people who have it, encouraging people to network with each other and to consciously leverage knowledge in their organizations.

2.1.3 Impacts on Our Study

There are two impacts that Ruggle's study has on ours. First, the way that companies implemented data warehousing/knowledge repository as he described shed light on our design of Knowledge Net. Most of the warehouses are relatively devoid of context and

require significant interpretation by users. However, some companies attempt to use more sophisticated repository approaches to wrap more context around information as it is captured. For example, Intraspect's software allows users to comment on the vast assemblage of materials collected within its database. Knowledge Net can apply these methods to wrap more contexts around the information captured from past students.

Secondly, although Ruggle has reviewed what most companies do to manage knowledge and their realizations of what they should do, he did not mention the incentives for knowledge sharing. Therefore, our study will investigate the incentives for sharing knowledge.

2.2 If Only We Knew What We Know: Identification and Transfer of Internal Best Practices

O'Dell and Grayson's (1998) famous work, *If only we knew what we know: identification and transfer of internal best practices* was a fresh wind that brought many new ideas to the knowledge management field. In this section, we review their findings on how companies internally transfer their best practice, the barriers to such transfer and the possible solutions.

Identification of best practice and benchmarking against it are effective ways to re-use knowledge to reduce cost, to increase efficiencies, and to improve organizational performance. Many cases have proved their enormous benefits. For example, Chevron built a network of 100 people to share ideas on energy-use management. This network has generated an initial $150 million savings in Chevron's annual power and fuel expense. By 1996, this best practice transfer team has generated over $650 million in savings. In addition, the internal know-how has helped Skandia, a big corporation to significantly reduce the start-time for new ventures to seven months where the industry average time is seven years (O"Dell & Grayson, 1998).

However, there are still some firms that suffered from failing to transfer best practices. We need to ask: what are the barriers to best practice transfer and internal benchmarking and how can an organization overcome them?

2.2.1 Four Approaches and Main Barriers to Internal Benchmarking and Best Practice Transfer

There are four common approaches for best practice transfer. Companies often employ a **benchmarking team** to identify, understand, and adapt outstanding practices from organizations, including their own, anywhere in the world. **A best practice team** focuses on identification, transfer, and implementation of best practice. **Knowledge and practice networks** aim to bring the professionals together in order to share expertise. **Internal assessment and audit teams** assess different practices in companies, recognize and reward the excellent ones, and then share these practices organization-wide.

However, there are many hurdles that an organization can encounter to best practice transfer. They are summarized as below:

- Organization structures that promote "silo" behaviors. Departments are awarded for their own accomplishments instead of the whole organization's success. Departments are thus encouraged to compete with each other and to consciously or unconsciously hoard information and therefore hinder performance of the organization as a whole.
- A culture that values personal technical expertise and knowledge creation rather than knowledge sharing. Another cultural barrier is the "not-invented-here" syndrome and the lack of experience learning from others.
- The lack of contact, relationships, and mutual perspectives among people who do not work side by side. People do not know what other people do in the same organization.
- An over-reliance on transmitting "explicit " rather than "tacit " information. Most of the important information people need to implement practices is difficult to

codify or to write down. Instead, it has to be shown to them or at least requires dialogue and interactive problem solving.

- Not allowing or rewarding people for taking the time to learn and share.

2.2.2 Creating an Environment of Sharing

As O'Dell said, culture and behavior are the key drivers and inhibitors of internal knowledge sharing. How does an organization get people to contribute to and to use the system? How does it reward people for taking the time to share or to seek out best practices? These are real issues in best practice transfer that need to be addressed.

Two large-scale studies on knowledge management by American Productivity & Quality Center reached similar conclusions about the role of incentives:

> *If the process of sharing and transferring is not inherently rewarding, celebrated, and supported by the culture, then the artificial reward won't have much effect and can make people cynical.*(American Productivity & Quality Center, 1996; American Productivity & Quality Center, 1997).

As a result, a good transfer system should provide intrinsic rewards to its users. For example, can users better, more easily, and efficiently achieve their objectives; do they receive more recognition as contributors and experts; and is their work faster, richer and more rewarding? If the practice helps people to do their work, they will share. For example, at the World Bank, the analysts like to update data in the Africa Live Database because they become much more efficient at using the database. At Sequent Computer Systems Inc., sales and marketing teams love to use knowledge management systems since they can rapidly get the best advice, sales presentations, and systems solutions from them (O'Dell & Grayson, 1998).

Only a minority of firms uses formal financial rewards to stimulate sharing behaviors. Instead, most successful firms embed knowledge and practice transfer into their employee's work and professional development systems and recognize them for

contributions. For example, Texas Instruments has a Best Practices Celebration Day to reward the organizations that have most successfully shared best practices and knowledge and that have produced great results.

2.2.3 Impacts on Our Study

O'Dell and Grayson's work has impacts on our study in the following ways. First of all, best practice has proved to bring many benefits for the companies involved. Therefore, it may have the same effects for universities.

A few of the barriers for knowledge transfer and some possible solutions may apply in a university context. First, universities may also have an organizational structure that promotes "silo" behaviors. For example, students are mostly rewarded for their own work or their team's work. There is no reward for the whole generation of students. Therefore, possible incentives for getting students to share their knowledge with their counter-parts are worth investigation. Second, universities seldom reward students for taking the time to learn and share and to help each other.

Furthermore, their solutions for the above-mentioned barriers enlighten our study. Most of the incentives are derived directly from the usefulness of the systems. If the users find the systems useful and helpful, they will use them regardless of any formal incentives. In addition, recognition of contribution is more valued than financial rewards. Similarly, the usefulness of the information in Knowledge Net may be the decisive factor controlling whether the students like to use the system or not. And the recognition of contribution may encourage students to share.

In summary**,** the works from Ruggle and from O'Dell and Grayson both point out the importance of mapping resources with people who need them. In this way, the right knowledge can be available and apparent to the people who need it. In addition, engaging people and building a community of sharing is also vital. Although technologies such as databases, e-mails and collaboration tools can play a role in knowledge transfer, their

forms and capabilities are limited to storing explicit knowledge. These functions may not be enough to repeat best practices. Therefore, involvement of people can help to transfer tacit knowledge and repeat the process of work better. Effective ways may include building networks of professionals, recording contact information from experts in the systems, and encouraging knowledge seekers and owners to interact.

In addition, people may ignore knowledge sharing because it occupies their time. Many successful companies, therefore, embed knowledge sharing in their employees' work and provide a very supportive culture for sharing knowledge. Moreover, the real motivation for using knowledge management systems cannot come from artificial incentives. It lies in their ability to provide help to professionals in their work and recognition of their knowledge-sharing behaviors.

The findings from the study about knowledge management applications in industry have significance to our design of the knowledge management systems. Since our students will continue to use knowledge management systems in industry after their graduation, a consistency in the design of Knowledge Net with those industrial applications will help the students to adjust quickly to the new systems in the workplace.

2.3 Knowledge Management in Courseware Development

Van Aalst (2001) examined ways to facilitate project teams in producing courseware. A knowledge management system, Performer, was built to facilitate different knowledge sharing roles in educational project teams. In this section, we review major problems encountered by the project teams, the design and implementation of Performer, and the results of the study and their effect on our research.

2.3.1 Design of Performer

Courseware development teams faced all kinds of problems that slow down their development. Through a pilot study interview, the researchers observed that the level of

working-professionalism or maturity caused most of the problems. In particular, they made the following observations (Van Aalst, 2001):

1. *The process of educational multimedia projects was not well defined. Even though the project phases, project roles, and general responsibilities and tasks were documented, they were either employed very loosely or not at all. The reason was that there was no clear overview of what the project process looked like. Few people formally employed it.*
2. *There was no organized way of controlling the acquisition, dissemination, use, and achieving of the knowledge and experiences of the educational multimedia experts. In other words, knowledge management was not employed.*
3. *There was no program that allowed the organization to assess the basic process and product quality at one time and measure possible improvements at another time. In other words, there were no efforts on software process improvement and no organized way of determining whether or not any improvements were made.* (p.62)

As we can see, most of the above problems come from the process of development rather than from the product description. Therefore, the focus of her study is on the process aspect rather than the product aspect. She focused on the quality of the process of developing courseware, not so much on the quality of the courseware product itself. The quality of the development process is dependent on some complex aspects such as interdisciplinary communication, multidisciplinary project management, stress due to time and budget constraints, and the robustness of the sophisticated multimedia tools used.

Performer was built to facilitate the development of educational multimedia projects (mostly courseware). It modeled the project phases and activities for each project role in each project phase. Activities were grouped into objectives.

Since different project roles may carry different weights of work in different project phases, Performer provides a ***role view*** to show the relative importance of each project

sub-phase for each role. From this view, members of the team can determine what their roles require in each sub-phase.

The roles for educational projects are:

- Commercial manager
- Consultant
- Project leader
- Professional: content
- Professional: design
- Professional: technical

In addition, Performer provides views on the tasks to be achieved in each project sub-phase, regardless of the role in the project team. This view is called the ***aspect view***. The Performer aspects for educational projects are:

- Culture (company culture, geographical culture)
- Content (subject matter of the subject domain involved)
- Project management
- Organizational (procedures, roles, responsibilities)
- Technical

Objective Matrix

A *Objective Matrix* (Figure 2.1) is created, so-called because of the content of the cell. The Objective Matrix is made up of project phases and roles. Each cell shows the number of tasks (objectives), which need to be completed before moving on to the next cell. Each objective is achieved by carrying out a list of activities, including prerequisites and deliverables. Therefore, each project role is able to get a quick overview of the most important project sub-phases and the objectives to complete for his/her particular role, merely by making a quick glance at the matrix.

Objectives for Educational Performer

Y-Axis / Roles	Conception		Initiation		Realisation					Closure		
	Arouse Interest	Make bid& contract	Staff the project	Set up project	Analysis	Design	Realisation	Test & accept	Implementation and product eval.	Assess project	Evaluate	Archive
Account Manager	1	10	2	1	1			1			2	1
Business Consultant	1	1			3	1					1	
Project Manager	1	1	1	5	1	3	1	1	1	1	1	3
Professional: content	1			3	1	9	4	4	2		1	2
Professional: design	1			3	1	8	4	4	2		1	2
IT Professional	1			3	1	6	4	4	2		1	2

Figure 2.1 Objective Matrix (Van Aalst, 2001, p.72)

Knowledge Element

Employees highly valued one attribute of the objective called a Knowledge Element. Knowledge Elements consist of templates and best practices of courseware that have been generated through the years for each objective. The employees were able to carry out their tasks better by accessing these templates and best practices.

Furthermore, different ways of approaching the knowledge elements were designed to facilitate the use of Performer for both junior and experienced users. First, a matrix view was created. It shows not the objectives in the cells, but rather the number of knowledge elements for each cell directly (Figure 2.1). The colour of each cell in the matrix denotes the number of knowledge elements in the cell (Figure 2.1). The more the number of the elements, the darker the cell is. This design provides convenience for experienced users who already know the objectives fairly well. Second, a Knowledge Search Page was provided. It can filter the knowledge elements through their characteristics such as the role, the usage type, and the file format.

Individual Estimates

Another type of knowledge captured is the ***Individual Estimates***. For example, employees know what the approximate cost for one hour of basic browsing CBT on a personal computer. This approximation is a consensus estimate, which is especially useful for a consultant or project manager in the early phases of the project. Therefore, a set of questions about consensus estimates was asked for each combination of project phase and project role. The individual answer to each of these is an *Individual estimate*. These results are presented in a matrix, called the ***Individual estimates matrix***.

In the *Individual estimate matrix*, the y-axis represents the roles of the team. The x-axis represents the tasks they carry out. The number in each cell denoted the number of experience questions available in that project phase (Figure 2.2). All of these questions

were formulated in the following ways: “How much time/money/effort does it take to achieve this or that? “ Contextual attributes, preconditions, constraints, and a best-before date accompany each answer to such a question. If a sufficient number of employees submit their own answers to such a question, the overall average becomes an approved consensus estimate. These consensus estimates serve to improve the quality of project bids, and they help project team members to estimate the efforts needed to carry out tasks.

Experience numbers for Education Performer

Y-Axis Roles	Conception		Initiation		Realization					Closure		
	Arouse Interest	Make bid& contract	Staff the project	Set up project	Analysis	Design	Realization	Test & accept	Implementation and product evaluation	Assess project	Evaluate	Archive
Account Manager	2	113	22	1	2			1			2	1
Business Consultant	2	103			122	48					1	
Project Manager	2	103	22	97	25	61	18	16	11	1	1	3
Professional: content	2			10	79	74	17	15	63			
Professional: design	2			10	54	66	22	15	63			
IT Professional	2			10	86	90	55	15	63			

Figure 2.2 Experience questions and answers in the Performer Individual Estimate Matrix (Van Aalst, 2001, p.77)

Help files were provided. A question mark sign was put on Performer screens. Clicking the question mark brings up a small popup window containing a layout similar to a standard windows help file.

Furthermore, a very useful way of finding knowledge elements is to capture the available expertise. All knowledge elements are tagged with various keywords in addition to their titles and description. This tagging allows people to search on a given topic through the list of all available knowledge elements and to generate a list of employees whom have submitted knowledge elements with that topic.

In addition to retrieving knowledge from Performer, employees can contribute knowledge elements or their individual estimates in an easy way. They can also add their opinions about certain knowledge elements. If a sufficiently large number of people add their opinions to specific knowledge elements, the value of those elements becomes more evident.

In summary, Performer stores the information about the tasks that a certain role needs to carry out for projects, such as prerequisites and deliverables. The information is presented in the *Objective Matrix* with the y-axis as the roles in the team and the x-axis as the tasks. *Knowledge elements* including templates and best practices are provided. *Individual estimates* about certain projects such as cost, efforts, and time are offered. These estimates can provide reference for people dealing with similar projects. Performer can be accessed in different ways. One can search by characteristics of knowledge elements or even click on the cell including the knowledge elements.

Employees can contribute knowledge elements and individual estimates to Performer. If a sufficient number of employees submit their answers to one question, the overall average become an approved consensus estimate. Similarly, if there are many comments about a certain knowledge element, the element is shown to be more important. Another important use of Performer is that one could find knowledge elements by keywords and find all the people whom have submitted similar knowledge elements.

2.3.2 Implementation of Performer

In addition to the technical component of Performer discussed in the previous sections, there are three major components that facilitate the successful implementation of Performer. They are content, organizations, and culture.

Content

A senior employee was in charge of making an inventory of all available and useful templates and best practice in the teams by interviewing employees and by evaluating relevant documents. He was also in charge of filtering all the knowledge elements and of putting the most useful ones in Performer.

Organization

Different roles were assigned to different employees to assist the implementation of Performer. For example, Performer Editor has edition rights such as adding signs to a knowledge element and granting download access to employees. Performer Champion makes sure that people remain motivated to use Performer. Performer Moderator carries out all administrative tasks within Performer, such as re-arranging knowledge elements in the objective matrix and adding new roles/aspects/objectives etc.

Culture

The largest part of the budget for implementing Performer was spent on cultural aspects. Many social activities were carried out to promote Performer.

First of all, the design of Performer was introduced to employees in regular meetings. Second, Performer Champion held interviews and browsed through employees' desks and cabinets to find useful knowledge. This process turned out to be a motivator in itself because employees felt that their knowledge was in demand. It also made them curious to

find out just what was being designed and how much the tool could help them in finding the necessary knowledge at each sub-phase of an educational project. Third, Performer usage sessions were held. In this way, employees could experience in a direct way just how quickly certain types of knowledge could be traced. Most importantly, a statistical counter was added in the main menu. Each time an employee added a new knowledge element, his counter of knowledge elements increased by one. It was easy to see who contributed more and who contributed less. Therefore, the employees were motivated to contribute knowledge to move up in the ranks.

In summary, Performer captured process knowledge of educational project development and presented it in an easy and direct way. It helped different roles of project teams access knowledge for their tasks at different stages of the development process. In addition to the technical systems, a large amount of efforts were put into the social system for knowledge management. Different employees were assigned different roles to facilitate the use of Performer. Performer was introduced in presentations and also through interaction between Performer Champion and other employees. Most significantly, the use of Performer and knowledge-sharing were motivating in two ways. On one hand, employees felt that their knowledge was important through interviews with Performer Champion. On the other hand, they liked to be ranked high for their contributions of knowledge.

2.3.3 Results

The overall feedback for Performer was quite positive. Project experience became significantly more positive for projects that use Performer. On an individual theme level, the experiences about project management and the communication and the customer/user relationship became more positive than those before. In addition, Performer allows employees to do more much more in less time.

Generally speaking, the researchers concluded that Performer positively affected the development process and saved the users time.

2.3.4 Impacts on Our Study

Since our study is also in the domain of courseware development, the design of Performer and the findings have great significance to our study. Through the interviews with the employees, Van Aalst found that a lack of a certain kind of process knowledge generated most problems in the project development. This type of process knowledge includes interdisciplinary communication, multidisciplinary project organization, stress due to time and budget constraints, and robustness of sophisticated multimedia tools. Similarly, this knowledge may be important to our students too.

Furthermore, in Performer, employees contributed their experience mainly through knowledge elements and through individual estimates. They can add best practice and valuable templates to knowledge elements or submit their estimated time/money/effort to reach specific objective. These methods are relatively easy and convenient and thus they facilitate contributing knowledge.

Moreover, Performer has two interfaces: one for novice users, another for experienced users. The two interfaces match different users' needs and save them time searching. Similarly, in the design of Knowledge Net, we may want to consider different users' needs.

However, Performer does not catch other kinds of project knowledge such as a scope statement and design issues and process knowledge such as how to come up with the design issues and how to solve them. In our study, we will try to catch that knowledge. In addition, we plan to capture it in a retrospective way. The students are encouraged to articulate what they think they should have done instead of what they actually did, i.e. "lessons learned".

2.4 Contributing To and Using a Shared Design Memory: Effects on Learning Analysis and Design Skills

Daniela Giordano (1998) designed a shared memory system to offset some of the cognitive biases and difficulties that novice designers faced in information systems analysis and design in one course at a college in Italy. In addition, she conducted research on how this shared memory system affects individual and organizational learning.

2.4.1 Design of StoryNet

The course under research was called *Information Systems Analysis and Design* in the electronics and information engineering degrees at the University of Catania, Italy. Basically, it was about modeling data and processes operating on such data to design systems that support the information requirements of a business organization.

Giordano (1998) summarized common and recurrent difficulties and biases of novice analysts and designers as below:

Key difficulties:

1) *Scoping the problem and performing problem decomposition.*
2) *Generating and testing hypothesis about the model of the system by robust problem-solving strategies, mental model formation.*
3) *Reasoning on model completeness.*
4) *Lack of strategies for dealing with complexity.*
5) *Lack of familiarity with the domain.*

Biases / errors

1) *"Anchoring": fixing the initial model or hypothesis, failing to detect errors or weaknesses*
2) *Piecemeal modeling by "literal translation" of nouns to entities and verbs to relationships that leads to design sub-optimization.*

3) *Biases related to information overload, data availability and lack of feedback*
4) *Tendency to concentrate immediately on implementation issues at the expense of high level analysis concerning the requirements*
5) *Working at too detailed a level*
6) *Lack of specificity in the universe of discourse* (p.18)

StoryNet was designed to offset the above biases and difficulties encountered by novice designers. It is a shared design memory aiming at supporting both individual learning (by promoting the ability to perform a deep, user-centered analysis of the business organization, and to critique and verify the design) and organizational learning (by facilitating the circulation, acquisition and transformation of design ideas and practices).

In the context of learning Information System design, it was beneficial to view projects from different angles, e.g. the analysis of a certain type of organization and a solution adequate or innovative of specific classes of problems. Therefore, the cases were linked in hypertext so that they allow one to see how aspects are related in ill-structured domains.

The primary organization subject of StoryNet was "stories" and "episodes" that model different organizations. They could be searched selectively according to the specific categories. Attached were multimedia documents indicating the data models and snapshots of the user-interface of an implemented prototype. Also, comments from authors about design issues or considerations were attached. Most importantly, each design unit was linked to any design whose ideas had been used or taken into account. In this way, StoryNet was like an evolving system, made up of a network of annotated design cases incrementally linked by the students.

To show how the precedents was taken into consideration, links were marked as "correct", "extend", "detail", "adapt", "restructure"…

Furthermore, “design critiques” were attached to the design representations. The critiques were presented in a structured document, which addressed various dimensions in the design. For each dimension different aspects were suggested that might be taken into account in order to justify the overall judgment. These guidelines were developed as an implicit model of how an expert would approach the evaluation of the design. Figure 2.3 depicts the architecture of StoryNet:

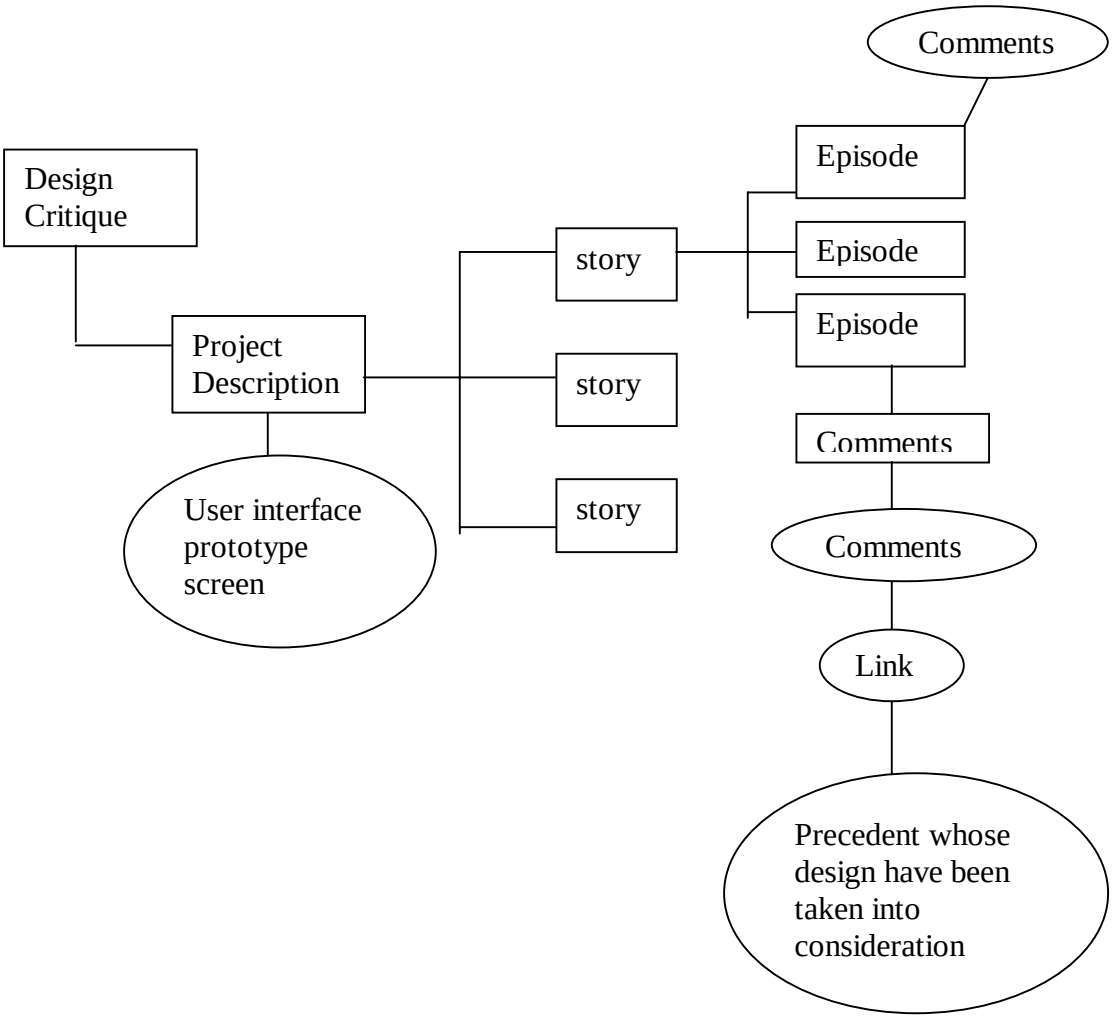


Figure 2.3 Architecture of StoryNet (Giordano, 1998, p.34)

StoryNet helped to offset the difficulties and biases encountered by novice designers in the following ways. First, in linking models to scenarios, it helped capitalize on the previous experience of the learners. It offset the learners’ difficulty of lack of referent

knowledge. Second, it supplied enough variety in the examples of how the problem domain was tackled which facilitated the re-use of drafted solutions and reasoning behind the simple solution. Third, the story-based approach to structure requirements helped to scope the problem, recognize its boundary and decompose problems and lessons. Fourth, peer-review and collaborative annotation facilitated in evaluating model correctness and in cultivating communication skills.

2.4.2 Research Model

The students were informed of the purposes of the course's shared memory. They understood that they would be involved in building it and using it. It was part of the course requirements to contribute to StoryNet.

The researcher played the role of teaching assistant (TA) in the course. The students could discuss with the TA about the project they wanted to develop. The TA would select one or two relevant projects from the repository of former projects. It was the students' responsibility to insert into StoryNet at least one of the projects that they had reviewed along with their own critique. Their critiques were based on a given guideline. In addition, the students were encouraged to add any other dimension they felt like. They were also required to contribute their own design project. Furthermore, they could use elements from the previous projects, but were warned that the reuse was limited and could be only for didactic purposes.

The researcher considered the shared design memory as part of a distributed system. Therefore, the study of its effects on individual and organizational learning should take into account the design artifacts, the community of learners, and the shared design memory. StoryNet was studied with an ethnographic approach, to understand the social factors and the cognitive factors governing the way it was perceived, used, and accepted and in what respects it modified the pattern of informal exchange of information and design artifacts among the students.

Figure 2.4 depicts the relationship among the shared design memory, the community of learners, and their design artifacts:

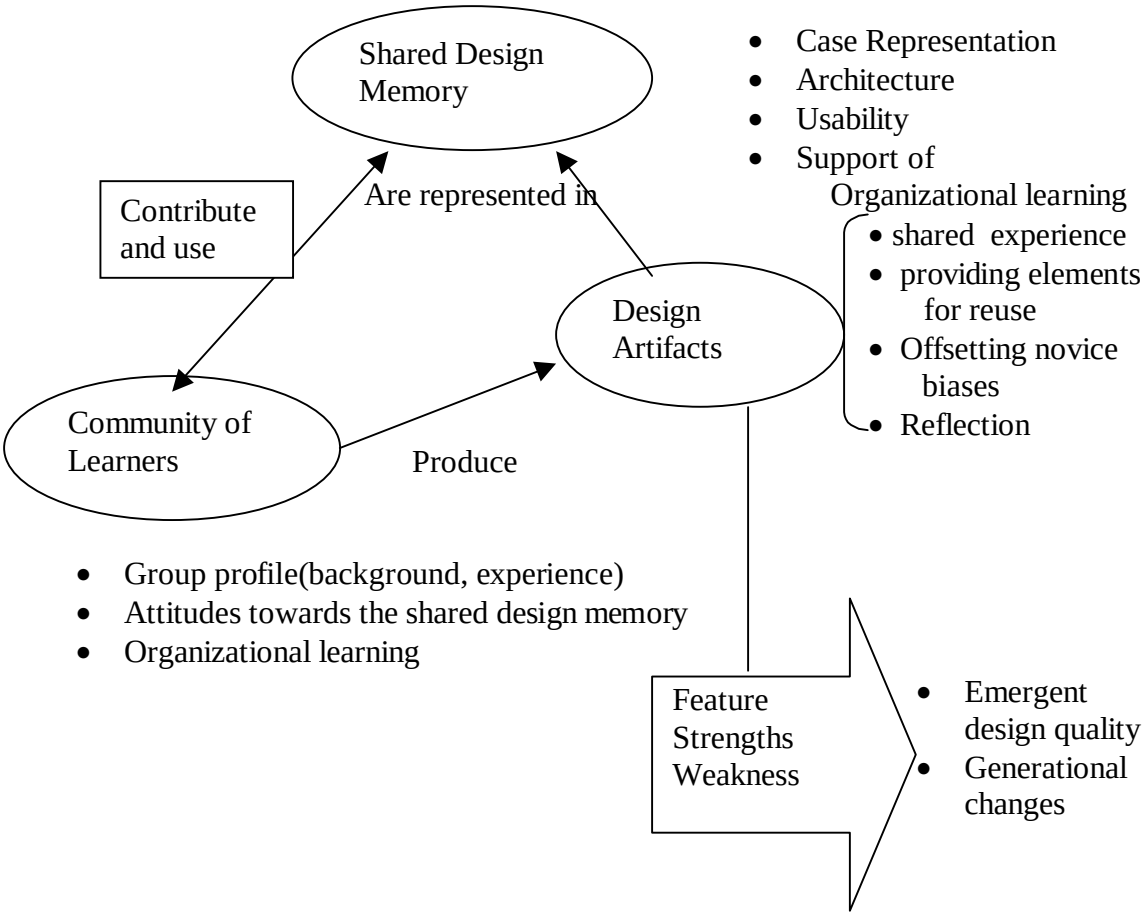


Figure 2.4 Research Model for Studying the Shared Memory
(Giordano, 1998, p.48)

The relevant dimensions to the community of learners were the group profile, the attitudes towards the shared memory and the overall organizational learning of the community as a whole. Shared design memory support individual learning and organizational learning by its case representation, its usability, its sharing of experience, and its providing of elements for re-use etc.. The organizational learning embodies in the certain design artifacts such as its quality and generational changes.

The study was organized in two parts. The first part addressed the relationship among the individual characteristics, the use of precedents, the perceived difficulty of the design

activities, and the attitudes towards StoryNet. It also addressed the issues of how StoryNet served to highlight design weaknesses in context, and to convey additional design knowledge through formulated statements to future students. The questionnaire survey was conducted in this part. The second part was a longitude study based on comparing the quality of designs across three generations of students whom have used StoryNet. A feature-based approach was employed. Certain important features that should be included in the design were listed. If the feature was presented in the design, a 1 would be given to the design. If not, a 0 would be given.

2.4.3 Results

From the questionnaires, it was found that the precedents were used mostly as exemplars for which rules about structure and organization of the design were derived and as a baseline for the quality standard to be achieved in the new design. In addition, the students perceived the critique exercise as a useful means for learning to recognize and avoid errors.

The design artifacts, after use of shared memory, showed significant progress. Some of the individual weaknesses were offset and in the new generations as they became less frequent. For example, the specificity in the language improved while the difficulties in scoping the problems and performing decomposition were not perceived as much. This progress demonstrated the organizational learning in the community of learners.

Giordano argued that the success of the shared memory was due to the belief that the shared memory was not only StoryNet. Instead, StoryNet was just part of the distributed system that kept track of what had been done and of the artifacts that were being created, augmented by the information in the links and in the design reviews. It aimed to develop the continuity among generations of designers and complement the communication beyond the informal network. Around StoryNet was “the real, living and breathing community” (Giordano, 1998, p.142). Activities such as talking with the professor,

talking with the TA, watching the presentations of their colleagues, and engaging in the process of learning were very important parts of the shared memory system.

In summary, the diversity of the motivations and of the ways of approaching the use of precedents indicated that the students accepted the shared design memory. The precedents were used as exemplars for design requirements. The critique exercises helped the students to avoid similar mistakes from occurring in the precedents. As a result, the new design artifacts were improved from the old in many ways. Some of the individual weaknesses were offset and some innovative ideas appeared.

2.4.4 Impacts on Our Study

Giordano's study helped form ours, since it was also conducted in a course in a university. Her results suggested that students accepted well a shared memory system and found it useful for their project development. Similarly, our Knowledge Net may be accepted by students if well-designed. Furthermore, she included the comments from the authors about design issues to help the students to see the reasoning behind the models. Similar comments may be effective for our students too.

In addition, our study will contribute to the understanding of the application of knowledge management in universities in a different way from hers. First, using the shared design memory is part of the course requirement in her study. In our study, it is volunteer action. We want to see whether the students will still approach knowledge management systems without "push" from the instructor and whether the students can find the useful information in the systems without directions from a teaching assistant, as in Giordano's study.

Second, the comments from the authors for the projects are mostly product knowledge describing the features and the models of the products. However, in our study, we try to capture process knowledge including how to come up with design ideas, how to communicate more effectively with team members and clients and how to decompose the

tasks as well. We will encourage students to recall this knowledge in a retrospective way, i.e. what they should do instead of what they did do. We feel that the process knowledge is as important as the product knowledge in Giordano's study.

In summary, works such as that of Ruggle (1998) and of O'Dell and Grayson (1998) provide us with knowledge about knowledge management application in industry. Van Aalst's work enlightens us on the design of Knowledge Net for courseware development. Giordano's study has provided valuable knowledge about how students perceive knowledge management systems and how the system affects their individual and organizational learning. In addition, there are much literature about learning theories such as situated learning and anchored instruction (Garwin, 2000; Stillman et al, 2000; Alessi & Trollip,2001) and learning practices that may provide theoretical grounds for our research.

Chapter 3 Research Models

This chapter has three sections. The first section outlines the design experiment and the research questions. The second section describes in detail the design for Knowledge Net. It is further divided into four parts. The first part characterizes the IS303a course. The second part specifies the user scenarios for Knowledge Net. The third part presents the preliminary design of Knowledge Net. The fourth part describes the pre-test of Knowledge Net. The last part clarifies the revision of Knowledge Net, following this initial testing.

3.1 Design Experiment and Research Questions

A design experiment method is employed in this research. Design experiments (Collins, 1998) are modeled on the procedures of design sciences such as aeronautics and artificial intelligence. It is educational research experiment carried out in a complex learning context, which explores how a technological innovation affects student learning and educational practice (Brown, 1992). The researchers have to consider the effects of different educational objects on students' learning and practice. These educational objects include the software system, lesson plans, curriculum sequences, activity structure as well as other artifacts for instruction (Bell, 1998).

Generally speaking, design experiments:

- *Address learning programs involving important subject matter*
- *Are usually mediated by innovative technology*
- *Are embedded in everyday social contexts which are often classrooms,*
- *Can serve as models for broader reform, and contribute simultaneously to fundamental scientific understanding of learning and education* (Hsi, 1998)

Basically, the researchers engineer the environment to promote learning. They take their knowledge about learning, theories of learning, knowledge of practice and put them together to figure out what they want to go on in there in order for learning to happen. In

addition, predictions are made about what is going to happen as a result of the different things that are going on. Then, one can study the how the environment facilitates learning and answer questions within that environment (Kolodner, 1998).

Our design experiment was conducted in the IS303a course – *Designing Learning Activities with Interactive Multimedia* at the University of Waterloo. It is a project-based course in which the students are required to design some learning objects to solve instructional bottlenecks for professors. We introduced a knowledge management system called Knowledge Net in this course. Knowledge Net was designed based on past literature of knowledge sharing, knowledge transfer and learning behaviors and used to store past projects and comments from previous students.

The experiment was conducted at the fourth week of the class in which the students have basic knowledge of the course. In that particular class, the instructor reviewed the content of last class first, illustrated a little bit about teamwork and planning and then introduced Knowledge Net's basic functions and purposes. After that, the students were asked to browse Knowledge Net for half an hour and fill in a questionnaire for its usefulness to their work afterwards.

In this way, the classroom environment was engineered to be one with a computer system storing past students' comments and projects and also the instructor's minimal guidance on this system.

The key research questions under investigation are:
1.Can students easily find the information in Knowledge Net?
2.Can they understand it?
3.Can they apply it?

In addition, we would also like to explore what the incentives are for the students to share and apply knowledge and how willing they will be to do so. Our goal is to explore the

students' ability to find, understand and their willingness to apply the information from Knowledge Net with minimal guidance.

In addition, an interview was conducted with all the students to capture their knowledge in this course and feedbacks on Knowledge Net and the IS303a course at the end of the term. Through the survey and the interview, we studied how Knowledge Net worked to facilitate students' learning in the IS303a course.

3.2 Design of Knowledge Net

3.2.1 The IS303a Course

Knowledge Net is designed for a course at the University of Waterloo -- IS303a, *Designing Learning Activity with Interactive Multimedia*. It is sponsored by the Centre for Learning and Teaching through Technology (LT3) at the University of Waterloo. Although it is an undergraduate course, many graduate students or graphic designers take it for interest. It is a project-based course in which teams of students work with faculty members to design and prototype educational multimedia applications for on-campus courses. Faculty members who have educational bottlenecks and are interested in potential technology aids submit their projects to LT3. Then the students select the ones they are interested in.

Usually 3 or 4 students form a team. The team normally consists of students with a variety of interests and backgrounds in technology, pedagogy, aesthetics and discipline knowledge (Carey et al, 1999) so that they can bring different skills and values to the team. The faculty members identify the instructional bottlenecks to the students. The team works closely with the faculty members to design both educational and technical solutions.

By the end of the course, a solution with its prototype has been developed and tested with students in class. Developing the prototype is a process with a lot of mini goals along the

way. The students are required to complete the following milestones gradually as they progress through their projects:

- Scope statement: It summarizes the instructional challenge or bottleneck that the project is supposed to address and the purposes/goals of the project (Liang, 2002).
- Learner Profile. It describes the learners' characteristics, competencies, limitations, and familiarity with the subject area (Alessi & Trollip, 2001).
- Storyboard. It describes each learning experience that users encounter in using the learnware. It can be built with paper or computer.
- Prototype. It provides a basic solution for the instructional challenge. Although each function may not be fully implemented, a clear picture of what the full product looks like should be presented (Carey et al,1999).

The students will develop an understanding of the potential, the process and the limitation in the multimedia educational project development, components of an effective design and the learning process relevant to mediated learning (Light, 2002a) through completing these milestones.

The following activities occur in a 13 weeks' teaching term for the IS303a course(Carey et al, 1999):

- Group instructions about the fundamentals of learning theories, instructional design and multimedia development. The students are required to complete the scope statement. (three weeks)
- Faculty members, as clients for the teams, describe the learners, learning outcomes and instructional bottlenecks to the students. The student teams interview the clients and the students. They document learner profiles and design new scenarios with Detail Kit, a performance support system. Furthermore, they design other computer-based activities. (five weeks)
- The teams construct paper prototypes to test critical portions of their designs. Each team conducts a walkthrough session for the storyboard with one student from other teams. (four weeks)

- Students present the prototype before the instructor, clients and other teams. The audience gives the recommendations for changes. The students document their reflections on the overall learning experience in the course. (one week)

In summary, the IS303a is a project-based course aiming at training the students to design interactive activity with multimedia. Participants in the projects in clude students, faculty and professional staff in multimedia design. By developing prototypes for real world applications, the students acquire design skills by applying their knowledge and reflecting on their experience as a collaborative team. In addition, faculty members develop similar understanding in multimedia design and get feasible solutions for their instructional challenges. The prototypes completed in the IS303a could serve as the basis for future application development. The project development at the IS303a accommodates both the students and the faculty' needs. Furthermore, it helps LT3 to establish a repository of exemplary instruction and to encourage development and use of interactive multimedia for support of learning and instruction (Light, 2002a). In a phrase, the IS303a course is a "win-win" solution for the students, the faculty and LT3.

3.2.2 User Scenarios in Knowledge Net

As Knowledge Net is mainly for the students of the IS303a course, the design of an easy-to-use system has to consider the needs of the students. Therefore, considerations in the design included the students' motivations to use Knowledge Net, their usage patterns and how it could help them to achieve their goals.

As a result, we used the scenario-design methods in combination with adapting ideas from other good designs, which were reviewed in the last chapter in the design for Knowledge Net.

User scenario is a narrative description of what people do and what they experience (Carey & Minstrell, 1996). By creating user scenarios, the designers are forced to think from the perspective of the users rather than the context of

their design. Therefore, the final product will be more usable and acceptable by the users.

The following are the user scenarios prepared for Knowledge Net:

Mike, Lora and T.J. are in the same group for the IS303a course.

Scenario 1: Coming Up with Scope Statement

Mike is a new student of the IS303a course at the University of Waterloo. He is assigned to write the scope statement for his group. " Well, what does scope statement look like and what is it for?" He puzzles. "Oh, we may want to check the Knowledge Net." He turns on his computer and logs into the Knowledge Net and begins to view the prototypes and past design rationales from other teams.

" Here is one. " He reads aloud the scope statement. " By the way, there are also some comments on how to write scope statement from the authors: ' *Scope statement should be approved by the client as soon as possible*.' Mm- I wonder why they say that? … Here is a story of why."

" ' *There could be some gap in understanding the scope between the team and the professor.*' OK, I see. " " So, after my writing, I will submit it to the instructor of the IS303a and also the professor of our project. After they agree with it, we can begin to work. "

From this scenario, we can see that Knowledge Net not only provides Mike with past prototypes and scope statements, which serve as exemplars for his work, but also comments from previous teams. Those comments remind Mike to deliver the scope statement to and get approval from the instructor and the client as soon as possible. Therefore, Mike gets some new knowledge, which he did not intend to get.

Scenario 2: Using Voice as an Interactive Technique

Mike and his group members are considering whether to use voice in their design. There have been some arguments among them. Finally they decide to check previous work done by other students. They log into the Knowledge Net. " Well, there are so many projects. How can we know which is useful? " Lora asks.

" Knowledge Net has a key word search function. Let's try ' voice '. " Mike suggests. After "voice" is typed into Knowledge Net, a few projects appear.

" Let's try this one." Mike clicks on one of them. It is a kinesiology project, which used voice as narration for the text. " Here are some comments from the reviewers: ' *do not read the text on the screen otherwise the audience may feel bored. '* This is a good suggestion. " " Let's try the other project. They developed a prototype without using voice. They considered ' *as our users are mostly distance education students, the professor's voice is taped in all the lessons they have. As a result, we think it not necessary to have the professor's voice again in this prototype. Rather we prefer them to concentrate on the text and video. ' "* " Their situation is different from ours." After viewing a few prototypes using and not using voice and the comments, Mike's group has some ideas of how and under what situation voice should be used.

Scenario 3: Interface Design

Mike and his group members have conquered a few difficulties in the first few stages of the projects. Now they come to the design of the storyboard. " Well, the instructor said that other teams would review our storyboard in the next class. Why don't we review it first and fix as many problems as we can now? " Mike proposes. " Great." Cries Lora. Then the three of them go through the storyboard and look for problems.

" Three heads are still limited. " Mike says. " Let's search on the web about what other teams have done. " T.J. types " interface design " in the keyword search. Then a few

projects come up. " Let's see this one. ' *Our reviewer reminded us that clarification with the users about their positions in their browse was necessary. Thus, we put a subtitle for each page*.' "

" That is a good idea. We did not have any title in our pages. " T.J. notes. … After reviewing a few interface design comments, they have some basic ideas of the common problems in user interface design and solutions.

Scenario 4: Drafting Design Rationale

The development of the project approaches its end. The team presented their project in class last week. Now it is time for writing design rationales. Although Mike's group knows that design rationale should be written all along the way of the development, they did not have time to do so. Now the due date is near. " Hey, it is hard to think back on all the issues that we have discussed. I do not even remember what we have considered and what we have not." T.J. cries. " Well, it is fortunate that the Knowledge Net has recorded all the discussions. " Laura replies. " That is wonderful. Let's check them and hopefully we could remember what we have discussed and concerned in the design process. " Through the record of the discussion from Knowledge Net, Laura and Mike reorganise some issues they have discussed and put them into the design rationale.

From the above scenarios, we can see that Knowledge Net is mostly used in the following ways:

1. It is a repository of the IS303a projects. Previous projects serve as exemplars for students in the IS303a course. Through these projects, the students develop better understanding of what their future projects should look like and the instructors' requirements. In addition, it helps the students to accomplish their milestones. For each milestone, the students can check works of other students to get some hints.

2. Comments from previous students serve as reminders and warnings to new students. Because of the similar contexts of projects in the IS303a course, students over generations are likely to encounter similar problems. Therefore, a new problem facing today's students might have been experienced by previous students. As a result, the comments from previous students of what they did and their results could be a great help to new students. In this way, new students could adsorb some lessons learned from previous students and thus avoid some unnecessary mistakes.

   In addition, the students can also have a view of the common problems occurring in different phases of project development and watch out for them as their projects progress.

3. Students can search Knowledge Net through the keywords of the comments. In this way, they can more easily get the things they are looking for.

4. Knowledge Net records discussion for the students. When the students need to revisit their discussion and recall their key considerations for the project in the past, they could track it through Knowledge Net.

3.2.3 Preliminary Design of Knowledge Net

We incorporate the functions derived from the previous scenarios to the design of Knowledge Net. One thing to clarify is that Knowledge Net is not an isolated application. It works hand in hand with other applications in the IS303a course to facilitate teaching and learning. Currently, two applications are used in the IS303a – Discussion Forum and Detail-Kit. Through Discussion Forum, the students and the instructor can hold on-line discussions. The students can ask the instructor questions or discuss issues with peers on line. Detail-Kit is a performance-support system, which aids students in drafting their learner profiles. Therefore, we are not going to rebuild the functions that have already been embedded in Discussion Forum and Detail-Kit.

First, Knowledge Net is designed as a web application, which allows both the students and the instructor to access it 24 hours a day, seven days a week. This provides the flexibility to access the information any time and anywhere.

Second, the main page is designed as a big iceberg. It denotes that each person's knowledge is just like the little tip of the iceberg. Unless one absorbs knowledge from other people, he cannot learn all that is necessary for the project (Figure 3.1). The main page is divided into three parts. The top part is the welcome message to the users. The left part shows the directory of Knowledge Net and links to other software and useful websites in the course. The right part is the detailed content of the category that one is currently in. By clicking any links on the left hand side, one can view its content on the right hand side. Such a frame can ensure students know where they are in searching the Knowledge Net. As a result, it is easy for them to go to another directory.

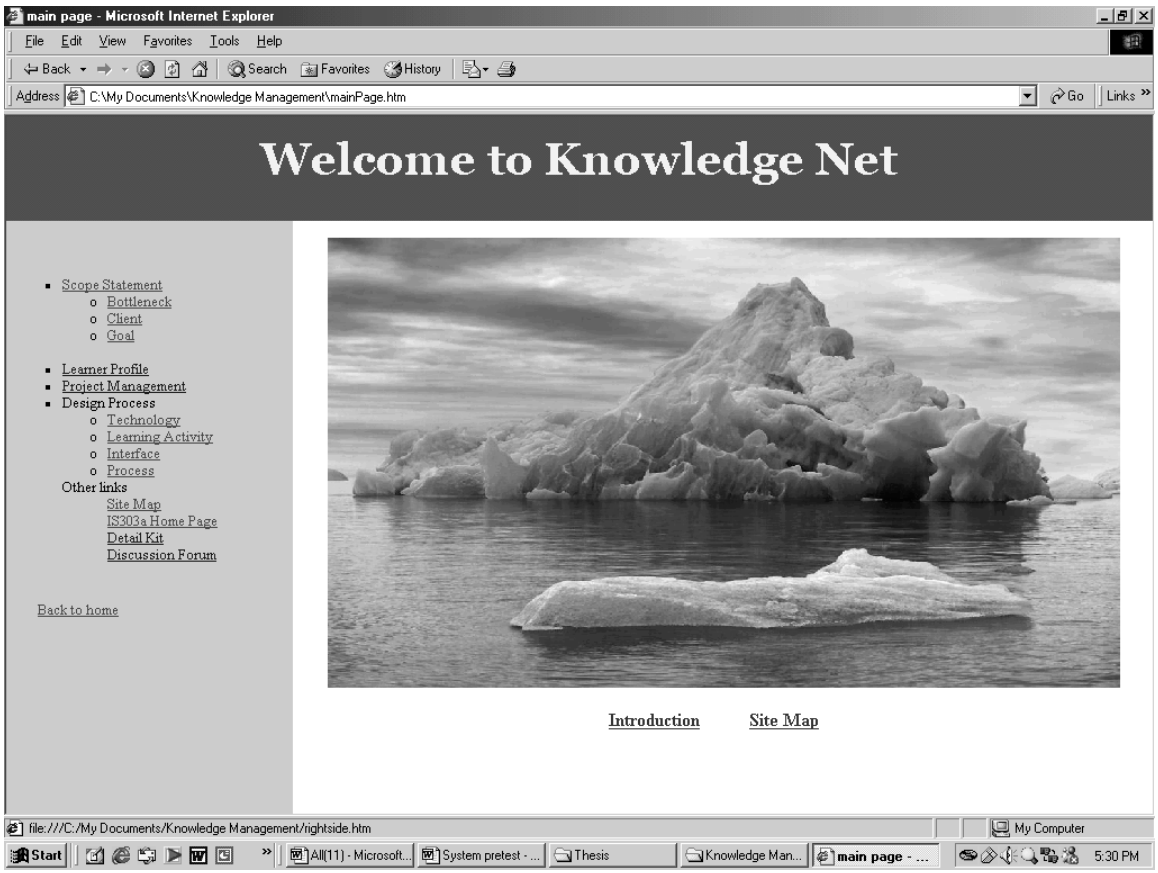


Figure 3.1 Main Page of Knowledge Net

Third, an introduction is linked to the main page. It introduces the aim, the basic functions, relevant software and the structure of Knowledge Net so that the students know what the system is for and how to access it (Figure 3.2).

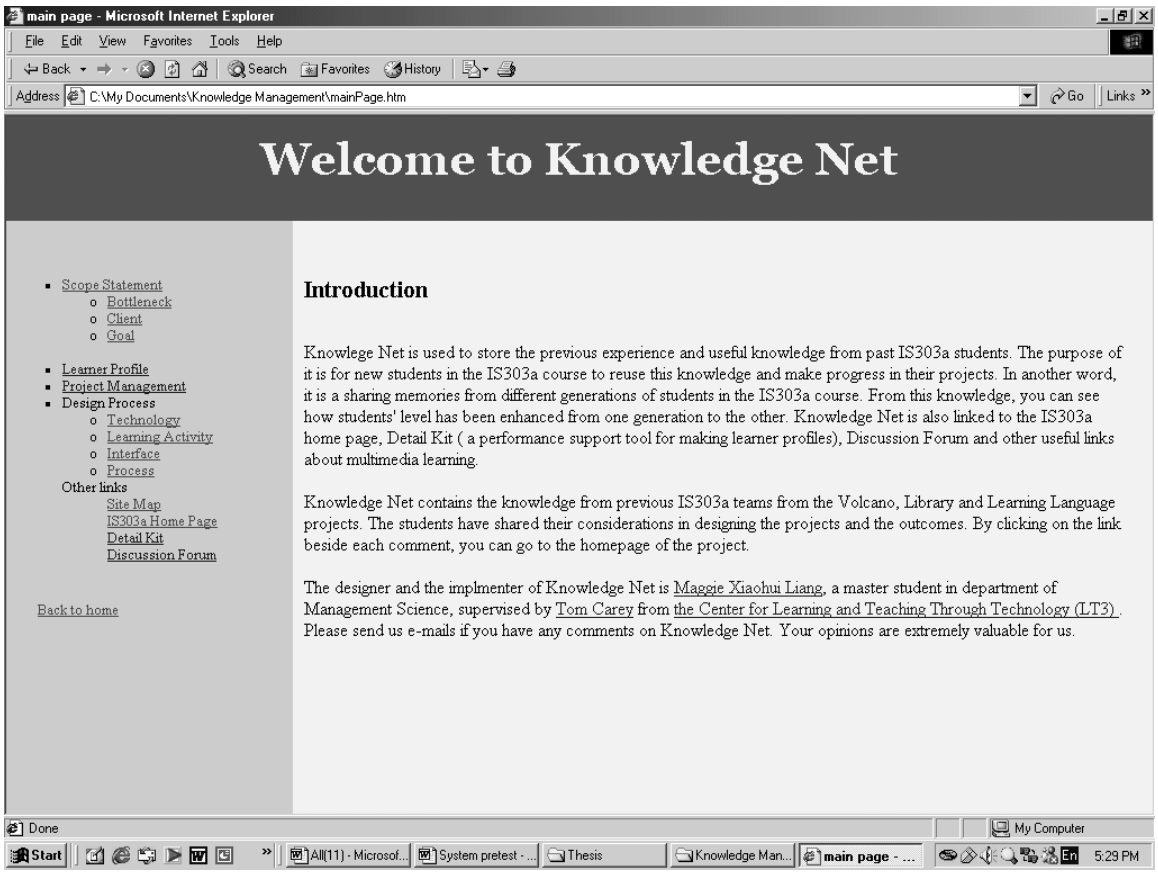


Figure 3.2 Introduction of Knowledge Net

Fourth, since the student treats works from previous students as exemplars and uses the attached comments as references in building their milestones, information in Knowledge Net is organized according to the milestones and major themes in this course. It is composed of four parts with each part containing relevant stories and experiences from previous students as follows (Table 3.1). “Scope statement”, “learner profile” and “design” all target at helping the students to accomplish their milestones. According to Van Aalst(2001), England and Finney(1996), project management is listed as the first in the disciplines required for multimedia courseware. Therefore, “Project management ” is listed as one category in Knowledge Net. Since design activity is more complex than other milestones, it includes dimensions in both technology and learning activities. Thus, we divide it into four parts. They are technology, learning activity, interface and process.

Name		**Content**
Scope statement		Identify bottleneck, communicate with clients and define scope for the project.
Learner profile		How to collect good learner profiles, what is a good learner profile and how to design the project accordingly
Project Management		How to breakdown the task and the estimate time for each phase
Design		
	Technology	Trade-offs of different technologies
	Learning Activity	Interactive learning activities and their contexts
	Interface	How human and computer interacts and key things in interface design
	Process	Prepare before the design starts

Table 3.1 Structure of Knowledge Net

Fifth, the students' comments are denoted by threads in Knowledge Net. Each has a title exposing its main content. These comments are collected through the researchers' interviews with previous students and recorded by the researchers with verification and approval to publish on Knowledge Net from previous students. These comments contain both project knowledge including the issues about the features of the prototype and process knowledge including how to come up with design ideas and how to communicate with clients.

Sixth, as past projects are treated as exemplars for the students, a link to the project's website was put beside the students' comment as Giordano(1998) did in StoryNet. In this way, the students can click to have a look at the project and develop a better understanding of the context in which the comment is written (Figure 3.3). Furthermore, a symbol characterizing each project is provided beside

the comment so that the students can have a picture for the project in their minds and recognize it quickly while browsing through the comments.

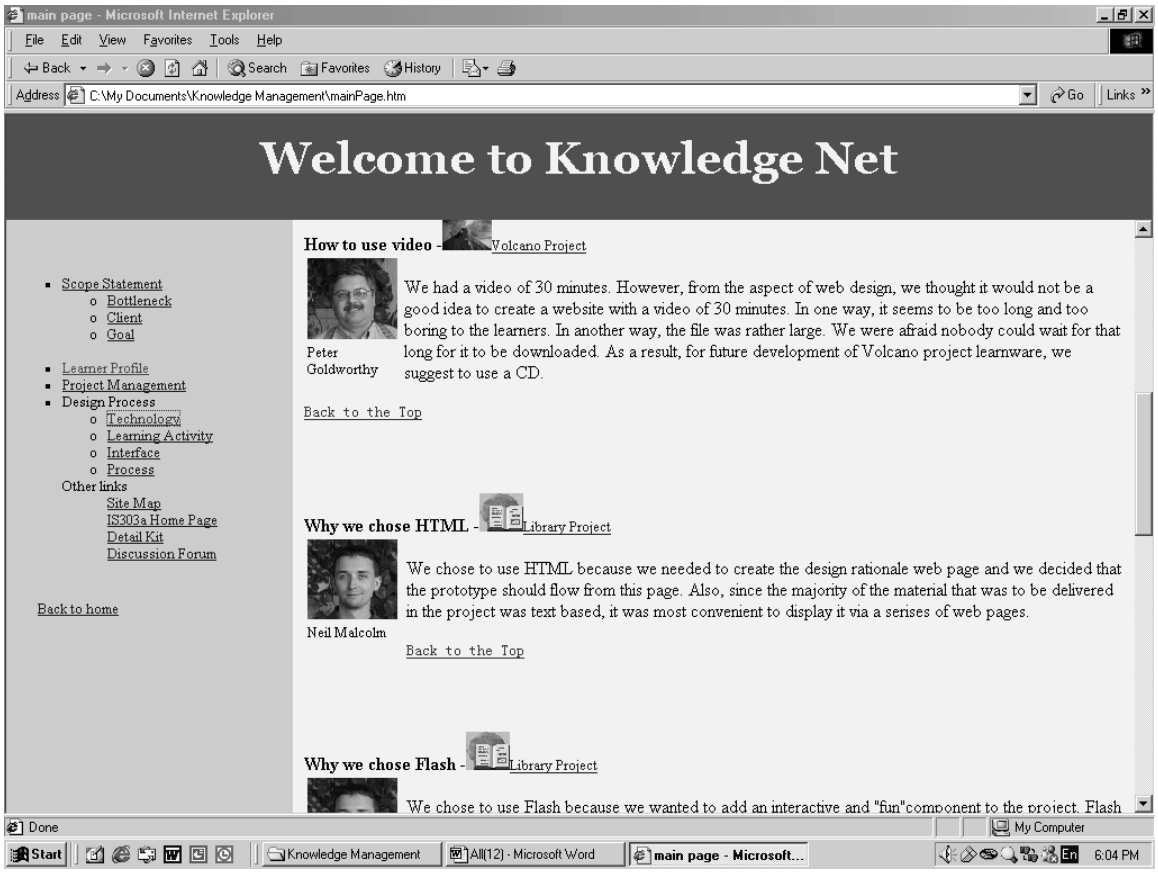


Figure 3.3 Students' Comments in Knowledge Net

Seventh, according to O'Dell and Grayson(1998), for effective knowledge transfer, the knowledge recipients have to trust the providers of the knowledge. Therefore, pictures of the teams who make the comments and their names are presented beside the comments. Through the lively personal pictures, we want to convey the information that the comments from previous students are true and based on real life experiences. As a result, the students may trust the information more.

Eighth, Knowledge Net is linked to related software and websites for the IS303a course. It is linked to the IS303a home page, Discussion Forum and Detail-Kit. It proves that Knowledge Net is not an isolated application. Rather it is part of a set of tools for the IS303a course.

Ninth, a knowledge map is provided for the users. According to Davenport (1998), knowledge map serves like a Yellow Pages directory, which lists the knowledge available and points it. Through it, the users can have a clear vision of what knowledge is available and how they are categorized (Figure 3.4). Therefore, they can find it more quickly.

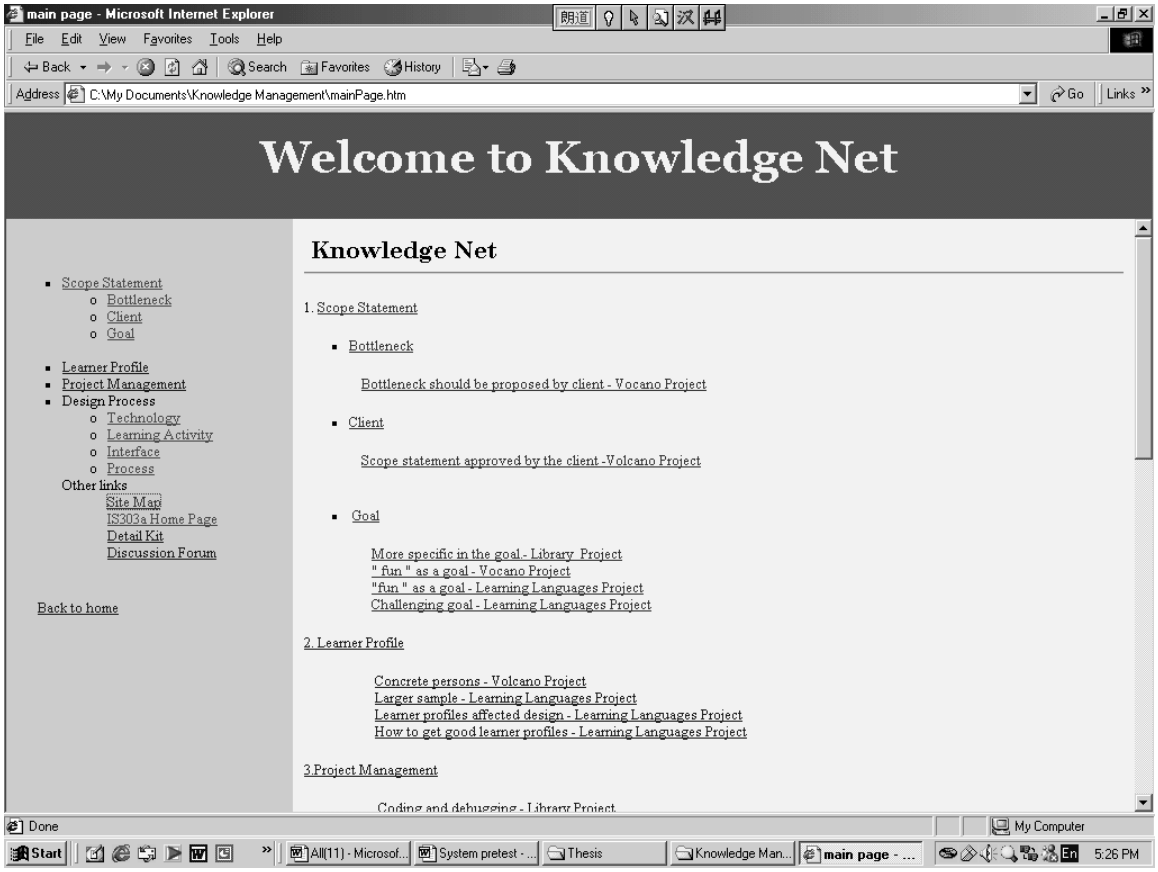


Figure 3.4 Knowledge Map

Due to time constraints and the limited content in Knowledge Net, a searching engine is not implemented. It will be implemented when the repository of comments and projects reach a certain extent.

In summary, Knowledge Net is designed to support user scenarios. It contains four categories and some subcategories. Under each category, there are past students' experience and comments about the project development process. Attached is a link to the project's website. A knowledge map (site map) is provided for the users to develop a clear idea of the content in Knowledge Net and therefore to search more easily.

3.2.4 Pre-test

To ensure Knowledge Net contains the right content for users and is easy and friendly for searching information, a pretest was conducted before the design experiment in the IS303a course. It could clarify some of the designer' assumptions in the design of Knowledge Net and find out whether the design could fully facilitate the use of the students.

Three students -- John, Mary and Alan (anonymous names) participated in the pretests. All of them have taken the IS303a course and have worked in Centre for Learning and Teaching through Technology at the University of Waterloo for a certain period of time. Therefore, they were familiar with the domain of multimedia interactivity for learning.

The test was conducted individually. (Details of the process and the results of the pre-test are presented in Appendix I). The three students were given the following three scenarios for searching information from Knowledge Net:

1. Suppose you are a new IS303a student. You attend classes and are assigned a project. However, you are not very sure of how to do the project. The instructor asked you to hand in your scope statement in two weeks. You are

provided with Knowledge Net, which stores the experience from previous students. What will you do?

2. The scope statement is finalized. Now the instructor asks you to write the learner profiles and turn them in two weeks. What will you do?
3. The scope statement and the learner profiles are well done. Now, you have to sit down and start your design. You do not know what activities you are going to include and what technology you are going to use.

The researcher observed the students' behaviors as they searched the information from Knowledge Net. Then the following questions were asked at the end of the search:

1. Can you easily find the information in Knowledge Net?
2. Can you understand it?
3. Would you apply that information if you had it while developing your project in the IS303a?

The aim of the three scenarios is to simulate the design experiment for the IS303a students. The three questions target at testing the validity of the content as well as the usability of Knowledge Net. After the students used Knowledge Net, a discussion about the functions and suggestions towards Knowledge Net was conducted. The result from the observation and the discussion was consistent. Most of the students felt that they could easily find the information in Knowledge Net and understood some of it. Mary felt that she could apply the knowledge given more details. Andy was very interested in individual IS303a project. By viewing those examples, he felt that "the students may get a better idea of what is expected in the course". He recalled the time when he was an IS303a student. "We knew we had those milestones such as learner profiles and scope statement. However, we did not have a clear idea of what was expected because there were no past examples. "

The students' most difficulties and proposed solutions in using Knowledge Net are summarized below. The problems are categorized into content and usability problems:

Content Problems

1. The comments from previous students were presented under categories such as scope statement and project management. But Knowledge Net does not explain to the users what the category means and what it contains. John and Mary proposed that, for example, the students might not know what a scope statement is and how to prepare a good one. As a result, adding an introduction part in every category, which introduces basic concepts and the content in this section, is essential. Similarly, adding a summary at the end of each category helps to clarify fundamental steps for the task and helps the users to review why what they have read is important.
2. Similarly, Mary deemed that all kinds of opinions from different teams for the same matter might confuse the students. Instead, a summary of the ideal ways to carry on different tasks such as developing scope statement, learner profiles, comparing different technologies for the project might be presented before all the testimonies of different teams.
3. The three students felt that some comments were too brief and need more explanation. For example, John felt confused about one comment in learner profiles indicating that "*use a larger sample for learner profile*". He wondered why a large sample would be beneficial.
4. Some of the terminologies in Knowledge Net needed explanation. For example, previous students mentioned "*webCT front end*" and "*flow diagram*" technology in designing the prototype. However, for new students, those words may be foreign.
5. The sequence of subcategory under "Design". Under the category of "Design", "Technology" appears first and "Learning activity", " Interface " and " Process " follow (Table 3.1). John considered that the sequence of these subcategories should be reorganized according to the sequence of the tasks. "Process", which explains how a team prepares for the design of the prototype, should come first. Followed should be "Learning Activity". After what kind of learning activities should be involved is decided, one then considers "Technology" and "Interface".

In this way, the sequence of the subtasks of design process is more clearly presented.

6. The content under "Project Management" was not enough. John and Mary assumed that this part describe how to break down the project and manage the tasks in a timely manner. However, there was only one thread about coding and debugging, which did not meet John's needs.
7. Andy proposed that for the students who have less knowledge about multimedia, an example or a link to resource pages might be very helpful. For example, if one needs to compare HTML and Flash, it would be helpful to view the products developed with HTML and Flash. In addition, relevant websites including details about the software may be very useful. For example, www.macromedia.com or www.flash.com may contain a lot of interesting things about Flash.

Usability problems

1. There was a link to each project beside each paragraph of comments. However, John failed to notice it. Therefore, he suggested the link be clearly demonstrated to the users in the introduction of Knowledge Net.
2. Knowledge Net did not introduce the functions for Detail-Kit.
3. Andy felt that if several threads comment on the same thing, they should be combined.
4. Andy suggested an index of all the threads (hyperlinks) in one category be presented at the beginning of each section. In this way, the students could have an overall view of the content of this section and click to go to the information of interest quickly.

In summary, the three students participated in a usability test of Knowledge Net and frankly shared their opinions and proposed significant suggestions for improving its content and usability. Generally speaking, there appeared to be more content problems than usability problems. Some assumptions from the designer were not valid. These assumptions include: the students should have certain knowledge towards the terminology used in class such as scope statement and learner profile; the students know

what Detail Kit is; the students know the difference among different technologies such as HTML and Flash.

3.2.5 Revision

After careful consideration of the pre-test, we made the following revisions in Knowledge Net. We divide them here into content revision and usability revision.

Content Revision:

1. A paragraph of "instructor's briefing" was added to each section (Figure 3.5). It introduced the content, defined key words such as "scope statement" and pointed out the importance of this section. Hopefully, the students could develop some interests towards this section after reading it. In addition, to make the briefing more real and convincing, we put an IS303a instructor's picture beside it. To avoid possible biases it may have on students' attitudes towards Knowledge Net, we used the picture of a previous IS303a instructor, who was unknown to the IS303a students in Winter 2002.

Figure 3.5 Instructor's Briefing

2. Samples of the technologies were presented. Samples of projects using HTML and Flash were presented to give the students a real feeling of what those technologies could do (Figure 3.6).

Figure 3.6 Samples of Works with Different Technologies

3. The sequence of the categories in "Design" was reorganized as follows (Table 3.2). "Process" was renamed to "Learning analysis" for it better described its content. "Learning Analysis" came before "Learning Activity" and "Interface". "Technology" came the last.

Name	**Content**
Scope statement	Identify bottleneck, communicate with clients and define scope for the project.
Learner profile	How to collect good learner profiles, what is a good learner profile and how to design the project accordingly
Project Management	How to breakdown the task and the estimate time for each phase

Design		
	Learning Analysis	Prepare before the design starts
	Learning Activity	Interactive learning activities and their contexts
	Interface	How human and computer interacts and key things in interface design
	Technology	Trade-offs of different technologies

Table 3.2 New Structure of Knowledge Net

4. More content was added into Introduction. They included introduction to the hyperlinks to different projects beside each thread and the functions for Detail Kit and Discussion Forum.

Usability Revision:

1.A list of the threads (hyperlinks) was added to the beginning of each section (Figure 3.7). In this way, the students could have an overview of the content in this section without browsing the whole page and could go to any thread easily by clicking on the list.

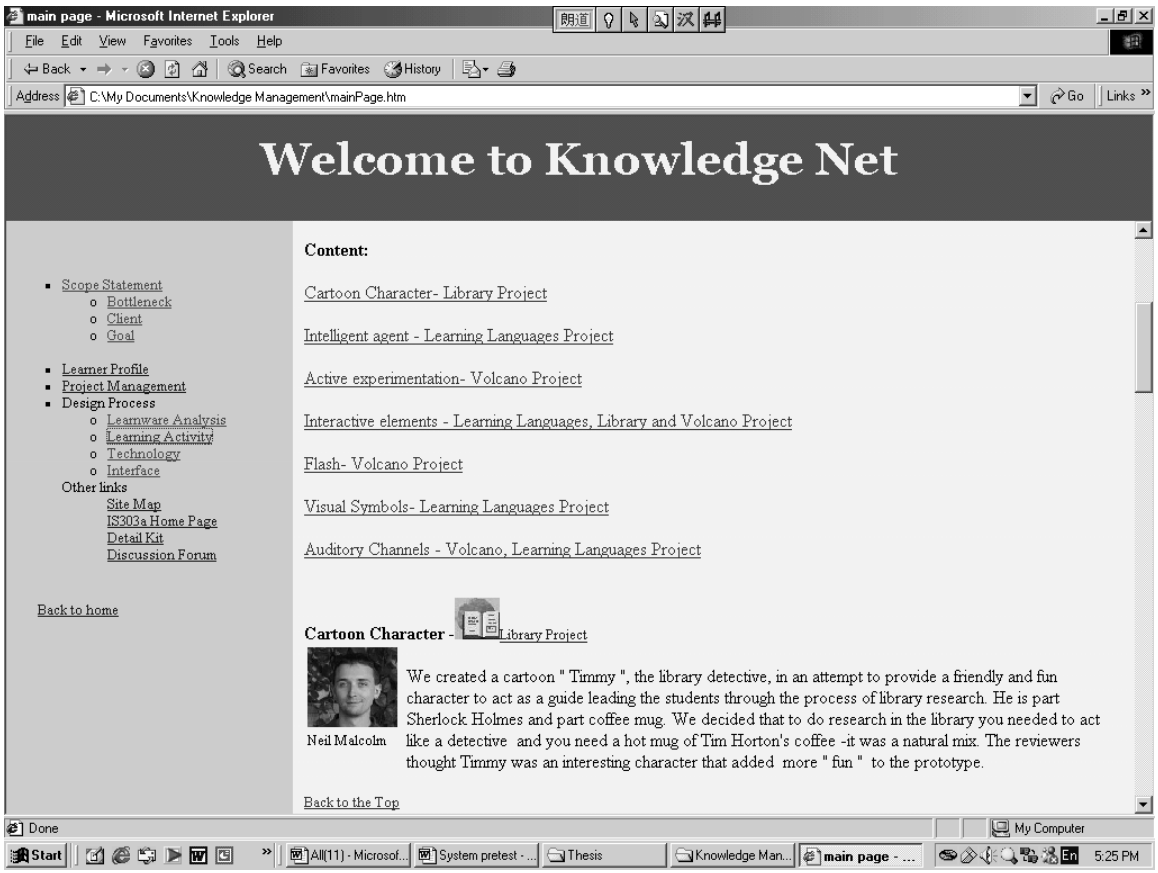


Figure 3.7 A List of Threads in One Section

2. Different threads about the same problems are combined. For example, both the volcano and learning language teams discussed issues of auditory channels. Thus, these two threads were put together (Figure 3.7).

Unsolved problems:

The students felt that the content in project management was not enough. However, the content of Knowledge Net was based on interviews with past IS303a students. Those students hardly articulated any experience in project management. Therefore, it was difficult to get more content in project management from past students. Similarly, some comments needed more explanation. However, because past students were not available on campus at the time, further interviews for their comments on previous projects were not feasible.

After the user-scenario design and pretest, the design of Knowledge Net was finalized. It was implemented and ready for test in the IS303a course in Winter 2002.

Chapter 4 Data Gathering and Results

This chapter has four parts. The first section introduces the data collecting procedures including the questionnaire survey and the qualitative interview. The second section presents the result of the quantitative survey. The third section presents the result of the qualitative interview. The fourth section concludes the findings from the questionnaire survey and the qualitative interview.

4.1 Data Gathering

Eight students registered in the IS303a course at the University of Waterloo in Winter 2002. All participated in the design experiment. Among them, half were female and half were male. Therefore, a gender balance was reached in the design experiment. All of them were undergraduate students from a variety of disciplines including computer sciences, electrical engineering, geography, and art. They were divided into three teams.

Our study employed both the qualitative and quantitative research methods. The following is the scheduled time line for the activities in the IS303a course, including the questionnaire survey and the interview (Light, 2002b).

Week 1 (Jan. 8)

- *Course Introduction*
- *Understanding How We Learn*

Week 2 (Jan. 15)

- *What is Learnware?*
- *Exploring Learnware (MERLOT)*
- *Learnware Walk-Throughs*

Week 3 (Jan. 22)

- *Project/Team Assignments*
- *Working on Teams – Creation of Team Profiles*
- *Team brainstorming and initial project planning (Project Management)*

* *Scheduled Meeting with Faculty Member Client*

Week 4 (Jan. 29)

* ***Browse Knowledge Net and fill in questionnaire surveys***

- *Learner Profiles*
- *Learnware Analysis and Preliminary Gantt Charts*

Week 5 (Feb. 5)

- *Initial Storyboards*
- *Team presentations of Learnware Reviews and Project Plan*

Due: Scope Statement/Stakeholder Identification, Gantt Charts, Learnware Analysis, Learner Profiles

**Scheduled Meeting with Instructor and Faculty Member Client*

Week 6 (Feb. 12)

- *Turning Storyboards into Paper Prototypes*

Week 7 (Feb. 19)

- *No Classes - Reading Week*

Week 8 (Feb. 26)

- *Critiques of Prototypes*
- *Identifying Available Learning Technologies*

Week 9 (Mar. 5)

- *Evaluation*

* *Scheduled Meeting with Faculty Member Client*

Week 10 (Mar. 12)

- *Revising the Prototypes*

Week 11 (Mar. 19)

* *Scheduled Meeting with Instructor and Faculty Member Client*

Week 12 (Mar. 26)

- *Work on Prototypes*

Week 13 (Apr. 2)

- *Team Presentations of Prototypes/Design Rationale*

* ***Qualitative Interview with the students***

By the time of the questionnaire survey, the students had learned basic concepts of this course and ideas of the essential process for their projects. In the survey, the students were asked to browse Knowledge Net for half an hour and to fill in a questionnaire. The questionnaire was designed with both multiple choice and open-ended questions (Appendix II). The main purposes of the questionnaire survey were to examine: Can the students easily find the information they want in Knowledge Net? Can they understand it? Can they apply it? Are they willing to retrieve the information from Knowledge Net and also share their information with others? Most of these questions were designed as multiple choice ones in order to accurately measure the students' evaluation of Knowledge Net.

In addition, some other questions were also explored. These questions include: The students' evaluation of Knowledge Net (their favorite and least liked parts) and their expectations towards Knowledge Net and the IS303a course. Most of these questions were designed as open-ended ones so that they might better give the students latitude to express themselves freely.

The multiple choice questions applied Likert Scale response formats ranging from " totally disagree " (1) to " totally agree " (5). The choices were given right after each statement in order to avoid ordering problems arising from the need to transfer answers to another sheet of paper.

Furthermore, to prevent any personal influence by the researchers on the students' evaluation on Knowledge Net, the instructor conducted the survey. To obviate possible bias from the student, the instructor instructed the students that the survey was anonymous and that their attitudes towards Knowledge Net would not have any influence on their grades in this course.

In addition to the survey, a qualitative group-interview was conducted with all eight students in their last class. Both the instructor and the researcher conducted a face-to-face interview. The interview's aim was to comprehend the students' accumulated experience

and knowledge in this course, their ability to apply past students' knowledge and their attitudes towards sharing knowledge.

The group-interview was conducted by the means of the "DRASTUK!" protocol, an event-based, retrospective, and narrative approach (Carey & Maclean, 1993). With this approach, the students were encouraged to recall and elaborate on the important moments when their team made decisions in the development of the project. By doing so, the issues that were vital to properly understanding the design could be reconstructed. Compared to using short statements, the storytelling feature of this approach is more effective in identifying the design problem, possible solutions, and the criteria for evaluating said solutions. The key elements in the DRASTUK! protocol are listed below:

D- Designers deliberate over a decision. This can also describe a situation where a single designer is working out the issues affecting his/her decision on their own.

R- Reviewers raise an issue. Designers external to the design team are invited to look at the design and they raise issues about a design decision.

A- Attribution. A design decision is determined by events beyond the designer's control and for reasons beyond the context of the design. As such, the decision can be attributed to some factor external to the design.

S- Special knowledge. New knowledge gained by the designers is used to shape the design decision. More specifically, this knowledge can be described as something that other designers are not likely to know.

T- Testing. Formal evaluation of the design on its target population or an appropriate analog raised issue with the design.

U- Uncertainty. The designer implements a design that may work, with known uncertainty about whether or not it is the "right" way to go. For example, the decision may be determined by resource limitations.

K- Kludge. The designer implements a design that may work, but is unsatisfied with it. Given more time and resources, a better design would have been implemented.

!- Inspiration. The designer implements a design that is innovative, and of which he/she is particularly proud.

In summary, the DRASTUK! protocol facilitates the researchers to probe the students to articulate their design decisions in a retrospective way. In this way, the students articulate which decisions were made under which situations with which constraints. Since the project was already developed, they could retrospectively articulate issues raised by the design process. If they could do it a second time, what would they do? Furthermore, some innovative ideas could be illustrated.

4.2 Questionnaire Survey Result

The results of the questionnaire survey are presented in Appendix III. Now, let us review our research questions: given that the information is process and product information about projects from past IS303a students and is presented in their comments in Knowledge Net,

1. Can the new students easily find the information they need?
2. Can they understand it?
3. Can they apply it?
4. What motivates them to access the information and apply it?

The students registering in the IS303a course in Winter 2002 are like new students that access Knowledge Net to accomplish their milestones and projects. From the survey, we could see that most of them (87.5%) felt that they could easily find the information they wanted from Knowledge Net (Figure A.1 in Appendix III). 87.5% articulated that they could understand the content in Knowledge Net (Figure A.2 in Appendix III). 87.5% felt that the content in Knowledge Net could be applied to their projects. Most of the motivations for using Knowledge Net came from their findings that the information in Knowledge Net was useful and that it could provide them shortcuts for their projects. Another important motivation was the belief that the comments from other students were true. Some other reasons mentioned were the interesting components of the information and the experience it provided.

The results from the survey indicate that the design of Knowledge Net was judged to be friendly and easy for the users to understand. The information on process and product knowledge presented in previous students' comments seemed to be widely accepted by the students. In addition, it was perceived to be applicable by the students.

The motivations for using Knowledge Net, consistent with the findings from O'Dell and Grayson(1998), come mostly from the usefulness of the information. From literature review, we can see that O'Dell and Grayson claimed that successful knowledge management systems should provide intrinsic incentives for people such as assisting them to do their work more efficiently and for that work to be of a higher quality. Artificial incentives can not go very far in motivating people.

Similar with their findings, in our survey, the usefulness and the authenticity of the information in Knowledge Net are the major motivations for the students. Previous students' experience is viewed as a very important source of experience. Moreover, the content of the information (boring or interesting) is very significant as well. One student suggested that more details could be given.

Most of the students (87.5%) would like to share their information. The most motivational factor is that sharing itself can facilitate them to understand their work and goals better. The other two major motivators are their belief that sharing information can provide a satisfying experience and their willingness to exchange information with others. There was only one student who mentioned that the request from the instructor might motivate him.

Generally speaking, the students expected both product knowledge including examples of projects and project feedback and also process knowledge including project management from Knowledge Net.

From the perspective of the content of Knowledge Net, we can see that it can be improved in the following ways. The students expected to learn learnware techniques and

project management including a scope statement definition and planning, time management, and teamwork skills from the IS303a course. Knowledge Net presents the information using a scope statement, a learner profile, a project management layout and a design process. Thereby, it met the students' requirements for the course in the perspective of learnware techniques and of a scope statement definition. However, the category of project management contains only one thread on coding and debugging. Therefore, it could not satisfy the students' needs for learning planning, time management, and teamwork skills. Adding more content in project management will add value to Knowledge Net. However, although there is a great demand for information about project management, this kind of information seems to be difficult to articulate and to share. The information collected on project management is the least among all the information we gathered from the previous students. Thus, how to collect more information about project management is worth exploring.

In addition, the students expected past experience and definitions for terms and process (steps) in designing learnwares in Knowledge Net. Past experience includes past mistakes and hitches, common problems and challenges, example of projects, project feedback and tips and advice. Knowledge Net contains past experience including the students' view upon their mistakes and hitches, their alternative methods of doing things if given a second chance and feedback from the reviewers. It also contains example projects. However, there is not enough information about definitions of terms, summary of common problems and challenges and tips and advice. The reason for the lack of definition of terms is that we assume that the students will master those terms in class. Since Knowledge Net was considered to be a complementary tool for class, it did not include the same information in class. However, we found that the students were not very clear about the terms they have learned from classes or textbooks. Therefore, defining relevant terminologies more clearly, adding a summary of common problems and challenges and providing tips and advice will be an asset to Knowledge Net. Instead of being a complementary tool for the IS303a course, Knowledge Net should be a tool that helps to review all of the in-class content.

Furthermore, the students also articulated their favorite parts and least liked parts of Knowledge Net. They liked the design process part and the introductions in Knowledge net the most. Some students also mentioned the scope statement, the personal experience section and the interface structure. Their least liked parts were its small amount of cases, an unclear explanation for the Detail Kit and the project management section. Actually, the functions of the Detail Kit were clearly explained in the introduction of Knowledge Net. Maybe some students failed to notice the fact. Therefore, adding more cases and information about project management to Knowledge Net will be beneficial. In addition, the location of the Detail Kit information should be reconsidered.

In summary, from the survey, we can see that Knowledge Net has reached its basic goals: enabling the students to find, understand, and apply information. Most of the students were willing to access and share information using Knowledge Net. The authenticity and usefulness of the information is important. In addition, the students articulated their expectations towards the IS303a course and towards Knowledge Net and also provided evaluations of different parts of Knowledge Net. Their evaluations offer invaluable resources for future revisions of Knowledge Net.

4.3 Interview Result

To capture the valuable knowledge created and accumulated by the IS303a students in Winter 2002 and to explore the concerns underlying their initial answers in the survey, a group-interview was conducted. Some of their answers involved the possibility of applying the information in Knowledge Net and their opinions towards the IS303a course.

The interview was conducted in the last class of the IS303a course after the students' presentations of their prototypes. Both the researcher and the instructor conducted the interview. To motivate the students to share information, pizzas and non-alcoholic drinks were provided.

The results of the interview can be divided into three parts. All the names in the interview are anonymous. The first part presents the useful knowledge accumulated by the students during the semester. The second part presents the students' discussion about whether the previous students' knowledge could be applied if it was available. The third part presents the students' reflection on the portion of the IS303a course relevant to Knowledge Net.

4.3.1 Useful Knowledge for New Students

Encouraged by questions according to the DRASTUK! protocol, the students were able to recall the important moments of their projects. The details of the interview are presented in Appendix IV. The following is what they thought might be valuable to subsequent students in this course.

Communication with the client

The students felt that communication with the clients was pivotal to the success of the project. Sometimes, the clients might have a totally different idea from the students of what the final product should be like. The gap would severely block effective communication between the two and hinder the progress of the project. Betty described the circumstance of how her team encountered the above problem in the following paragraphs:

> *Betty: We were getting frustrated. We didn't know what was going on. We kept on going to our clients all the time. And we were never getting anything back.*
>
> *We sent him (the client) an e-mail. I listed to him everything we needed from him exactly. "Tell me this. Tell me that." And I basically said "can you give it to me by tomorrow?" We have been asking him for three weeks (the whole time).* ***But we did not lay [it] all out in the e-mail directly "this is what we need you to give us".***

And his reply was our "a-ha " moment. He was like "why are you guys asking for all these contents? I don't think you are supposed to get anything done, like any kind of working model.

That, to us was our "a-ha " moment because then we could understand where our problems were all along because it wasn't us having problems communicating so much. … It was more that [what] ***he had in his mind [was] completely different than [what] we had in our minds [about] what our final results [were]*** ~~***are***~~ ***supposed to be***. *So he didn't answer the questions in the way we were looking for.*

When asked their suggestions to the new students for avoiding this type of problem, they proposed the following methods: specify the requirements on paper, have a third person observing the meeting with the client, and go through some previous projects with the client:

Betty: We went to the client so many times to try to get that [-- the requirements for the project]). For us, if we had tried to put ~~*it*~~ *[them] down on paper, 'see, this is what we tried to do', he would have understood more.*

Betty: The only thing I regretted is that the instructor volunteered to sit in the meeting with us for a few times. But we did not let her come because we thought we could solve the problems ourselves. The only thing I could possibly suggest is that to have another person there[-- in the meeting with the client], maybe she [or he] could point out the fact that he [-- the client] wasn't looking at it the same way we were looking at it.

Gorwin: Or going through with him ~~*with*~~ *an example of previous project. "This is what we need in a month and a half."*

Storyboard

The students recalled that they did not realize the importance of the storyboard (paper prototype) until later in the semester. If they had drafted the storyboard earlier, they would have had more time to correct their mistakes and to deliver a better project.

> *Researcher: If I am a new student, want to learn from you, and will really believe in what you say, what will you tell me?*
>
> *Glasha: Content and paper prototype. Up until the instructor showed us the paper prototype, that day or that night, we really didn't know we were supposed to do [it].*
>
> *Betty: As we move to the deadline, some of the things like storyboard … Although it is hard to conceptualize things, but actually sitting down and even doing a paper one will help us to have an idea of what is built and [to] get things done.*

Furthermore, some hoped that the prototype could be due earlier so that they would not bump into problems too late.

> *Betty: The final quality of our project would be better if we have moved some of the things up ~~earl~~y [earlier]. We would have run into some of the difficulties we ended up running [into] at the end of the term earlier and we ~~will~~ [would still] be able to incorporate those changes.*

What the students said can be summarized into two major lessons. They learned that effective communication with the clients is key to get the content for the prototype and that work on the storyboard should commence earlier.

4.3.2 Applicability of Others' knowledge

After sharing useful knowledge learned from this course, the students were asked that if this knowledge had been stored in Knowledge Net or told to them by other students, would they able to apply it in their projects**? Most of the students said that they would not be able to use it.** There are a variety of reasons. Betty and Gorwin believe that it is a learning process where self-experience is more valued than the experience of others.

> *Researcher: Would it be helpful if someone had told you (some of the knowledge you have just shared with us)? For example, if someone told you that implementing the storyboard ~~took~~ [takes] a long time, would it help you to do better with your project?*
>
> *Betty: You mean "start earlier"? No, I don't think so.* ***I think if there are some deadlines [such] that you have to present something by a certain date, that will make me start early.*** *But if somebody ~~just~~ tells me "O-Oh, it is going to take long time. You'd better start early". Sometimes maybe that really helps. Like CS241 [-- a course], they told you about the horrors of assignment 5 from the beginning of the year. You hear horrible stories from everyone. Yes, I started assignment 5 and got it out. But* ***other than that, I will not.***
>
> *Gorwin:* ***I think it is part of learning.*** *Like students from this Internet [presented in Knowledge Net], they told you that were hard. I won't listen to them, right? Even if every student told me that I need to do it quickly, I don't think I would have followed them.*

One reason accounting for belief in self-experience may be that the students do not believe that the lessons and failures from other people will actually apply to them. Instead, they think that those only apply to other people.

Researcher: If the instructor says something, will you believe her?

Betty: I would think maybe it is true ***generally, but not it is going to necessarily apply to me****. As we have talked about different rules people can have, OK, those are old … something happened or may happen. Well, let's see how it works for us.*

Gorwin: Even if, like I am sure that we were told to expect problems, but we did not really think **WE** ~~will~~ [would] experience these things.

Gorwin stated that he would not easily believe in the information from the Internet unless he knows the person sharing the knowledge. He felt that face-to-face contact was much more convincing than contact with people using the Internet.

Instructor: Do you think [that] if you spend more time and depth on those [past projects] like in terms of what we did in learnware analysis, should we analyze some of those past projects?

Gorwin: I think it would be ***nice if you could have them [the students] come in and talk.***

Gorwin: By talking to them, it is more believable. I don't know why I don't believe it [-- information from Internet]. ***Sometimes I just prefer to talk to them.*** *It's more believable.*

Researcher: What kind of information will you believe?

Gorwin: I think it really depends. Sometimes I don't believe it even it's on the Internet. ***It really depends on if I know the person.*** *If you just put a few people [on the internet] telling you that you should to start something, I tend not to listen*

to them. But if you have them coming to [me] face-to-face or something, I may be more willing to accept it.

Mike and Lily like videotapes of other students sharing knowledge more than Knowledge Net because the information from videotapes appeared to be more real than that from the Internet. They also felt that after information was written down, it was edited and lost the original meaning. Betty shared the same view.

Mike: I think I will believe video a lot more.

Instructor: Video like they are talking about their experience?

Lily: ***It is hard to fake something like that.***

Mike: I kind of like ***informal discussion*** *as in the video.*

Betty: A lot of the times when something got written down, it's so formalized. It seems not real. … "Yes, we had such a problem with our client." They are more open to say [that].

4.3.3 Reflections in the IS303a Course Relevant to Knowledge Net

The students also proposed some disadvantages of the setting of the IS303a course and some useful suggestions for the course relevant to Knowledge Net. The following were their major concerns and suggestions for the IS303a course.

Content

The students were not so clear of what the instructor meant by "content" and did not know how much was enough for the project. They thought that some definitions or past examples similar to their projects would be helpful in explaining it.

Instructor: Well, it is an interesting thing because I know I have told you a number of times "you need content long before you need it". I know I have said that the crunches were going to come at the end.

Betty: I think that for "get content", " get content", ***we do not know what we need*** *…" Content" may not be the same sense you mean. Maybe the definition will help.*

Instructor: I wonder what specific kind of information we could give to the students upfront that could make them go "OK, I understand what that means for my project".

Mike: I think you could sort of categorize the types of projects. Oh, this project, you are going to need this kind of information. Or previous projects that have been similar in content.

Lily: I think for us, I didn't realize just how much content we needed. I guess it depends on the actual learnware module [as to] how much ~~it~~ [is] actually ~~needs~~ [needed]. But for us, a little bit [hint] would have probably been a great help. Just how much we actually needed for this project.

Balance for the content between the prototype and the product

Some students were confused about the balance between the actual content in the design and in the prototype. They expected it to be clarified with some definitions or past examples.

Lily: I thought we had a difficult time balancing how much content ~~do we~~ actually ~~need~~ [needed] to have [for a] design and [for] actually prototype. Maybe from the beginning, if it is clearly defined for the expectation for [each] stage, more

examples of how they did, have the prototype due earlier or the paper prototype due earlier, so [that] we will not be so frustrated at the end. 'Oh, my God, we need to get everything done. ' "

Comments from the instructor for the past projects

Some students would like opinions from the instructor about past projects because she was more experienced.

Mike: ~~The~~ [With the] past projects like the Galaxy, we know what we like about them. But we would like to know (your view), if you told us. We did that in the first month of class and ***we did not have much experience doing that.***

More deadlines and small tasks

Most of the students admitted that the marks were their biggest incentives for doing things in the course. They suggested that instead of having one deadline for the whole project, having more deadlines and smaller tasks would help them to decompose the jobs all along the semester without piling work up at the end. Here is how Jack described his preference.

Jack: [I] can't do things until the deadline. ~~Having~~ [Have] more deadline and [give] ~~small~~ [smaller] tasks every two weeks time. Small tasks worth 10% and 5% of something [will] ***~~Just to~~ give the students a reason, a practical reason for doing something.*** *For this course, half of the project is not due until the last week. Breaking down the marks will be good.*

Instructor: Do you think small assignments [such as little milestones] along the term will be better?

Jack: You can give 2% for just coming up with the title.

Have the storyboard due early

There was a debate over when the storyboard or the final prototype should be due. Some students would like the storyboard and the final prototype due a little earlier so that they can be able to incorporate the suggestions from the clients in the final project. However, some students preferred the prototype due on the last day.

> *Lily: Have the prototype due earlier or the paper prototype due earlier so that we will not be so frustrated at the end. 'Oh, my God, we need to get everything done.'"*

> *Betty: The "why" [for having things due earlier] for me is that we would have made a lot of progress. It would have been clearer what we were doing . The final quality of our project would be better if we have moved some of the things up ~~early~~ [earlier]. We would have run into some of the difficulties we ended up running [into] at the end of the term earlier and we ~~will be~~ [would have been] able to incorporate those changes..*

> *Gorwin: I like it [-- the prototype] due ~~in~~ [on] the last day.*

In summary, in the interview, the students shared their most significant lessons – effectively communicating with the clients and starting work on the storyboard early. In addition, they also admitted that they could not apply the knowledge even if it was in Knowledge Net or articulated to them. The reasons vary. Some students believed in self-experience more than secondary experience (others' experience). Some students did not trust information from the Internet. They preferred face-to-face contact with past students or videos of students' sharing knowledge. Finally, they also proposed valuable suggestions about the course. The main suggestions were: communication with the instructor (clarify the definition of content and the balance of content in the prototype and

the product), have more opinions from the instructor about past project, have the storyboard due early, and set more and smaller task for the project.

4.3.4 Summary of the Interview Result

The interview had amazing results. By using this interactive format of communicating with the students, we are able to understand what the students think about Knowledge Net and the IS303a course.

In this section, we summarize the interview result and provide suggestion for changes to Knowledge Net according to the students' reflection. Although we did not directly ask the research questions, the students' recall about their important moments in their project development and their reflection towards the IS303a course relevant to Knowledge Net implied the answers to the questions.

In the interview, the students were persuaded to share the useful knowledge learned from the IS303a course. The questioning process ran very smoothly. The students were quite willing to recall some important moments in their decision making processes for their projects, to share their experience, and to give out suggestions for the students of next generations. This response was consistent with O'Dell and Grayson's (1998) experience – people by nature are more willing to share than to hide information. However, the kind of mechanism for sharing influences whether people share and how much they will share. Our study finds that the students are willing to share in a group interview setting. In a group interview setting, after one responds to a question, others can complement his/her answer. If anything is not very clear to the interviewer or the interviewee, it can be clarified immediately.

From the perspective of the content of the knowledge that is being shared, we have interesting findings. Some of the important experiences recalled by the IS303a students were in line with those of the past students. For example, Kevin, a former IS303a student illustrated how his team misunderstood the professor's initiative of the project and how

the mistake was corrected in the following paragraph in the "scope statement" category in Knowledge Net. Their problem was quite similar to what Betty's team had come across with their client in Winter 2002:

> *We originally chose to focus on the social science factors in the project because our client -- Dr. Halley from department of earth sciences -- constantly mentioned the value of his [research] materials ~~in research in~~ on the social-economic aspects of volcanoes. However, we were quite wrong. Dr. Halley wanted to focus on the geology side instead.*

In the end, Kevin added, "*It was fortunate that the scope ~~got~~ [was] clarified and corrected. Otherwise, we would have wasted time in organizing materials for the wrong scope"*. This message was like a warning for new students.

The common knowledge about communicating with the client shared by the two teams implied that the same happenings have occurred again and again to IS303a's students. In addition, they are very likely to occur again in the future due to the similarities of the nature and the clients of the IS303a projects. Therefore, key research questions are: Can students apply the knowledge learned from others from Knowledge Net? Can sharing knowledge assist in building a learning curve among different generations of students and therefore save their time and efforts in developing projects? The students' responses to these above questions were negative in the interview.

Although students frankly shared their valuable experience and lessons learned in the past semester, most of them admitted that they would not be able to apply this knowledge even it had been stored in Knowledge Net. A variety of reasons accounted for this interesting phenomenon. Some students such as Betty and Steven would rather experience everything including lessons and mistakes by themselves rather than by listening to others' stories because they tended to believe more in their own experience than in that of others'. Some students deemed the information from the Internet(including Knowledge Net) unreliable and fake and therefore preferred face-to-face contact in a real

sense. Similarly, other students such as Gorwin would be convinced more by face-to-face contact than by information from the databases or the Internet.

The students' longing for meeting previous students whom could share the knowledge was consistent with Szulanski's findings(1994). He found that "people absorb knowledge and practice from other people they know, respect, and often like"(Szulanski, 1994) "If two managers have no personal bond, no tie or link which preestablishes trust, they are less likely to incorporate each others' experiences into their work." (Szulanski, 1994) Therefore, a tie of trust can be built if the knowledge recipients know the knowledge contributors. The tie can therefore facilitate sharing and reusing of knowledge.

There might be different reasons for the students who tended to believe in their own experiences rather than in the experiences of other people. Hence the saying: "seeing is believing." This old proverb may explain why the students preferred experiencing things for themselves. Another reason might be that the students did not have the absorptive capability. For example, they might not have enough experience to understand the knowledge from others and therefore could not apply it. For example, even if Betty reads the knowledge shared by Kevin about the communication with the client in Knowledge Net, she might not link this immediately to her own situation. Therefore, she is only aware that there may be some problems in the communication with the clients, but could not understand the true meaning of this information and therefore could not apply it.

In addition, the students have provided many significant suggestions for improving both the way that the IS303a course is taught and Knowledge Net itself. First of all, they proposed more past project examples be shown and that more definitions be provided. The reasons for providing definitions may be that the same terminology may mean different things to different people. For example, the IS303a instructor emphasized the importance of "content" again and again to the students. However, the students did not understand what she meant. Also, it may be comprehended as something totally different by the clients. Therefore, definitions for the terminologies coupled with more examples will help to clarify definitions and ideas to the students. In addition, some students were confused about the balance between the content of the prototype and the product. They

said that a little hint such as guidelines or past examples would be of great help to them. Second, although Knowledge Net contains different teams' opinions for projects, the students valued the instructor's ideas more. As Mike mentioned in the interview, they knew what they liked about the past projects, but they would very much like to hear a review or comments from the instructor. Third, most students admitted that marks were their biggest motivations for doing work in class. They usually would not do their work until the deadline approached. Therefore, they suggested having the project divided into smaller tasks, with each worth some marks. As a result, they could be motivated to accomplish those little milestones gradually. In addition, some students suggested having the storyboard due earlier so that they could realize and fix their problems earlier.

In summary, in the interview, the students provided valuable knowledge that they have accumulated during the semester. Such knowledge includes how to communicate with the clients more effectively and a suggestion to start working on the storyboard early. In addition, the students admitted that they could not apply the information in Knowledge Net. Part of the reason might be a lack of prerequisite knowledge and experience. Furthermore, from the interview process, we can see that the students like to share information in a group setting. The students also said that they would prioritize the tasks that counted for marks in the course. This idea implies that giving out marks is motivator for students to use knowledge management systems and to share knowledge.

4.4 Summary of the Design Experiment Results

The questionnaire survey and the qualitative interview explored the students' opinions towards Knowledge Net and towards knowledge sharing from different angles. The questionnaire survey systematically recorded the students' opinions while the interview probed into the students' thinking process underlying their answers in the questionnaires.

Overall, the students could easily find the information they need. The structure and the interface of Knowledge Net were both well accepted by the students. However, interestingly, although most students (87.5%) initially said that they understood the

information and could apply it as their project progressed, they contradicted this idea in the final interview. A number of reasons may account for this phenomenon. One is the timeline. The questionnaire survey was conducted four weeks after the school began. At that time, the students just had a basic understanding of the terminologies in the course and had not started on their projects. However, the interview was conducted during the last class of the course after the students had developed and presented the prototype in class and had mastered the skills in this course. Therefore, the time gap between the two studies might explain their conflicting behavior.

Another reason may be the nature of the method of study. The students were asked to fill in the questionnaires independently without discussing with other students. But they were interviewed on a group basis, which allowed them to interact with each other and to reflect on their experiences in the course. Therefore, their thinking processes may be different under these two circumstances.

As the interview was conducted in an interactive way and since it was done at the end of the semester, at which time the students had more knowledge of the course, we consider the results from the interview as more important findings than those of the questionnaire survey. From the interview, the students clearly stated that they did not feel that they would be able to apply the knowledge from Knowledge Net. Since our study did not employ any artificial incentive method to stimulate or to force the students to apply the knowledge, we could see their response as being negative to the question of "will the students apply the knowledge in Knowledge Net?" However, we are not sure if the students "can" apply the knowledge in Knowledge Net if they are forced to do so.

Different reasons account for their unwillingness to apply the information. We are not sure if it is solely because that they do not understand the information or that they do not trust the knowledge provider. As a result, the answer to the second research question remains unclear in our study.

The usefulness and the authenticity of the information are the motivations for the students to use Knowledge Net. From the interview, we can see that the students considered the marks to be a major motivator for their behaviors in class. Using Knowledge Net could have been prioritized if it had counted for marks.

Chapter 5 Conclusion

This chapter is divided into three sections. The first section illustrates the suggestions for revision of Knowledge Net and the associated social system used to encourage students to access, apply, and share useful information with other generations of students. The second section suggests limitations of our study and a future research agenda. The third section discusses some reflections about the design experiment.

5.1 Future revisions for Knowledge Net and its associated social systems

The results from the questionnaire survey and the qualitative interview provide significant resource for revision of Knowledge Net and its associated social systems for knowledge sharing and reusing. In this section, we are going to discuss these revisio ns.

According to the students' response, Knowledge Net and its associated social systems can be changed in the following ways:

1. Personal contact between the knowledge contributors and the knowledge recipients should be established. As the students stressed in the interview, they tended to believe more in the people rather than in the information from the Internet and from databases. Therefore, arranging meetings between the current IS303a students and the previous students may enhance the credibility of the information contained in Knowledge Net. Personal contact can establish ties between the two parties. This contact can stimulate the students to access the information in Knowledge Net and can add credibility to the information. Face-to-face contact can help to clarify questions and puzzles and to facilitate both sides to see the necessity of sharing knowledge more clearly. Usually, there is some important tacit knowledge that is hard to articulate. Personal contact can help to expose tacit knowledge. In addition, personal contact can help in recognizing the contributions from the knowledge providers and thereby stimulate the students to share knowledge.

2. If personal meetings between previous students and current students are hard to arrange, videos of the students sharing knowledge would be a great complement to Knowledge Net. Some students doubted the reliability of the information from the Internet and browse-based information like that contained in Knowledge Net, but they considered the videos of testimony from previous students trustworthy. For more information of how the storytelling feature of videos could help students to understand the information, please refer to Palmer's (2002) thesis proposal.

3. Some marks could be assigned for using Knowledge Net. As marks play an important role in motivating the students in the course, assigning marks to use Knowledge Net could encourage the students to use the system and to gradually turn this usage into a habit.

4. The instructor should play a more important role in guiding the use of Knowledge Net. As a recent article of Liang et al (2001) points out from research in knowledge sharing among peers in a class in Stanford University, when the teaching staff recommended a certain piece of information to a team, the team was more likely to check it out and to continue to use the associated system.

   Similarly, the IS303a instructor could stress the usefulness of Knowledge Net and incorporate it into the course agenda. In addition, specific information in Knowledge Net may be recommended to certain teams in order to solve particular problems. In this way, the information is filtered and is made certain to be useful for the team. It can enhance the team's trust of the information and can encourage their future use of Knowledge Net.

5. Situated learning and anchored learning may be implemented to complement Knowledge Net. One of the reasons that the students would not apply the knowledge in Knowledge Net may be that they do not understand it. They do not understand what kind of problems will occur in their project development and why they will happen.

   According to Garvin (2000), unanchored ideas and contexts are hard to understand unless they are taught in familiar contexts, settings and environments. Similarly,

accessing the information in Knowledge Net without an in-depth understanding of its context makes it hard to understand.

Situated learning (Stillman et al, 2000), suggests that knowledge and skills should be acquired in contexts that reflect the ways in which that knowledge will be used in a real life situation. The learning process may be more effective when it is situated and grounded.

Therefore, the instructor can provide different problems to the students and can ask them to provide solutions. These problems are the common problems encountered by the IS303a students. Working to solve the problems, the students can then try to reexperience what the previous students have experienced in their project development and can then relate their shared knowledge to the problems. In this way, the students can have a clearer picture of the scenarios in project development and can understand the knowledge in a more practical way. This procedure can help them to internalize the knowledge and to apply it.

6. Increase the amount of projects in Knowledge Net. As some students mentioned, the amount of information and projects were not sufficient for them to have a comprehensive view of the course. Thereby, adding more projects and more comments from the students is essential.

7. A case study could be employed, since, one student asked for more details of the project. According to the findings of Carey and his colleagues (1998), a case study method is suggested in this situation. " A case study is a partial, historical, clinical study of a situation which has confronted a practicing decision maker...to give students an opportunity to put themselves in the problem solvers' shoes" (Christensen & Hansen, 1987). The storytelling feature of a case study can transport the students' experience into key situations encountered by past students and can involve them as though they were the actual participants (Wenger, 1998).

Our study has been significantly different from Giordano (1998)'s in the perspective of the social systems that facilitate knowledge access and sharing. Giordano simply made the use of shared memory a course requirement, forcing the students to use it. Under this

circumstance, the students had no choice but to use the systems. This behavior could not explore the students' preference in the social systems around knowledge management systems. In our study, the students accessed Knowledge Net on a voluntary basis. Under these circumstances, they could reflect on their experience and could better articulate what kinds of social systems could possibly better facilitate their use of Knowledge Net. They expressed a preference for face-to-face contact with past students and requested more guidance from the instructor. They also suggested incorporating use of Knowledge Net into the course requirements so that they would be more motivated to use it.

5.2 Limitations of our study and future research agenda

5.2.1 Limitations of our study

The following are the limitations of our study: 1. Due to time limitations, we cannot collect more comments from the students. 2. We do not study the relationships between the characteristics of students such as their gender, their familiarity with computers, their disciplines, and their attitudes towards Knowledge Net. Kevin, a previous student in IS303a, showed that he would be able to save some time and energy if his knowledge of effective communication with the clients was obtained before he started his project. His attitude was completely different from those of the students in the IS303a course in Winter 2002. Part of the reason might be that Kevin was more mature with more working experience than the IS303a students in Winter 2002 semester. This point suggests that personal characteristics may have an effect on use of Knowledge Net. 3. The sample size is not big enough due to the limited number registering in the IS303a course.

5.2.2 Future research agenda

The following issues can be studied in the future: 1. The relationship between the characteristics of the students such as their gender, their familiarity with computers, their disciplines, and their attitudes towards Knowledge Net can be explored. 2. If using Knowledge Net is a part of the requirement of the course, will the students benefit from the information in it? 3. We can employ case studies and anchored learning methods to complement Knowledge Net. The effects of how these methods affect students' understanding of the information may be studied. 4. The same design experiment can be

tested using graduate students. Different from undergraduate students, the graduate students are expected to collect information and to take charge of their studies without the reinforcements of marks and the instructor. Therefore, graduate students may have different opinions of the same questions than undergraduate students. 5. The students' attitudes towards knowledge management systems can be investigated in another course or in another university. This method could test the generalization of our study and discover new issues for enhancing the students' positive attitudes towards knowledge sharing. 6. For the students who have used knowledge management systems at school, will they adjust to the sharing environment more quickly in companies than others will? A follow-up study can be employed in order to study the different attitudes of graduates for sharing knowledge in companies.

5.3 Reflections about the design experiment

Reflecting from our study results and from the process of our design experiment, we would like to change the experiment in the following ways, given a second chance:

1. The students were asked to **browse** Knowledge Net in the questionnaire survey. Therefore, they may not think to look for specific information. As a result, the test of whether Knowledge Net facilitates the students to find the necessary information may not reflect the truth accurately. Next time, different scenarios similar to those in the pre-test could be given to the students, requiring them to search for specific information.

2. The questionnaire survey of Knowledge Net was conducted during the middle of the class. At the beginning of the class, the instructor reviewed the content of the last class including planning, project management and teamwork. This ordering may have had an effect on the students' expectation towards Knowledge Net and the IS303a course in the survey. Next time, the survey could be conducted at the beginning of the class when the students have no recent memory of any lectured content from the course.

3. To avoid possible bias caused by the instructor, we used a previous IS303a course instructor's picture in Knowledge Net. However, this instructor happened to be a

client working with a team in Winter 2002. This may cause some biases of the students' attitudes towards Knowledge Net.

4. The students were only asked to browse Knowledge Net for half an hour. This amount of time may not enable them to understand the functions of Knowledge Net or to understand the information in it thoroughly. Next time, we could give the students the URL of Knowledge Net and ask them to search for information after class for the whole semester. This method may allow them more time to explore it.

5. Project management was categorized differently from scope statement in Knowledge Net. However, in some experts' opinions, project management should include scope statement. The "Project Management" in Knowledge Net may refer to time management and team work.

6. Since the students value the instructor's opinions, the instructor could play a more significant role in the experiment. According to Collins(1988), the design experiments with teachers as co-investigators tend to be more successful. The instructor can have a view of Knowledge Net at its design stage and provide valuable suggestions. Instead of just introducing Knowledge Net in the survey, the instructor could incorporate it into the course agenda. He/she can introduce Knowledge Net in class, encourage the students to use it, and recommend relevant information contained within it to them. In this way, the students may value Knowledge Net more.

7. The questionnaire survey and the qualitative interview should be conducted in the same period of time. In our design experiment, the qualitative interview was conducted eight weeks after the questionnaire survey. Therefore, conflicts between the two studies could not be conclusively explained as being due to the time gap or due to other issues. Conducting the questionnaire survey and the qualitative interview at approximately the same time could eliminate the variable of time in our analysis.

8. More specific questions could be asked in the questionnaire. In the questionnaire, the students were asked if they could understand the information in Knowledge Net. This type of question is very general in a way that is hard for the students to answer. In addition, although most of them answered "yes", they may not know to what extent of

understanding the question refers. In a future experiment, we would want to ask questions on more specific information contained in Knowledge Net. In this way, we could judge whether the students really master the information or not.

In conclusion, we have performed a design experiment in the IS303a course in Winter 2002 at the University of Waterloo. A knowledge management system, Knowledge Net was used and evaluated by the students. We have employed both a questionnaire survey and a qualitative interview to gather data. Our results show that the students can easily find the information in Knowledge Net. Whether they can understand it or not is unknown. In addition, they felt that they would not be able to apply the knowledge. They suggested that the biggest motivation for accessing information in Knowledge Net is the usefulness and the authenticity of the information. Furthermore, the students also proposed many good suggestions for revising the settings of the IS303a course and Knowledge Net. We concluded that using personal meetings between past students (knowledge providers) and new students (knowledge recipients), using tapes of knowledge sharing to complement Knowledge Net, having instructor's involvement in guiding the use of Knowledge Net, using marks as an incentive, and employing case studies and anchored learning to complement Knowledge Net could all help the students to better understand the content in Knowledge Net and to stimulate their sharing behaviors.

References:

Agrawal, A. (2001) University-to-Industry Knowledge Transfer: Literature Review and Unanswered Questions. *International Journal of Management Reviews*, 3(4), 285-302.

Ahmed, K. P., Kok, K. L. & Loh, Y. E. A.(2002). *Learning through Knowledge Management.* Oxford: Butterworth Heinemann.

American Productivity & Quality Center (1996). *Emerging Best Practices in Knowledge Management.* Houston, TX: American Productivity & Quality Center.

American Productivity & Quality Center (1997). *Using Information Technology to Support Knowledge Management.* Houston, TX: American Productivity & Quality Center.

Bell, P. (1998). *The Knowledge Integration Environment: Relating Debate and Conceptual Change through Design Experiment.* Paper presented at the Annual Meeting of the American Education Researcher Association in 1998. Retrieved September 17, 2002, from http://www.kie.berkeley.edu/events/aera98.html

Brooking, A. (1999). *Corporate Memory.* New York: International Thompsom Business Press

Brown, A. (1992). Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings. *The Journal of the Learning Sciences*, 2(2), 141-178.

Carey, T. T. & Maclean, A. R. (1993). *Discount Design Rationale: Event-Based Retrospectives.* Unpublished Internal Research Report, Rank Xerox Europarc Research Center, Cambridge U.K.

Carey, T. T., & Minstrell, J. V. (1996*). Experiences with learning scenarios in an authoring support environment.* Proceedings of EdMedia'96.

Carey, T. T., Mitchell, S., Peerenboom, D. & Lytwyn, M. (1998). *Design Evolution in a Multimedia Tutorial on User-Centered Design.*. Proceedings of CHI 1998, 109-116.

Carey, T.T., Harrigan, K., Palmer, A. and Swallow, J. (1999). Scaling up a Learning Technology Strategy: Supporting Student/Faculty Teams in Learner-Centred Design. *Journal of the Association for Learning Technology*, 7(2), 15-26.

Christensen, C. R. & Hansen, A. (Ed) (1987). *Teaching and the Case Method*. Boston MA: Harvard Business School Publishing.

Collins A. (1988). Toward a Design Science of Education. *In E.Scanlon & T. O'Shea (Ed.)*, New Directions in Educational Technology (pp. 15-22). Berlin Heidelberg: Springer-Verlag.

Corral, S. (1998). *Knowledge Management: is it Our Business.* Retrieved May 6, 2002, from http://www.ariadne.ac.uk/issue18/knowlegde-mgt/

Davenport, T. H. & Prusak, L. (1998). *Working Knowledge.* Boston: Harvard Business School Press.

Dixon, N. (2000). *Common Knowledge.* Boston: Harvard Business School Press.

Drucker, P.F. (1998). *The Coming of the New Organization.*. In Harvard Business Review on Knowledge Management (pp.1-19). Boston: Harvard Business School Press.

England, E. & Finney, A. (1996). *Managing multimedia*.. Massachusetts: Addison-Wesley.

Garvin, D. A. (1998). *Building a Learning Organization*. In Harvard Business Review on Knowledge Management (pp.47-80). Boston: Harvard Business School Press.

Garvin, D.A. (2000). *Learning in Action.* Boston: Harvard Business School Press.

Garvin, T. (2002). Birds of a Feather. *Trainin,*38(3), 58-68.

Giordano. D. (1998). *Contributing to and Using a Shared Designed Memory: Effects on Learning Analysis and Design Skills.* Unpublished Ph.D dissertation at University of Concordia, Canada.

Hsi, S. (1998) *Overview & Motivation.* Paper presented at the Annual Meeting of the American Education Researcher Association in 1998. Retrieved September 17, 2002, from http://www.kie.berkeley.edu/events/aera98.html

Jarvis, P., Holford, J., & Griffin, C. (1998). *The Theory and Practice of Learning*.. Kogan Page

Kleiner, A. & Roth, G. (1998). *How to Make Experience Your Company's Best Teacher.* In Harvard Business Review on Knowledge Management (pp.137-151). Boston: Harvard Business Press.

Kolodner, J. (1998). The Design Experiment as a Research Methodology for Technology Education, *Proceedings of the American Association for the Advancement of Science in 1998*. Retrieved June 17, 2002, from http://www.project2061.org/meetings/technology/Kolodneredited/Kolodneredited.htm

Liang, T., Bell, D. G. & Leifer, L. J. (2001), Re-Use or Re-Invent? Understanding and Supporting Learning from Experience of Peers in a Product Development Community. *Journal of Engineering Education,* October, 519-526.

Liang, X.H. (2002). Welcome to Knowledge Net. Retrieved May 5, 2002 from http://www.eng.uwaterloo.ca/~x5liang

Lee, J. N. (2001). The impact of knowledge sharing, organizational capability and partnership quality on IS outsourcing success. *Information & Management,* 38, 323-335.

Liebowitz, J. (2001). Knowledge management and its link to artificial intelligence, Expert System with Applications, 20, 1-6.

Light, T.P. (2002a). *Introduction to IS303a Course.* Retrieved May 6, 2002, from http://lt3.uwaterloo.ca/

Light, T.P.(2002b). *The IS303a Course Notes.* Unpublished Teaching Material, University of Waterloo, Waterloo, Canada.

Lundberg, B. G. (2000). *The Academic Organization: An Approach to Knowledge Management.* Paper presented at International Conference on Decision Support through Knowledge Management July 2000, Stockholm, Sweden.

Nonaka, I. (1998) *The Knowledge-creating company*. In Harvard Business Review on Knowledge Management (21-45), Boston: Harvard Business School Press.

O'Dell, C. & Grayson, C. J. (1998). *If Only We Knew What We Know – the Transfer of Internal Knowledge and Best Practice.* New York: The Free Press.

Palmer, A. (2002). Storytelling System: Evaluating an Online Educational Storytelling Environment, Master Thesis Proposal, University of Waterloo, Waterloo, Canada.

Peffer, J. & Sutton, R.I. (1999), *Knowing "What" to Do is Not Enough: Turning Knowledge into Action.* California Management Review, 42(1), 83-108.

Pervaiz, K.A., Lim, K. K. & Loh, Ann. Y.E. (2002). *Learning through Knowledge Management*. Woburn, MA: Butterworth Heinemann.

Polany, M.(1966). *The Tacit Dimension*, New York: Bantam Doubleday and Company.

Ramasubramanian, S. & Jagadeesan, G. (2002), Knowledge Management at Infosys, *IEEE Software,* 19 (3), 53-55.

Ramesh, B. (2002). Process Knowledge Management with Traceability, *IEEE Software*, 19(3), 50-53.

Rowley, J. (2001). Knowledge Management in Pursuit of Learning: the Learning with Knowledge Cycle. *Journal of Information Sciences,* 27(4), 227-237.

Rus, I. & Lindvall, M.(2002). Knowledge Management in Software Engineering. *IEEE Software,* 19(3), 26-38.

Stillman, G., Alison, J., Croker, F. & Tonkin, C. (1998). Situate Learning as a Model for the Design of an Interactive Multimedia Program on Medication Administrative for Nurses. *Innovations in Education and Training International*, 35(4), 329-336.

Stoddart, L. (2001). Managing Intranets to Encourage Knowledge Sharing: Opportunities and Constraints, *Online Information Review,* 25, 19-28.

Skyrme, D.(1997). *Knowledge Management: Making Sense of an Oxymoron*. Retrieved March 3, 2002 from http://www.skyrme.com/insights/22km.htm

Szulanski, G.(1994). *Intra-firm Transfer of Best Practices Projects.* Houston, TX: American Productivity and Quality Center.

Teece, D.J. (1998). Capturing Value from Knowledge Assets: the New Economy, Market for Know-How and Intangible assets. *California Business Review,* 40(3), 55-79.

Van Aalst, J. W. (2001). *Knowledge Management in Courseware Development.* Netherlands: DUP Science.

Wenger, E. (1998). *Communities of Practice: Learning, Meaning and Identity.* New York, NY: Oxford University Press

Wijetunge, P. (2002). Adoption of Knowledge Management by the Sri Lankan University Librarians in the Light of the National Policy on University Education. *International Journal of Educational Development,* 22, 85-94.

Appendix I Pretest Procedures and Results

December 10, 2001

After I have implemented my knowledge net in HTML files, I invited four previous IS303a students to test it to ensure that knowledge net meets the requirements. The first tester is John from Science and Business major, a fourth year student. He has taken IS303a course in winter 2000 and also had done one co-op job at Learning and Teaching through Technology center. Therefore, he provided quite a few useful pieces of suggestion not only from his own perspective, but also from the perspectives of novice designers.

The knowledge net has different categories for the users. They are " scope statement ", " learner profiles", " project management " and " design". Under " design ", it is divided into " process", " learning activity ", " technology " and " interface ". Under every category, there contained threads from different teams of previous students to share their decisions for the projects, what had worked and what had not. It is hoped that, in this way, the new students can understand the expectations for them in IS303a projects and reuse those knowledge in their process, and therefore make better projects.

I provided three scenarios to John.
1. Suppose you are a new IS303a student. You attend classes and are assigned a project. However, you are not very sure of how to do the project. The professor asked you to hand in your scope statement in two weeks. What will you do?

Now you are provided this Knowledge Net, which stores the experience from previous students.

2. The scope statement was finalized. Now the professor asked you to write learner profiles and turn them in in two weeks. What will you do?

3. The scope statement and the learner profiles are well done. Now, you have to sit down and start your design. You do not know what activities you are going to include and what technology you are going to use.

I observed John's behavior as he surfed through the Knowledge Net and we talked about his feelings and opinions towards the Knowledge Net afterwards. In all three cases, John easily found the relevant information (usually in just one click). Overall, he was satisfied with the Knowledge Net. He thought it was well designed and was fairly useful for new students. If he were the new student and did not have a clue of how to do the project, he would turn to Knowledge Net for help. He thought the information built in Knowledge Net was good and useful. After reading it, he had a better understanding of what the project should be looked like and also got some ideas of how previous students did it. In addition, since he has taken IS303a course, he shared the same visions with some opinions in some threads.

He proposed a few valuable ideas which are important to improve my design:
1.The threads from past groups of students were presented under the category. But it did not explain to the users what the category meant and what was there. John proposed that the students might want to know what a scope statement was and what could help to write a good statement. As a result, an introduction part in every category may briefly introduce the concepts to the users and the following content. Under the same principle, a summary part at the end may help to summarize the fundamental steps for conducting the task and impress the users.

2. A link to the projects was presented by each thread. However, John failed to notice that. Therefore, it should be emphasized in the overall introduction for Knowledge Net or the respective introduction paragraph for each category.

3. In some threads, John suggested it to explain in more details. For example, there is one thread in " learner profile" that demonstrated " using a larger sample for leaner profiles will be good". He wanted a clearer explanation of why " a larger sample " was better.

4. There are some terminology John thought need some brief explanation. For example, novice designers may not understand the terms of " webCT front end" and " flow diagram ".

5. The sequence of the category. " Technology " used to appear first in " design " and followed by " learning activity ", " interface " and " process ". John felt that " process ", which explained what a team did before they actually designed anything should come first. Then will be the " learning activities". After deciding what interactivity will be included in the design, there comes the problem of technology and implementation. As a result, " process " and " learning activity " should come before " technology " and " interface ".

6. The content under " project management " is not enough. By viewing " project management ",John assumed that it should illustrate how to break down the project and manage the task in a timely manner. Instead, there was only one thread there about coding and debugging, which could not meet his needs.

7. The " introduction " to Knowledge Net may need more details about its current content.

8. There is nowhere in the interface that can link back to the homepage.

December 14, 2001

Mary is working at Learning and Teaching through Technology center. She studied at University of Guelph and has taken IS303a course in fall 2000.

Basically, Mary understood the information in Knowledge Net and could find it easily. She thought she was able to apply the knowledge if more details were given. And she would look for this information if she were a student of IS303a.

The suggestion that she had is as follows:

1. The font may vary from page to page.
2. Instead of just putting all the opinions from different projects, an overall summary of what is the best way to do the scope statement, learner profile, what should be considered for technologies for design should first be presented first. Otherwise, the students will be confused. They are seeing the testimonies of different experience of making scope statements from different groups. However, they may not even know what scope statement is and what a good scope statement consists.
3. Mary did not understand what " bottleneck", " client " and " goal " mean. Definitions for the categories and subcategories should be provided.
4. It did not appear that the opinions are from students from volcano project or library project. In the languages, instead of saying " we ", one should say " the students from volcano project thought ".
5. The phrases. There are quite a few threads called " ' fun ' as a goal ". However, it did not appear to be very obvious to her what it meant. The titles of the paragraphs should be clearer.
6. In the learner profiles, an introduction of Detail Kit should be presented. It should be stated in a leading paragraph that Detail Kit could be used for learner profiles building.
7. In " project management " category, she was looking for information for how to manage the project which is not included there.
8. The " search hint" in the front page should be change directly to " site map".

December 18, 2001

Alan is an undergraduate student in Kinesiology. She had taken IS303a course in and also done one co-op term at LT3.

Alan was able to find the content according to the scenarios. And she was very interested in visiting each individual IS303a projects by clicking on the hyperlinks beside the examples. By viewing those examples, Alan felt that " the students may get a better idea of what are expected. " She recalled the time she was an IS303a student. " We knew those milestones such as learner profiles and scope statement. However, we did not have the clear idea of what is expected because there were no past examples. "

There is some threads that Alan thought of not too much value such as the thread of " use of interactive elements " under the category of " learning activity ". " It did not have much value in it. "

In addition, she also proposed sometimes two threads could be combined into one if the two threads were talking about the same thing.

Furthermore, she proposed that for the students who did not know much about multimedia, an example or a link to the resource page might be very helpful. For example, if someone is comparing HTML, Flash, it would be better for the students to have an example of HTML and Flash beside it so that they could know the effects of HMTL and Flash before considering them for the design. Some websites including more details about the software may be very useful as well. For example, one may find more details about Flash at www.macromedia.com or www.flash.com.

When asked if she would feel overwhelmed if there was large content under each category. She said that she would not. Additionally, she said that at the top of each page, there might be a index of what threads are under this category. This may give the users a better idea.

She said that the introduction should be more detailed. One should introduce that there were three projects in this website.

The last point is that things should clarify to the students which is the homepage of IS303a because that there are quite a few websites involved such as Detail Kit, Knowledge Net and other things.

Appendix II Questionnaires for Evaluating Knowledge Net

Please be frank and honest in answering the questions. Your responses will be used to evaluate the effectiveness of Knowledge Net and to improve its content and design. Your cooperation is greatly appreciated.

Please answer the following questions after evaluating the Knowledge Net.

1. I can easily find the things I want in Knowledge Net.

1	2	3	4	5
Totally Disagree				Totally Agree

2. I fully understand the content in Knowledge Net.

1	2	3	4	5
Totally Disagree				Totally Agree

3. The content in Knowledge Net can be applied to my project.

1	2	3	4	5
Totally Disagree				Totally Agree

4. I feel comfortable surfing through Knowledge Net.

1	2	3	4	5
Totally Disagree				Totally Agree

5. I would like to use Knowledge Net as my project progresses.

   Yes __ No __

   If yes, please answer question 5 and skip question 6. If the answer is " no ", please skip to question 6.

Please choose any answer that applies to you.

6. I will use Knowledge Net because:
   __ it seems interesting to me.
   __ I believe the comments from the students are true.
   __ I find the information useful and it provides me with shortcuts for completing my projects.
   __ the instructors asked me to use the Knowledge Net.
   __ Other reasons, please state: _____-
   _____

7. I will not use Knowledge Net because:
   __ I am too busy to use it.
   __ the information in it seems useless.
   __ the interface is not friendly.
   __ the information in it seems unreliable.
   __ the information in it is confusing to me. I do not know how to apply it.
   __ I have most of the knowledge there.
   __ I prefer to ask the instructor or other students questions instead of interacting with computers.
   __ I prefer reading books.
   __ Other reasons, please state:_____

8. I expect to learn the following things from this class (IS303a):
   _____
   _____
   _____
   _____

9. I expect to find the following information in Knowledge Net:
   _____
   _____
   _____
   _____

10. Would you be willing to share your experience of working on a project with other students?
    Yes ___ No ___

    If the answer is " yes ", please go to question 10 and skip question 11. If the answer is " no ", please go to question 11.

11. I would like to share my experience with other students because:
    __ I feel satisfied sharing my experience and knowledge with others.

__ I find other people's experience in Knowledge Net useful and want to offer my own.
__ It is flattering if my experience is useful to others.
__ The instructor asked me to do so.
__ By sharing my experience, I get a better idea of what I have done and where I am heading.
__ Other reasons, please state: _____
_____

12. I would like to share my experience with other students by:
__ talking about it in class.
__ submitting threads to Knowledge Net.
__ talking to someone about my experience and have them it written down for me.
__ submitting ideas to Discussion Forum.

13. I do not like to share my experience with others because:
__ I prefer not to share my ideas with people I compete against.
__ I think it is a waste of my time.
__ I don't think my knowledge is worth sharing.

14. Knowledge Net could be improved in the following ways:
_____
_____
_____
_____

15. The section I like best in Knowledge Net is: _____
16. The section I like least in Knowledge Net is: _____

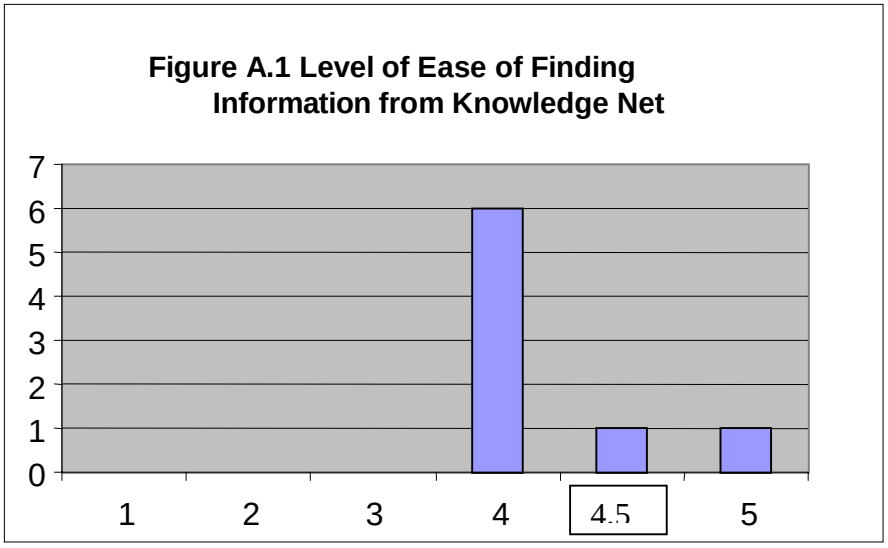
Thank you very much.

Appendix III Questionnaire Survey Result

This appendix presents the results from the survey. It consists of three parts. The first part presents the students' initial evaluation of Knowledge Net. The second part presents the students' expectations towards Knowledge Net and the IS303a course. The third part illustrates the students' attitudes towards sharing information. The question numbers in this section are consistent with those in the questionnaire (Appendix II).

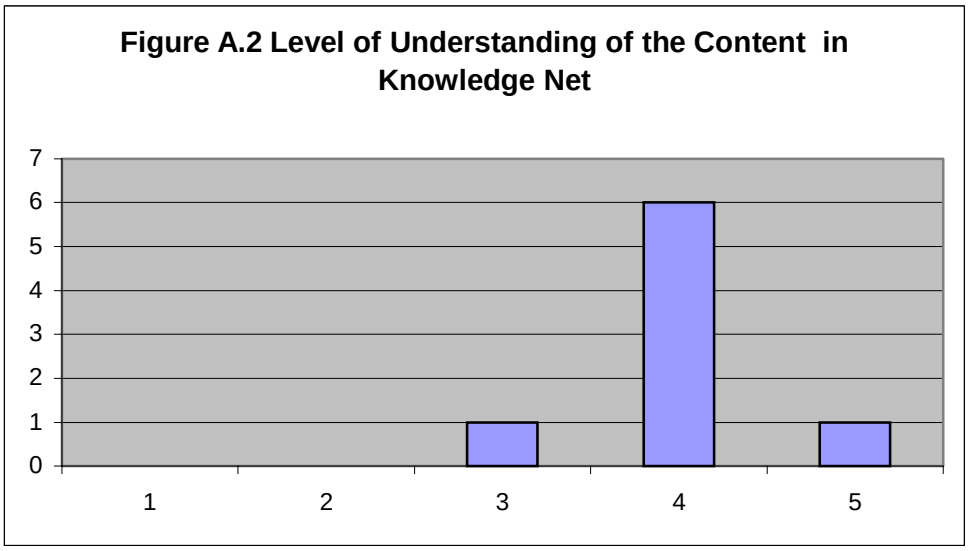
1. Students' evaluation of Knowledge Net

Question 1: I can easily find the things I want in Knowledge Net.



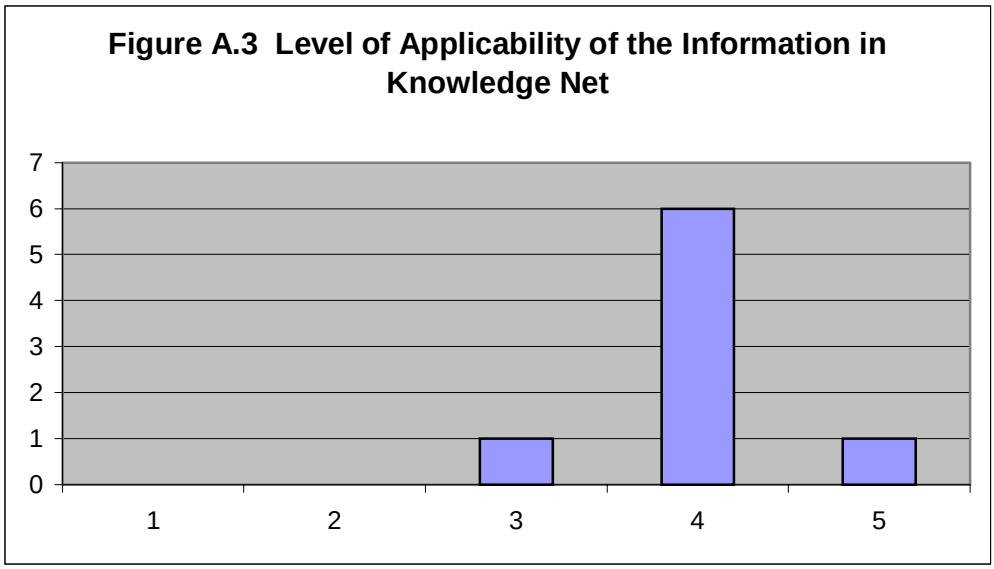
All the students (100%) indicated that they could easily find the information from Knowledge Net (Figure A.1).

Question 2: I fully understand the content in Knowledge Net.



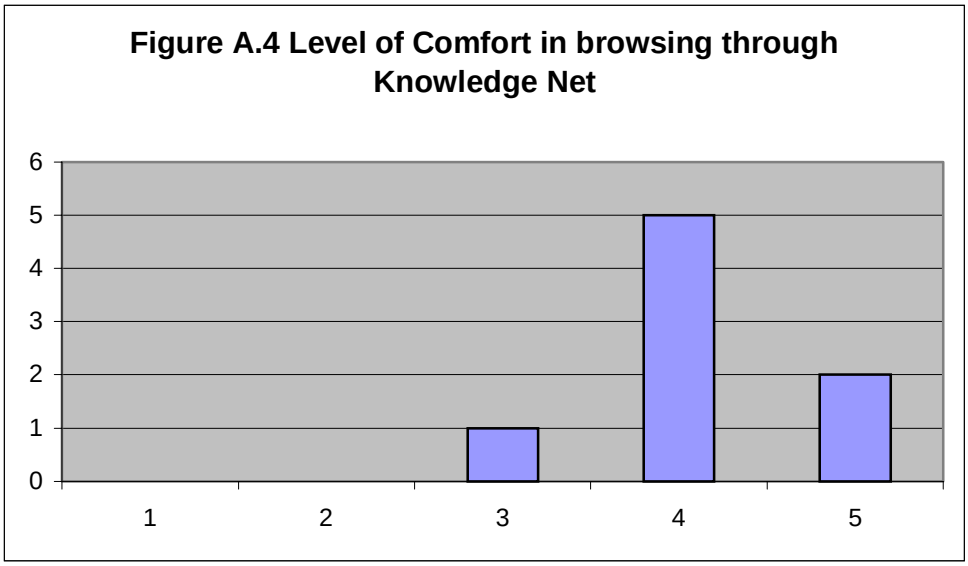
The vast majority (87.5%) agreed that they could understand the content in Knowledge Net. Only one student remained neutral about this question (Figure A.2).

Question 3: The content in Knowledge Net can be applied to my project.



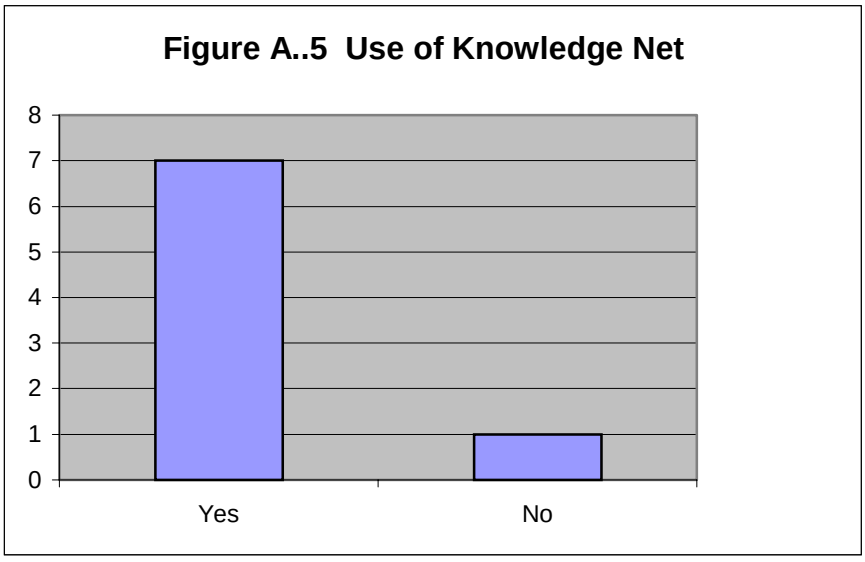
For the applicability of the information in Knowledge Net to their own projects, 12.5% of the students remained neutral while 87.5% agreed they could apply that information (Figure A.3).

Question 4: I feel comfortable surfing through Knowledge Net.



For the level of comfort of searching through Knowledge Net, 12.5% of the students remained neutral while the vast majority (87.5%) agreed (Figure A.4).

Question 5: I would like to use Knowledge Net as my project progresses.



The vast majority (87.5%) would like to use Knowledge net as their projects proceed. One student was reluctant to use Knowledge Net (Figure A.5).

The following are multiple-choice questions suggesting reasons to continue to use or not to use Knowledge Net. The students could choose whatever applied. In addition, extra space was provided to articulate any unlisted reason.

Question 6: I will use Knowledge Net because:

Choice	No. of Answers	Percentage among the students
I find the information useful and it provides me with shortcuts for completing my projects (given answer).	5	62.5%
I believe the comments from the students are true (given answer).	3	37.5%
It seems interesting to me (given answer).	1	12.5%
It is helpful as it provides experience (given answer).	1	12.5%
Other reasons (Subjective comments):		
It will provide me a good start if given in details.	1	12.5%
It is helpful as it provides experience.	1	12.5%

Table A.1 Reasons for Using Knowledge Net

On the whole, the majority (62.5%) admitted that they would use Knowledge Net because the information was useful and could provide shortcuts for their projects. 37.5% suggested that the true comments from previous students draw them there. One student

(12.5%) revealed the information was interesting. Another one (12.5%) chose the reason that it provided experience.

Two students gave their personal comments. One suggested that it would provide a better start if it could provide more project details. Another indicated that it was useful in terms of providing practical experience.

Question 7: I will not use Knowledge Net because:

Choice	**No. of answers**	**Percentage among the students**
The information in it seems useless	1	12.5%
I prefer to ask the instructor or other students questions instead of interacting with computers	1	12.5%

Table A.2 Reasons for not Using Knowledge Net

Only one student stated that he/she would not like to use Knowledge Net as his/her project progressed (Table A.2). Useless information in Knowledge Net and the preference to interact with the instructor and the students rather than computers were his/her reasons of continuing to use Knowledge Net.

2. Students' expectations towards the IS303a course and Knowledge Net

This section presents the answers to the open-ended questions about the students' expectations towards Knowledge Net and the IS303a course. In addition, the pros and cons of Knowledge Net from the perspectives of the students are presented.

The ideas and techniques that the students expect to learn from this course can be categorized into three parts. They are: effective learnware techniques, project management skills and other people's learning process. 67.5% displayed interests towards effective learnware techniques including methods for creating effective learnware and useful standards for designing websites. 25% indicated that their desires for project management skills including scope statement definition, planning, time management and teamwork skills. 25% mentioned their interest towards the learning process of other people. One student did not fill in anything for this question. It seemed that most of the students were quite clear about the purposes of the course -- learnware design. Only one student seemed to misunderstand the purpose of the course and focused on learning computer skills.

Question 8: I expect to learn the following things from this class (IS303a):

Category	Detail	No. of Choice	Percentage
1.Effective Learnware Technique	1) How to create effective learnware 2)What to look for in designing websites	5	67.5%
2. Project Management	1)Defining scope statement 2) Planning 3) time management. 4) Improving team work skills	2	25%
3. How people learn		2	25%

Table A.3 Students' expectations towards the IS303a course

Question 9: I expect to find the following information in Knowledge Net:

Category	Detail	No. of Choice	Percentage
Past experience	Past mistakes and hitches Common problems and challenges Example of projects Project feedback Tips and advice	6	75%
Definition of terms		1	12.5%
Steps/ Process in designing learnware		1	12.5%

Table A.4 Students' expectations towards Knowledge Net

The things that students expect from Knowledge Net can be categorized into three parts. One of them is past experience including past mistakes and hitches, common problems, example of projects, project feedback, and tips and advice. The other two parts are the definition of terms and the steps and process in designing learnware. The vast majority (75%) showed interest in utilizing past experience. 12.5% displayed interest in both the definitions of terms and the steps and process in designing learnware.

The following illustrates the best and the least liked part by the students in Knowledge Net.

Question 14: The section I like best in Knowledge Net is:

Category	No. Of Choices	Percentage
Design Process	2	25%
Introduction	2	25%
Scope Statement / client	1	12.5%
Personal Experience	1	12.5%
Interface Structure	1	12.5%

Table A.5 The Best Sections in Knowledge Net

7 students out of 8 pointed out their favorite part in Knowledge Net (Table A.5). 25% denoted that they like the Design Process part the best. 25% indicated that the Introduction was their favorite part since it defined the purpose of Knowledge Net clearly. One student mentioned the Scope Statement, especially the part describing the communication with clients. The other two students chose "Personal Experience" and "Interface Structure" respectively.

Question 15: The section I like least in Knowledge Net is:

Category	No. of Choices	Percentage
Small amount of cases	1	12.5%
Unclear explanation for Detail Kit	1	12.5%
Project Management	1	12.5%

Table A.6 The Least Liked Sections in Knowledge Net

3 out of 8 students gave their opinions for the part they like least in Knowledge Net (Table 4.6). One student mentioned, "There are no options in simply considering one project such as Volcano." Another student was not cleare about the functions of Detail Kit. The third student did not like the Project Management part.

3 Students' Attitudes towards Knowledge Sharing

This section presents the students' attitudes towards knowledge sharing including their willingness to share knowledge and the reasons for them to do so.

Question 7: Would you be willing to share your experience of working on a project with other students?

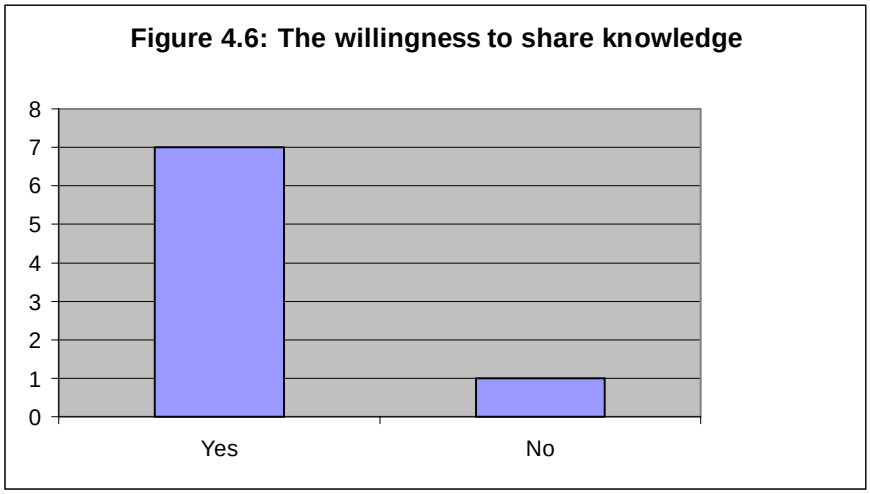


Figure A.6: Students' attitudes towards knowledge sharing

The vast majority (87.5%) expressed interest in sharing knowledge with other students. Only one student had no such interest.

The following questions about the reasons for sharing or not sharing information are multiple-choice, with an open-ended option. This format allows the students to choose whatever applies and to state their personal ideas if so desired.

Question 11: I would like to share my experience with other students because:

Choice	No. Of Choices	Percentage
By sharing my experience, I get a better idea of what I have done and where I am heading	4	50%
I feel satisfied sharing my experience and knowledge with others.	3	37.5%
I find other people's experience in Knowledge Net useful and want to offer my own.	3	37.5%
It is flattering if my experience is useful to others.	2	25%
The instructor asked me to do so.	1	12.5%

Table A.7 Reasons for Sharing Knowledge

50% of the students agreed that by sharing their knowledge, they could get a better understanding of their projects. 37.5% suggested that sharing knowledge could provide them a sense of satisfaction. 37.5% indicated that they would like to trade information with others in Knowledge Net. Only 12.5% said that they would do it if the instructor asked them to do.

Appendix IV Interview Results

An interview was conducted at the last class of IS303a course in Winter, 2002, after the presentations of the students before the instructor and their clients. Eight students, who registered in IS303a course, participated in the interview. The following is the approximate record of the interview.

Researcher: Do you have any lessons learned or anything to share?

Jack: Can't do things until the deadline. Having more deadline (every two weeks time, small tasks) is 0% and 5% of something. Just to give the students a reason, a practical reason for doing something.

For this course, half of the project is not due until the last week. Breaking down the marks will be good.

Instructor: Do you think small assignments (little miles) along the term will be better?

Jack: You can give 2% for just coming up with the title.

Instructor: What kind of assignments in IS303a you think would have helped you learn the process better? It sounds that a lot of you have that "A Ha" moment: "I should realize that in the beginning." It may be helpful if you could realize it sooner.

How can we change the structure of the assignments so that the students will not experience that kind of frustration or maybe that is part of the process?

Betty: As we move to the deadline, some of the things like storyboard…If we could sit down and do it on a paper earlier, I think it … Although it is hard to conceptualize things, but actually sitting down and will help us to have an idea of what is built and get things done.

Instructor: You can at least have it or paper so that you have an idea.

Researcher: Will it be helpful if someone has told you? For example, if someone told you that implementing the storyboard took a long time, will it help you to do better with your project?

Betty: You mean start earlier? No, I don't think so. I think if there are more deadlines that you have to present something by a certain date, that will make me start early. But if somebody just tells me that ' O-Oh, it is going to take long time. You'd better start early'. Sometimes maybe that really helps. Like CS241, they told you about the horror of assignment 5 from the

beginning of the year. You hear horrible stories from everybody ahead of time. Yes, I started assignment 5 and got it out. But other than that, I will not.

Instructor: So you mean that even you saw that, for example, gannt chart, all of them showed that estimated time and the actual time has a big discrepancy in a lot of the stages, even you saw that and you saw experience from other students, you do not think you would change how you would plan?

Gorwin: You fit the time with what you have. We sound like we have a lot of time to do our storyboard and our paper prototype. So, not till the end, we realize, 'Oh, Crap, our prototype is due." It was not a thing we could put it up. We have to present it. It's due.

Lily: I thought we had a difficult time balancing how much content do we actually need to have in the design and actually prototype. Maybe from the beginning, if it is clearly defined for the expectation for each stage, a lot more examples of how ~~they~~ [previous students] did, and then, have the prototype due earlier or the paper prototype due earlier. So we could actually feel not so frustrated at the end. ' Oh, my God, we need to get everything done. ' "

Instructor: In terms of that prototype due early, will it be helpful for your learning that have this presentation, say due two or three weeks ago? And then have you incorporate feedbacks from tonight something you have learned, and you could say, " no, it is wrong. we need to change it." Will that be help to have it due earlier so you have more time to incorporate? Or do you feel good about it is done, no more with: " feel OK with leaving it "

Gorwin: I like it due in the last day.

Lily: Yes.

Steve: (some other opinions, however, due to the low voice in the tape, it is hard to hear) Probably little presentations along the way.

Instructor: So you want me as walking around and seeing stuff along the way as it would been your classmates have seen it and you have to get up and address everybody? What do you think of your client? Would you think they should be involved in the presentations along the way as well?

Jack: I do not want to push the direction that the deadline is the way to go to do it. No matter how early or how late deadline is, the students have the extraordinary ability to finish it no matter how stress they are. … Instead of the motivation of having to reduce negative consequences, for me, I would like to see why you want to push the deadline early.

Betty:I think that the " why "for me is that we would have made more progress. It would have been a lot more clear what we were doing. The final quality of our project would be better if we have moved some of the things up early. We would have run into some of the difficulties we end up running at the end of the term earlier and we would be able to incorporate those changes.

We went to ~~him~~ [the client] so many times to try to get that. For us, if we had tried to put it down on paper, 'see, this is what we are trying to do', he would have understood more about what we were getting.

Instructor: Well, it is an interesting thing because I know I have told you a number of times " you need content long before you need it". I know I have said that the crunches were going to come at the end. In terms of knowledge net, do you think it is useful to have that feedback from other students, say " Oh, had we know we have done that a lot sooner we had done". Or do you think students learn that as part of the process, no matter what Knowledge net said, if you have not been to that yourself, you would not know. I do not know, what will you say?

Gorwin: I think it is part of learning. Like students from this Internet, they told you that were hard. I won't listen to them, right? Even if every student on the … told me that I need to do it quickly, I don't think I would have followed them.

Betty: I think we would. I think that for " get content", " get content". We do not know what we need. Like we could go to him (the client) and said we need some "content". " Content" may not be the same sense you mean. Maybe the definition.

Instructor: Sounds like that some of definitions about what does it mean when we say content. Maybe some examples. In the case of production, you need X. In the case of environmental resource studies, you need Y. In the case of project management, you need Z. I think that is part of the problem. When I say content, I sort of have a sense of what I meant. But it differs in different project in terms of what you needed. And also I think partly, your design dictate what content… I wonder what specific information we could give the students upfront so that they can understand "OK, I understand what you mean for my project".

Mike: Sort of categorize the types of projects. Oh, this project needs this kind of information.

Researcher: Maybe some example for what I mean by content.

Mike: Or maybe previous projects that have been similar in content.

Researcher: Will reviewing some relevant websites be helpful?

Ben: Yes, that would be helpful. It would be even more helpful if someone within this course and did the same type of thing so we can…

Researcher: That is the hard thing. Because part of the IS303a course is that you have to contribute something unique, nobody has done it before.

Instructor: Eventually, there are those past projects on the site. How many of you looked at those past projects to judge where you need to go?

(two or three raised their hands)

Lily: Very briefly.

Instructor: Do you think if you spend more time and depth on those like in terms of what we did in learnware analysis (maybe analyze the past projects), should we analyze some of those past projects?

Gorwin: I think it would be nice if you could have them come in and talk.

Instructor: So that is essentially what Knowledge Net, in a way, wants to do. It gives you access to past students and their knowledge so that you can learn from their experience in the course. But certainly that does not necessarily exclude face-to-face contact. But that is interesting.

Mike: Before the former prototype like the Galary, we could access what we like about them. But we would like more if you told us. This is a good project because of this or that. We did that in the first month of class and we did not have much experience doing that.

Betty: It would be helpful if we could learn some standards of websites.

Instructor: The subjective nature of the exercise is what you learn. Each individual designer is going to have a different way to approach the project. It is important for you to think what is good and what is not good.

Researcher: What kind of information will you believe?

Gorwin: I think it really depends. Sometimes I don't believe it like even it's on the Internet. I really depends on if I know the person. If you just put a few people telling you that you should to start something, I tend not to listen to them. But if you have some come to face-to-face or something, I may be more willing to accept it. By talking to them, it is more believable. I don't

know why I don't believe it. Sometimes I just prefer to talk to them. It's more believable.

Betty: A lot of these, when something got written down, it's so formalized. It seems not real "Yes, we had such a problem with our client. " They are more open to say.

Instructor: If you could download a discussion from last term, like this one when we discuss content, do you think you will benefit from it?

Glasha: From the discussion like this one with content, it is hard for me to pinpoint what information I really need ,what else is have a flop to be.

Lily: I think I have the same problem too. Get the content or skip to … .

Mike: I think I will believe video a lot more.

Instructor: Video like they are talking about their experience.

Lily: It is hard to fake something like that.

Mike: When you read what they said, it is kind of edited.

Mike: I kind of like informal as discussion in the video.

Instructor: Video, process of the course so that you know that on week one, you are going to be talking about learners. You can go to different clip about past classes talking how they have worked through understanding learners and how it impacts their design. Do you think the stuff on Knowledge Net should follow the process of the course so that you know when to go in and when to look for that information?

Steve: It can better prevent the stuff you are going through is a learning process instead of thinking bad things of the course, client or project. Just knowing that you are going to prevent these problems. Even if, like I am sure that we were told to experience things, but we did not really think WE will experience these things.

Instructor: You do not internalize while somebody is telling you " by the way, it is really hard. " Hearing other people's experience makes a little bit more real. Although to some extent I think you do need to experience by yourself before you really truly believe in it. But at least it may give you the extra hat up.

Mike: I think in a way that prof and students that can be go on may be doing class discussion afterwards. Go on the site and see what we are going to talk about next week. Maybe just ten or fifteen minutes.

Instructor: Task you do outside of the class and get feedback on.

Mike: You go on the site and look what those students have talked. And then you can discuss that in class, what you have learned.

Mike: Students are busy. They will not go on unless there is somebody pushing them on.

Instructor: That will be part of your mark.

Researcher: If it is not part of mark, will you do that?

Mike: I think a lot of people wouldn't if it was not part of anything just because they are really busy and there is other schoolwork to do.

Researcher: Like, will you do it after class or on your own?

Mike: If it is for marks, they would, I will do it on my own. But if it is not for anything …

Jack: If the discussion was not for any mark, personally, I will still join because I think it is interesting to open my mind to what other people think. But if the discussion is not leading anywhere, there is no point doing that. .

Instructor: Did you have any methods you have developed within your own team how you will get things done and how you will deal with each other?

Instructor: Would that be helpful to you if you hear how other teams negotiated? We did a little bit before that. But that was before you knew each other in a way.

Would it be helpful to hear some past team negotiated? How they learned to communicate with their clients? How they communicate with each other?

Betty: I don't think so. For myself, I think everybody has done a lot of team work before and other projects and everything. So I think that is going to be the information that is most relevant for you. And no matter what you hear other people's experience, you are going to reflect back on your own experience and ' well, that is not what I experienced. " And very well you are going to have a completely different experience than anything you had before or anything anybody else has. I would not really listen to what other people had for their team experience or their client experience because I just think you just be so different for everything.

Researcher: If the instructor says something, will you believe her?

Betty: I would think maybe it is true generally, but not it is going to necessarily apply to me. As we have talked about different rules people can have, OK, those are old something happened or may happen, well, let's see how it works for us. Even half ways through, if there were guidelines or something, it might be more helpful for you see how dynamically your team is working. But at the same time, it is kind of personal that how you are going to deal with something.

Instructor: Would you have experience running efficient team help you learn better the course?

Researcher: Is there any trade-off moments when you are not so sure of where to go?

Betty: We were getting frustrated. We didn't know what was going on. We kept on going to our clients all the time. And we were never getting anything back. I think I felt frustrated and my teammates thought I was mad because when I get frustrated, sometimes I can be harsh, you know. " Oh, what's going on. " Things like falling apart. We sent him - the client an e-mail. We had a meeting. I listed to him everything we need from him exactly. " Tell me this. Tell me that." And I basically said " can you give it to me by tomorrow? " We have been asking him for three weeks (the whole time). But we did not lay all out in the e-mail directly this is what we need you to give us. We had told him other time stuff like that. So it is not likely saying that we are throwing it all at him one day and asking for the next because we have asked him before. But anyway, we sent him an e-mail. And his reply was our " a-ha " moment. He was like " why are you guys asking for all these contents for? I thought you must be thinking about the project? I don't think you are supposed to get anything done, like any kind of working model. It seems to me that you are heading down the road to the development, not to the next phase. Basically, he was like " this was taking a lot of my time. It's just not meeting with you all the time, but it's preparing to meet you. " That, to us was our " a-ha " moment because then we could understand where our problems were all along because it wasn't us having problems communicating so much. It wasn't so much we didn't understand what he was saying or he didn't understand that. It was more that he had in his mind completely different than we had in our minds what our final and results are supposed to be. So he didn't answer the questions in the way we were looking for.

Researcher: If some new students come in to do a project, how would you advice them to deal with this situation?

Betty: I think it would be really difficult because it's hard to know [that] somebody else doesn't understand the final result. … Instructor said it was learning to

know that's clearer with the client. The only thing I could possibly suggest is that to have another person there, maybe she can point out the fact that he wasn't looking at it the same way we were looking at it.

Gorwin: Or going through with him with an example of previous project. " This is what we need in a month and a half. "

Betty: If he could see other ones, I think he might be able to better apply it to what he is conceptualizing and say "Oh, OK, that type of thing" because he knows his own project. He could say " Oh, this would apply for that. "

Instructor: In terms of content, what do you think when you get the project outline, couple of paragraphs, will it have helped to get preliminary content so that you at least had a jumping-up point or that taking out the process of that you have to think of your own

Lily: I think for us, I didn't realize just how much content we need. I guess it depends on the actual learnware module how much it actually needs. But for us, a little bit would have been probably a great help. Just how much we actually needed for this project.

Lily: We have a lot of brainstorming. The pos and cons . …

Researcher: If I am a new student and want to learn from you, an d will really believe in what you said, what will you tell me?

Glasha: Content and paper prototype. Up until Instructor showed us the paper prototype, that day or that night, we really didn't know we were supposed to do (so). And Betty's like " You want that by next week? " We were all quite surprised of for how much it's gone from just things that are fully out of our mind.

Betty: I would like to see it earlier if possible.

Instructor: Is there any a-ha moments that you have after taking this course? You know something you did not know before taking it.

Glasha: The learnware I had here was not the one I had envisioned.

Jack: Managing project for the title instead of designing interactive learnwares.

Lily: Getting the students involved in the learnware to the degree that a lot of us did is something I didn't really envision in learnware. I had sort of the maths game limited idea of learnware instead of students actually doing the learnware. Gradually I realize that " yes, that is most effective getting their ideas. "

Glasha: Something else I learn about learnware is that it is very much focused on learners. … Their performances on the course weighs upon how you teach.

The learnware profiles open my eyes for how people should learn and how they should teach.

Steve: Our client, when we asked him how students learned that, he said that he had never thought about it.

Appendix V Content of Knowledge Net

1.Introduction

Knowlege Net is used to store the previous experience and useful knowledge from past IS303a students. The purpose of it is for new students in the IS303a course to reuse this knowledge and make progress in their projects. In another word, it is a sharing memories from different generations of students in the IS303a course. From this knowledge, you can see how students' level has been enhanced from one generation to the other. Knowledge Net is also linked to the IS303a home page, Detail Kit (a performance support tool for making learner profiles), Discussion Forum and other useful links about multimedia learning.

Knowledge Net contains the knowledge from previous IS303a teams from the Volcano, Library and Learning Language projects. The students have shared their considerations in designing the projects and the outcomes. By clicking on the link beside each comment, you can go to the homepage of the project.

The designer and the implmenter of Knowledge Net is Maggie Xiaohui Liang, a master student in department of Management Science, supervised by Tom Carey from the Center

for Learning and Teaching Through Technology (LT3) . Please send us e-mails if you have any comments on Knowledge Net. Your opinions are extremely valuable for us.

2. Site Map

Knowledge Net

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1. Scope Statement

- Bottleneck

  Bottleneck should be proposed by client - Vocano Project

- Client

  Scope statement approved by the client -Volcano Project

- Goal

  More specific in the goal.- Library Project
  " fun " as a goal - Vocano Project
  "fun " as a goal - Learning Languages Project
  Challenging goal - Learning Languages Project

2. Learner Profile

  Concrete persons - Volcano Project
  Larger sample - Learning Languages Project
  Learner profiles affected design - Learning Languages Project
  How to get good learner profiles - Learning Languages Project

3.Project Management

  Coding and debugging - Library Project

4.Design Process

- Learnware Analysis

  Website and book review - Volcano Project

- Learning Activity

  Cartoon characters

  Cartoon Character - Library Project
  Intelligent agent - Learning Languages Project

  Interactive Activity

  Active experimenation - Volcano Project
  Interactive elements 1) - Learning Languages Project
  Interactive elements 2) - Library Project
  Interactive elements 3) - Volcano Project

Useful Technique

Flash -Volcano Project
Visual symbols - Learning Languages Project

Voice

Auditory Channel 1) - Volcano Project
Auditory Channel 2) - Learning Languages Project

- Technology

  Video - Volcano Project
  Why we chose HTML - Library Project
  Why we chose Flash - Library Project
  Choosing the right technology among HTML, SML and Flash - Learning Languages Project

- Interface

  Buttons - Library Project
  Locations for the users - Volcano Project
  Flow Diagram - Library Project
  Structure/ Navigation - Learning Languages

3. Scope Statement(6 threads)

From the instructor:

Liwana Bringleson

The Scope Statement summarizes the instructional challenge or bottleneck that the project is supposed to address or the purposes/goals of the project. Central to the identification of the goals of the project is the learners and their needs in relation to the program. Therefore, the Scope Statement should inclue what the learners should know or be able to do after completing the program. Before you begin generating your own scope statement, keep in mind the following: The bottleneck: The projects in IS303a are intended to solve an instructional bottleneck in a course. As a result, there has to be a bottleneck that the project targets on. The other component to keep in minds is that the communication between the students and the client is important. It is vital to arrive at a mutual understanding of what the bottleneck is, what the purpose is and what the methods are to approach the task.

Content:

Bottleneck should be proposed by clients - Volcano Project

Scope statement approved by the client as soon as possible - Volcano Project

More specific in the goal - Library Project

" fun " is one of our goals 1) - Library Project

" fun " is one of our goals 2) - Learning Languages Project

Challenging goal- Learning Languages Project

Bottleneck

Bottleneck should be proposed by clients - Volcano Project 


Peter Goldworthy

The bottleneck of a project should always be proposed by the professor. In our case, it was us who came up with the bottleneck, not the professor. The disadvantage of this was that the professor did not have his buy-in for the bottleneck. Thus, he might not totally agree with our assumptions and our way to deal with the project. As a result, by the end of the project, the professor was not very happy with the outcome.

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Client

Scope statement approved by the client -  Volcano Project


Dianne Roberts

We originally chose to focus on the social science factors in the project because our client -- Dr. Morgan from department of earth science constantly mentioned the value of his materials in research in social-economic aspects of volcano. However, we were quite wrong. Dr. Morgan wanted to focus on the geology side instead. It was fortunate that the scope got clarified and corrected. Otherwise, we would have wasted time in organising materials for the wrong scope.

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Goal

Specific goal -  Library Project


Neil Malcolm

Our project serves as a tool to help students searching for items in the library. The reviewers of our project proposed that more details related to the overall process of library research should be incorporated and the process of evaluating web pages should not be limited to a simple checklist as this may not effectively capture the actual usefulness of the page. Overall, they wanted our library research guide to be more specific and detailed in these respects.

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" fun " is one of our goals 1) -  Library Project


Neil Malcolm

The purpose of the project was to simplify the process of library research and to make it more fun. Ultimately, our goal was to add a certain amount of fun to spice up the sometimes-mundane process of library research. If the prototype wasn't at least a little fun or interesting to use, we did not think that anyone would bother to use it when so many other text based library guides are already available online and in the library. We attempted to incorporate fun into the design through the use of interactivity (quizzes, games) and a fun tour-guide (timmy).

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“ fun” is one of our goals 2) -  Learning Languages Project


Mary Bailey

By studying the aggregated learner profiles, we saw that degree requirement was a major motivating factor. We have all taken courses that we didn't like, or thought that they were a waste of time, but were required to attend and perform because of degree requirements. Making the subject matter lively and more interesting (which was difficult to do with verbal/textual based subject matter like learning a language) required an extra bit of "spice". Therefore, we used "Lifty" as the nongendered, non-threatening central figure for users to identify with.

As a result, the use of Lifty not only satisfied that, but also allowed a better way to use the audio capabilities of Flash and CD-Rom technology.

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Challenging goal -  Learning Languages Project


Tai Toh

Our scope statement was a) well structured, b) concise, and c) agressive but reasonable in the scope of the deliverable. By setting a deliverable that was challengingrather than easy, it may have pushed us to create a higher quality product.

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4. Learner Profile (4 threads)

From the instructor:


Liwana Bringleson

One way to ensure you understand the learners you are designing for is to create a document that describes them well. Learner Profiles describe the learners' characteristics, competencies, limitations, and familiarity with the subject area. The information in the document should include general learner characteristics, such as age, educational level, reading proficiency, and motivation. It also should include information relevant to the subject material, such as proficiency in the prerequisite skills for the current program and interest in its content. It is also useful to know what the users' familiarity with the computer is. (Alessi S. M. and Trollip S. R., 2000) The Detail Kit is a tool to help you create Learner Profiles and is linked from Knowledge Net. The following are the comments from IS303a students who worked on the Volcano, Library and Learning Languages projects about learner profiles.

Reference:

Alessi S.M. & Trollip S.R.(2000). *Multimedia for Learning: Methods and Development.* Allyn and Bacon

Content:

Concrete persons -  Volcano Project

Dianne Roberts

Good learner profiles can be a great help in designing the prototype. The designers had better talk to real students and professors in the course instead of imaging what characteristics the learners might have. By talking to real users, it is easy to grasp the learners' features while imagination may lead to unrealistic assumptions.

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Larger sample - Learning languages Project

Tai Toh

Using a larger sample in the learner profiles could help us to understand more about widely different learners and therefore facilitate in the design.

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How learner profiles affected our design - Learning Languages Project

Jane Buckingham

The aggregated learner profiles gave us the capability to build off of several things. Users wanted concrete infomation. Users were primarily female. Users' motivation was to a) learn the language or b) fufill their degree requirements. As such, we realised that we should create a design that was fun to motivate the students who really weren't too interested in learning the language but rather to get the credit.

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How to get good learner profiles - Learning Languages Project

Nathan Saliwonchyk

What we did right: : a) collected the data in a timely matter b) kept the questions clear c) kept the survey short, and eliminated extraneous questions.

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5. Project Management (1 Thread)

From the instructor:


Liwana Bringleson

Most people want projects completed by a certain date. You and your client must be clear about all the deadlines, not jus the delivery of the final project. Most projects have a number of intermediate deadlines that specify when different parts of the content are to be ready and approved, when the user interface is to be ready and approved, and when various assets, such as voice and video, must be ready. (Ale ssi S. M. and Trollip S. R. , 2000) A Gannt chart will help you to decompose the work that you need to accomplish to deliver the final project and give you a timeline for when to complete what. The following comments are from IS303a students who worked on the Volcano, Library and Learning languages projects about the project management issues.

Reference:

Alessi S.M. & Trollip S.R.(2000). *Multimedia for Learning: Methods and Development.* Allyn and Bacon

Content:

Coding and Debugging -  Library Project


Neil Malcolm

Coding the interface and testing/debugging took slightly longer than expected, but I think this is always the case in a project like this where we could simply have just kept adding more and more components to the overall piece.

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6. Design Process: Technical Component (4 Threads)

From the instructor:


Liwana Bringleson

To decide what technology should be used in the project, one must consider the ability of the team, the hardware and its capability to fulfil the needs of the project. The following are the comments from the previous students of what technologies they used, why they chose them, and what the outcome of those decisions was.

Samples of different technologies:

HTML - Volcano Project
Flash and HTML - Library Project
- Learning Languages Project

Content:

How to use video -  [Volcano Project]


Peter Goldworthy

We had a video of 30 minutes. However, from the aspect of web design, we thought it would not be a good idea to create a website with a vi deo of 30 minutes. In one way, it seems to be too long and too boring to the learners. In another way, the file was rather large. We were afraid nobody could wait for that long for it to be downloaded. As a result, for future development of Volcano project learnware, we suggest to use a CD.

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Why we chose HTML -  [Library Project]


Neil Malcolm

We chose to use HTML because we needed to create the design rationale web page and we decided that the prototype should flow from this page. Also, since the majority of the material that was to be delivered in the project was text based, it was most convenient to display it via a serises of web pages.

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Why we chose Flash -  [Library Project]


Neil Malcolm

We chose to use Flash because we wanted to add an interactive and "fun"component to the project. Flash allowed us to make interactive quizzes and fun animations.

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Choosing the right technology - Learning Languages Project

Jane Buckingham

The technology chosen had to be compact because it must coincide with the WebCT front end available on the Internet. The technology must also engage the user with audio and visual learning content while maintaining a high degree of interactivity. After many long hours of discussion over what available technologies were appropriate for the design of the tutorial, the group eventually settled on three different technologies:

- HTML+ Java Scripting
- Synchronized Multimedia Integration Language (SMIL)
- Macromedia Flash

HTML would be a simple, compact way of displaying the tutorial information. However, it lacked the interaction components necessary for the development of the IMM. It was felt that the technology would not be interactive enough for students to maintain their interests.

SMIL is an XML-based scripting tool that allows for the scripting of multimedia over the web. However, since all actions must be scripted in order for SMIL to work, interaction (or the illusion of interaction) would be difficult to implement as it would be impossible to script out all of the user's possible action. Moreover, none of the design team were familiar with SMIL at all.

The winner:

It was decided that Macromedia Flash would be the development environment of choice. It provided a way to create small, compact, but streamable applications to the users. Moreover, the free Plug-in and the standalone player could be downloaded and placed onto the CD-ROM for the students. Not did Flash satisfy bandwidth issues, it also gave us a way of creating an application with modular components. Each separate component would be easily editable and very small. Consequently this also offloaded any bandwidth issues for the WebCT front end that students could also use.

Macromedia Flash also arranges objects into layers and groups objects in what is known as a library. This afforded us the opportunity to create an easily localizable application where elements specific to the German culture, the language, and Lifty could be removed and replaced with little hassle.

Flash applications can combine auditory, textual, and visual information together. It can be used to create truly interactive applications for download off the Internet or CD-ROM.

The disadvantage of Flash is that it may make difficult for the professors to make editing changes to the learnware.

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7. Design Process - Learning Activity (10 Threads)

From the instructor:


Liwana Bringleson

" The process of instruction includes the presentation of information to learners, guidance of learners' first interaction with the material; learners practicing the material to enhance fluency and retention and assessment of learners to determine how well they have learned the material and what they should do next. " (Alessi S.M. and Trollip S.R., 2000, P10) This can also be applied to interactive multimedia. To decide what learner activities the project should include, one must consider the learner profiles including the learners' academic background and their preference for learning, the class and the related instruction or tutorial.It deals with the activities of assembling the content and deciding on how it is to be treated from both an instructional and interactive perspective. The following examples show what the previous students consider in this phase, what their decisions and their outcomes are.

Reference:

Alessi S.M. & Trollip S.R.(2000). *Multimedia for Learning: Methods and Development.* Allyn and Bacon

Content:

Cartoon Character -  Library Project


Neil Malcolm

We created a cartoon " timmy ", the library detective, in an attempt to provide a friendly and fun character to act as a guide leading the students through the process of library research. He is part Sherlock Holmes and part coffee mug. We decided that to do research in the library you needed to act like a detective and you need a hot mug of tim Horton's coffee -it was a natural mix. The reviewers thought timmy was an interesting character that added more " fun " to the prototype.

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Intelligent agent -  Learning Languages Project


Jane Buckingham

Perhaps the most risky decision that was made was the inclusion of an animated character called Lifty. Lifty was an animated Litfaßsäule, or information post.

Lifty was a non-gender specific character that worked well with the existing theme of the current CD-ROM. He was designed to be non-threatening, and easily identifiable by the students. His role in the CD-ROM was to provide a consistent look and feel, as well as act as a virtual student taking the course. Thus, students could empathize with some of the feelings and emotions that Lifty was going through. The animated character also had one advantage to digitized video --it was easy to manipulate, and can do things outside of the real world (i.e., dropping a large ONUS on Lifty's shoulders).

Much like the students of GM 202, Lifty would evolve throughout the tutorial, eventually turning from a naive student to a self-actualized individual ready to learn a new language. It was hoped that students would be engrossed in Lifty's travails and follow him throughout the tutorial, learning with him.

A second character was also added, that was the "Narrator" (voiced by the Team's own Mary Bailey), who acts as the guide to Lifty and the user. It was eventually hoped that Lifty would be integrated into the entire the CD-ROM, and have a more visible presence in the entire IMM package than just being limited to the tutorial module.

On an aside note, Lifty's inspiration can be attributed to a character from a Lucas' Arts game called "Day of the Tentacle". Lifty bares a remarkable similarity to the main villain: Purple Tentacle. Other people have also pointed out that "Lifty" shares a strong similarity to some other well known product.

Active experimentation -  Volcano Project

Peter Goldworthy

The active experiment was highly valued by the reviewers.We allow the users to click on the graphs to show the Atlantic boundaries that were demonstrated to them in the previous slides. We also allow them to select and drag the right rocks to the right categories. By doing these games, the reviewers became more interested in the geology concepts and were able to understand them better.

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Interactive elements 1) -  Learning Languages Project

Nathan Saliwonchyk

Interactive elements that were used were clickable menus and quizzes to test and engage the user.

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Interactive elements 2) -  Library Project

Neil Malcolm

The reviewers proposed that more interactive content would be good to help the students explore library research more thoroughly.

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Interactive elements 3) -  Volcano Project

Dianne Roberts

In our volcano project, our reviewers proposed that we could include some tasks that allow students to predict changes that could occur due to volcanic activity on the island and allow students to sketch out their ideas and submit to some offsite database.

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Flash -  Volcano Project

There are pictures of some places at the eruption and what it looked like twenty five years after the eruption. We put them side by side to compare and allow one to fade off into the other with Flash. This created more contrasts and impressed the learners.

Peter Goldworthy

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Visual Symbols -  Learning Languages Project

With 20 pages of content, it would have been difficult to create an interesting, engaging tutorial. We decided that the use of pictures and animation would be used to decrease text heavy material. Not only would this be faster to view than reading all the text, it would also appeal to the visual orientation of the users.

Mary Bailey

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Audio Channel 1) -  Volcano Project

We originally considered using voice in the learnware. Upon further investigation, we realized this was not a viable choice. Majority of the target learners were distance education students and they already listened to their instructor's voice via the lecture tapes. We would prefer the students to concentrate on the text and the pictures.

Dianne Roberts

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Auditory Channels 2) -  Learning Languages Project

It was determined early on that some of the text could be read to the users. Not only does this lower the visual load, but it provides a personable feel to the application – a personal tutor if you will. Of course, for each auditory passage spoken, some analogous text would be displayed. It was decided that the textual cues would not be the spoken text verbatim, but rather a summary of the spoken line. This would require the users to think about the meaning of the statement while watching the animations, etc.This engages the user.

Tai Toh

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8. Design Process -- Interface (4 Threads)

From the instructor:

Liwana Bringleson

A good interface will be accurate and precise. It can guide the users to find the information easily and let the surfing process be fun and enjoyable. The following threads show what the previous students have considered in their interface design and what the feedback from the reviewers were.

Content:

Metaphors in button design -  Library Project

Neil Malcolm

Reviewers felt that the button representations for "home", "forward" and "backward" were better than plain text. In addition, the font of the text is a bit too small to read.

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Locations for the users -  Volcano Project

Dianne Roberts

The reviewers felt that they did not know their locations as they went through our storyboard. Thus, we added a title to each page and illustrated the position of it in the prototype. A site map might also be a good idea.

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Flow Diagram -  Library Project


Neil Malcolm

The reviewers proposed that an overall flow diagram would be useful to help students locate themselves in the entire process and within the specific learning activity.

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Structure / Navigation -  Learning Languages Project


Mary Bailey

We chose to use a similar layout as the current CD-ROM with a vertical, left-sided navigation bar. Each link on the left-hand side would link to an individual module, keeping with the current CD-ROM structure. A site map was included for direct navigation was well. One problem found was that the Flash prototype did share the same look and feel (although similar layouts and colours were used). It was decided that when a person first opened the tutorial link, a new window would spawn with the Flash application.

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9. Design Process - Learnware Analysis (1 Thread)

From the instructor:


Liwana Bringleson

Before the start of design, there are some activities that can better prepare you for the design. The following team proposed that visiting similar websites or browsing similar projects can provide them with a better idea of the goal and the content in the project.

Content:

Website and book review - Volcano Project

Website and book review  Volcano Project


Peter Goldworthy

We visited different websites of Heimey eruptions to decide what was the unique component in our design. We found that there was still no website that could illustrate in detail what exactly happened in Heimey in 1973 and later on. Our material contained valuable information about what happened in Heimey in 1973 and what it looked like in 10 and 25 years' time frame. As a result, we built more interactive components in terms of the details of the Heimey eruption and its changes during the past 25 years. In summary, reviewing the projects with similar content or function can broaden our view and foster our creativity.

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