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ABSTRACT

This document contains the full and short papers on collaborative learning from ICCE/ICCAI 2000 (International Conference on Computers in Education/International Conference on Computer-Assisted Instruction) covering the following topics: comparison of applying Internet to cooperative and traditional learning; a distributed backbone system for community-based collaborative virtual universities; a European learning environment; a flexible transaction model for virtual school environments; collaborative teaching for creating learning in an engineering class; the effectiveness of a World Wide Web-based collaborative learning system on school mathematics; an agent-based collaborative learning environment for intelligent tutoring systems (ITS); and agent-oriented support environment in Web-based collaborative learning; the effectiveness of Web-based application for mailing list; implementation of a campus distance learning system using Multicast; analyses of cognitive effects of collaborative learning processes on students' computer programming; building mathematics collaborative learning Web sites; collaborative learning using GSS (Group Support System) on the Internet; design and implementation of cooperative monitoring agent using mobile agent; designing extensible simulation-oriented collaborative virtual learning environments; development of the Web-based classroom system; the gap between the discourse and the application of socio-constructivist principles of pre-service teachers using information and computer technologies; domain specific information clearinghouses; developing successful collaborative projects among European initial teacher education students; evaluating children interacting, collaborating, and learning with computers; group composition methods for cooperative learning in Web-based instructional systems; initial evidence for representational guidance of learning discourse; forming effective collaborative learning groups with ontological engineering; learning protocols for knowledge discovery; supporting semantic indexing in a mediabase system that facilitates collaborative learning; peer help for problem-based learning; promoting student learning and development in computer-based cooperative learning; an XML (eXtensible Markup Language)-based knowledge sharing and management

system supporting research activities; a collaborative problem-solving environment for synchronous discussion; scientific revolutions and conceptual change in students; the distance ecological model to support self-collaborative learning in the Internet environment; the impact of learning style on group cooperative learning; the project-based cooperative learning on the Internet; tracking and guiding tools for learning groups in a Web collaborative learning system; and development and evaluation of computer-supported collaborative learning software for teacher education. (MES)

ICCE/ICCAI 2000 Full & Short Papers (Collaborative Learning)

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A Comparative Study of Applying Internet on Cooperative and Traditional Learning

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The Internet-based cooperative learning has become a new trend in education, thanks to the rapid development of the technologies. This study evaluates the effects of utilizing the Internet on cooperative and traditional learning. Aiming on an elementary school natural science topic, this study compares learning performance of two pupil groups that contains 36 twelve-year-old pupils for each group. We found the learners who adopting Internet-based cooperative learning outperform the other group on Memory-demanding, integration, and deduction type problems. Furthermore, the Internet-based cooperative learning group has uniform performance on the three types problems and is generally more aggressive. In contrast, the Internet-based traditional learning group tends to perform better only on Memory-demanding type problems and has relatively passive learning attitude. Based on the experience, we encourage using the Internet in cooperative learning for nature science. Teachers also need to compose a complete plan and familiarize learners with an Internet browser before conducting the course.

Keywords: **cooperative learning; traditional learning; Internet-based cooperative learning; difference of significance**

1 Introduction

Rapid progress of the Internet has greatly changed the way of teaching and learning. The Internet not only overcomes the space and time limitation of a closed environment such as a classroom, the Internet also contains many useful educational resources that motivate and attract students. This new environment demands teachers to adapt new teaching methods by using applications like World Wide Webs (WWW) and E-mail. Therefore, the means by which teachers efficiently take advantage the new technology is an essential education subject.

While many teachers have started integrating the Internet into their classrooms, little systematical researches has focused on using the Internet in cooperative learning. Aiming to combine the Internet with cooperative learning concept, we conducted this study to (1) evaluate feasibility and efficiency of Internet-based cooperative learning, (2) develop strategies that can help students to learn actively and independently by Internet-based cooperative leaning, and (3) compare students' performance while applying the Internet on cooperative and traditional learning methods.

This study designed a way merging the Internet into a cooperative learning environment. The designed course focused on Sixth grade Natural Science (for twelve-year-old pupils) in Taiwan. Our study demonstrated the feasibility of Internet-based cooperative learning. We showed that pupils leaning in an Internet-based cooperative learning environment can outperform those who learn in an Internet-based traditional learning environment. Pupils' performances were evaluated by questions requiring their problem solving capability in memory demanding, integration, and deduction. All the findings are supported by statistical quantitative analysis results with significant difference.

In other words, this study focuses on the following questions:

(1) What kind of role does the Internet play in Internet-based cooperative learning and Internet-based traditional learning?
(2) Do pupils have enough computer literacy for Internet-based learning?
(3) Is there any learning efficiency difference between Internet-based cooperative learning and Internet-based traditional learning?
(4) If such difference really exists, which one is better?
(5) Do these two teaching methods have significant difference in student's problem solving capability? Especially in the aspect of memory demanding, integral, and deductive ability.

1.1 Literature review

We now survey literatures related to our study.

1.1.1 Using the Internet in learning environment

With the popularity of the WWW, a great deal of interest and enthusiasm has being expressed among teachers concerning the use of the WWW as a learning tool.[2,7] The main reasons are that the Internet offers a new learning environment that is quite different from the traditional classroom, and teachers can utilize Internet resources to enrich their teaching.

The Internet offers a learning environment that can be characterized by the following [6]:
(1) It has no limitation on place or time. That is, students can learn all kinds of knowledge at any place and any time.
(2) It is interactive and flexible. Students can choose different contents based on their learning conditions.
(3) The Internet integrates global educational resources.
(4) Students can communicate and discuss subjects with each other on the Internet. They also benefit from cooperative learning
(5) Multimedia effects of the Internet enhance students' motivation in learning.

In addition, Donald and LeuDeborah [3] suggested instructional strategies including Internet Workshop, Internet Activity, Internet Project, and Internet Inquiry.

1.1.2 Roles of teachers and students in cooperative learning

In order to achieve a better result in the cooperative learning process, teachers and students need to be fully aware of the role they play. Wang [13] claimed that, in most cases, cooperative learning should be practiced by a small group of students. The students' ability to cooperate are emphasized in the learning process. By group discussion, students can learn actively and build their own knowledge. Cooperative learning stresses that students play a major role in all learning activities and learn independently. According to the mission, students do their own literature search and then read, analyze, organize, and experiment with their material. Students establish learning concepts and share what they have learned via discussion with group members. Cooperative learning also emphasizes heterogeneous group learning. Teachers need to understand the profiles, difficulties, and expertise of learning of each student in order to group student in the best way. Therefore, teachers need to be well prepared and have a good plan on course work before performing cooperative learning.[9]

Some authors also pointed out that cooperative learning is more than just having a group of students solve problems in a cooperative way. Most importantly the following factors need to be included in the process of achieving a common goal [14]:
(1) Group members need to understand that they are a part of a team sharing a common goal.
(2) Group members need to realize that the problem is for the whole group and they share the success or failure with the whole group.
(3) Students need to talk to each other and join the discussion after accomplishing the common goal.
(4) Every group member needs to be fully aware of the fact that his or her contribution has a direct effect on the success of this group.

1.1.3 Comparison between cooperative learning and traditional learning

Colonel Paker first introduced the concept of cooperative learning in late nineteenth century. The concept has further become an active research subject in the last three decades. [1] One main topic of this research

field is to compare the efficiency of cooperative learning to that of traditional learning. Many experimental results showed that cooperative learning is superior to tradition learning.[4,5,8,10,11] Actually, Slavin [10] further pointed that:
(1) 63% of studies had showed that cooperative learning is superior to traditional learning,
(2) 33% of studies had showed no significant difference between these two methods, and
(3) 4% of studies had showed that traditional learning is superior to cooperative learning.

1.1.4 The way of communication of traditional learning and Internet-based learning

Advantage of computer network mediated communications can further enhance the advantage of using the Internet in cooperative learning. Traditional learning allows only one-way communication between student and teacher. Tyan and Hong [12] mentioned in their recent study: "The way of communication in traditional learning has many limitations. It has to be simultaneous in space and time; it is only a one-way broadcast communication from teacher to whole students as a group; its messages are is by oral in most cases; special arrangement, such as tape recording, note taking, and etc., are needed to record the teaching material."

In contrast, computer network mediated communications are more versatile. It can be simultaneous or non-simultaneous in space and time. It allows multilateral communications between a teacher and students and between students. In addition to broadcast from a teacher to the whole class, it also allows private dialogue. Finally its messages are textual and graphic information displayed by a computer, which can be automatically stored in a computer.

1.2 Organization of the paper

We state the methodology and the process of the study in the next section. Experimental results are demonstrated and analyzed in Section 3. Findings and inducing suggestions are elaborated upon in Section 4. We conclude the paper and provide further direction in Section 5.

2 Methodology

2.1 The presumptions of this study

We assume that students are capable of using the Internet while engaging in Internet-based learning, and the Internet-based cooperative learning group is trained to have skills for cooperative learning. In addition, a suitable site is designed by teachers based on the learning goal. Teachers needs to be prepared before perform the Internet-based learning.

2.2 Flow chart of this study

Figure1 shows the flow chart designed for this study.

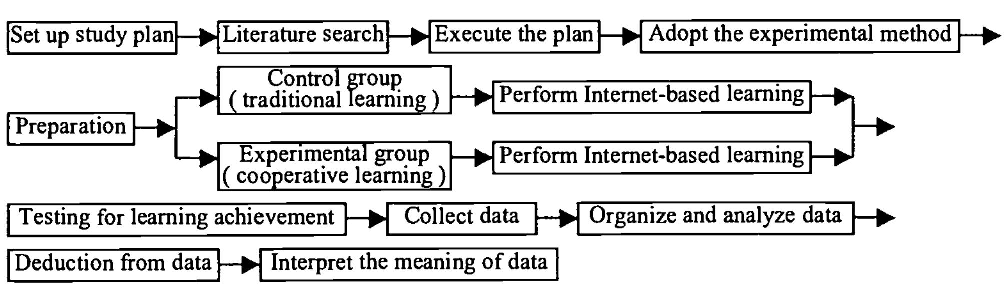


Figure 1. The flow chart for the process in this study.

2.3 The process of this study

2.3.1 The subject of this study

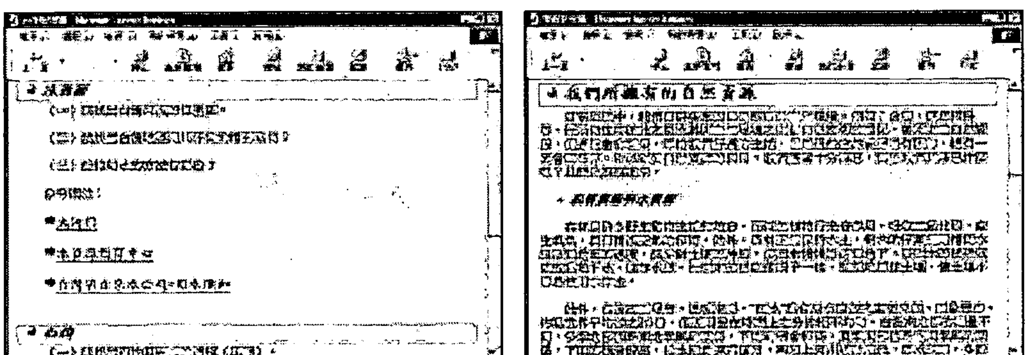
Two Sixth-grade "Computer Experimental Classes" of Hai-Tung Elementary School (Tainan, Taiwan) are the subjects of this study. Both classes have a normal distribution in students' learning capabilities. Each of these two classes has 36 student subjects.

We group the students by the following mean. All 72 students are listed sequentially according to their learning capability. Students with odd numbers are assigned to the experimental group; those with even numbers are assigned to control group. Students in each group are further divided into subgroups. Each subgroup has 3 members who have low, average, and high learning capability respectively.

2.3.2 The tool of this study

In this study, computers are the basic tool for both two groups. For the purpose of this study, a web site has been designed based on the twelfth volume of the nature science textbook for elementary school. Figure 2 shows some snapshot examples of the web. The Internet-based cooperative learning page contains only topics and possible URL links, but the Internet-based traditional learning page describes whole the knowledge for this course. The Internet-based cooperative learning group get knowledge about the topics from relative URLs and discuss with their members. However, the Internet-based traditional learning group only get knowledge from Internet-based traditional learning page. While the learning is proceeding, teachers need to help students to cooperate and make them more aggressive.

The experimental group receives Internet-based cooperative learning; on the other hand, the control group receives Internet-based traditional learning. An "Activity Page" (See Figure 3) is used to evaluate the achievement of these two groups and it contains memory-demanding, integration, and deduction problems that is designed based on the learning goal. For example, we design an integration problem about natural resource recycle to test students' ability to integrate the fractional knowledge thsy learned. The idea of letting student groups browse the Internet according to the "Activity Page" and then discuss and present the findings in a workshop is also suggested by Donald and Deborah.[3]



(A) Internet-based cooperative learning page (B) Internet-based traditional learning page

Figure 2. Web pages for Internet-based learning.

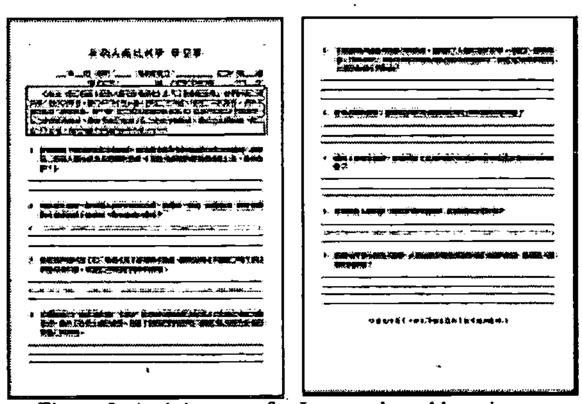


Figure 3. Activity page for Internet-based learning.

2.3.3 Data analysis

Figure 4 shows the flow chart for the data analysis. The data was obtained from the examination given after the learning experiment. The data was analyzed for statistically significant difference of 0.05 and 0.01. In order to investigate students' problem solving capabilities for different types of problems, the examination contains memory-demanding, integration, and deduction problems. We defined these three types of problems as follows:

(a) Memory-demanding type: this kind of problem is given to test students' ability to memorize the fractional knowledge they learned;
(b) Integration type: this kind of problem is given to test the students' ability to integrate the fractional knowledge they learned;
(c) Deduction type: this kind of problem is mainly to test the students' ingenuity and creativity after comprehending the knowledge they learned.

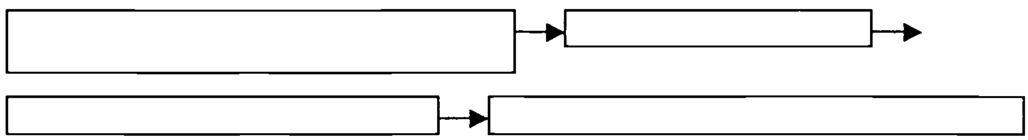
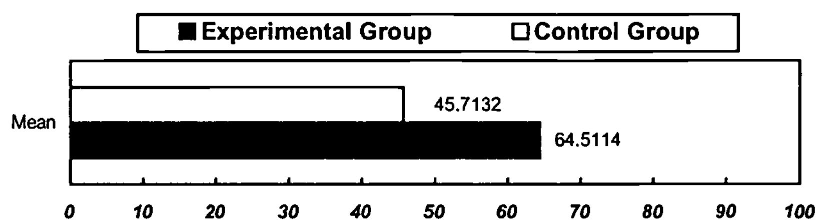


Figure 4. Data analysis flow chart.

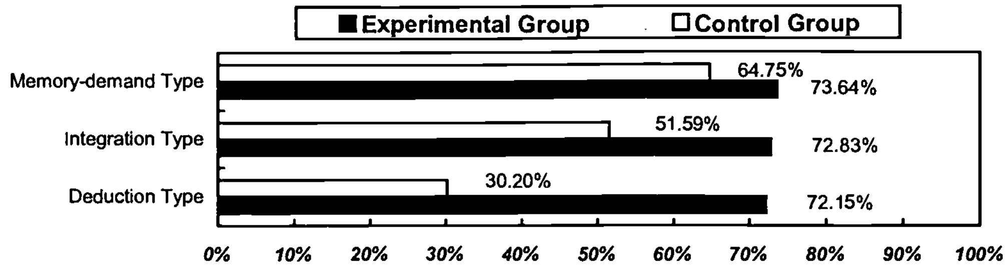
3 Experiment results

Both the experimental group(Internet-based cooperative learning group) and control group(Internet-based traditional learning group) are subjected to have a same examination for evaluation. Figure 5 shows total test scores for experimental group and control group, and Figure 6 shows a comparison on scores of memory-demanding, integration and deduction problems.



item / group	Samples (N)	Mean ($\overline{X}$)	Standard deviation (SD)	t-value	p-value
Experimental Group	36	64.5114	14.6882	4.5540	< 0.01
Control Group	36	45.7132	19.7863		

Figure 5. Total test scores for experimental group and control group.



Problem Type \ Item		Mean	Standard deviation (SD)	t-value	p-value	Ratio of correct answers
Memory-demand	Experimental Group	24.3007	4.0356	1.8285	< 0.05 > 0.01	73.64 %
	Control Group	21.3678	8.7102			64.75 %
Integration	Experimental Group	40.0590	7.4270	5.6315	< 0.01	72.83 %
	Control Group	28.3768	9.9087			51.59 %
Deduction	Experimental Group	7.9370	4.4192	4.589	< 0.01	72.15 %
	Control Group	3.3216	3.6473			30.20 %

Figure 6. Scores on various types of problems for experimental group and control group.

4 Findings and suggestions

4.1 Findings

Based on the data obtained and the observation made during the experimental process, the following conclusions can be drawn. Besides, due to the restriction on experimental samples, the excessive inference should not be draw from these conclusions.

(1) Internet-based learning is feasible in an elementary school nature science course.

This study shows that either Internet-based learning method can fulfill the learning goal after the analysis of examination according to "Activity Page". Most sixth grade students can easily adapted themselves to Internet-based learning environment. Hardware equipment is not an issue in Taiwan, on the other hand. Since the Taiwanese government has greatly prompted information education in recent years, all levels of schools are equipped with personal computers.

(2) There is a significant difference in students' total examination scores for Internet-based cooperative learning and Internet-based traditional learning.

The t-value of this difference is 4.554 that can be regarded as statistically significant at the level of 0.01. Therefore, Internet-based cooperative learning is greatly superior to Internet-based traditional learning.

(3) The Internet-based cooperative learning group has better learning results on Memory-demanding type of problems.

Students in the Internet-based cooperative learning group performed better in this type of problem than those in the Internet-based traditional learning group. The different is considered as level of significance of 0.05, but less than the level of significance 0.01. It means that the learning efficiency of Internet-based cooperative learning is superior to Internet-based traditional learning, but not in a large significance.

(4) On integration type of problems, the Internet-base cooperative learning group significantly outperforms the Internet-based traditional learning group.

Students in the Internet-base cooperative learning group need to piece together information from various Internet resources. During the process of integration, they build new models and images in their minds. By merging new models and images with old knowledge, they can form new knowledge. New and old knowledge is then integrated into a full concept. This is the reason why the Internet-based cooperative group had better learning efficiency on integration type of problems than the Internet-based traditional learning group.

(5) Students in the Internet-based cooperative learning group have higher scores in deduction type of problems.

In deduction type problems, students in the Internet-based cooperative learning group outperformed those in the Internet-based traditional learning group by 72.15% versus 30.20% in the ratio of correct answers. This reflects that students in the Internet-based traditional learning group lack logical inference capability. On the other hand, the Internet-based cooperative learning group had better logical inference ability and more creative ability.

(6) The Internet-based traditional learning group performed best in the memory-demanding problems.

In traditional learning, the teacher delivers teaching material and its highlights directly to students. Since the teacher has organized his material before class, the teaching method is more suitable for Memory-demanding type of problem. This is why students in the Internet-based traditional learning group score higher in memory-demanding problems than other types of problems.

(7) Students in the Internet-based cooperative learning group scored evenly in all kinds of problems.

Students in the Internet-based cooperative learning group score 73.64%, 72.83%, and 72.15% on memory-demanding, integration, and deduction problems. Thus, this teaching method is suitable to all kinds of evaluation methods.

(8) Students in the Internet-based cooperative learning group are more aggressive in learning than those in the Internet-based traditional learning group.

In dealing with problems, students in the Internet-based cooperative learning group acted cooperatively and aggressively in searching for answers using Internet resources. On the other hand, those in the Internet-based traditional learning group are less aggressive in overcoming difficulties, and give up at an early stage.

4.2 Suggestions

(1) Elementary school natural science courses can better utilize Internet resources to perform cooperative learning.

The massive resources on the Internet are an important and attractive factor motivating students to learn actively. Thus, teachers need to better utilize such resources to improve learning efficiency.

(2) During the process of Internet-based cooperative learning, a teacher needs to develop students' capability in cooperative learning.

The success of cooperative learning depends heavily on students' capability in cooperative learning. Teachers thus need to develop students' capability to learn cooperatively during their regular teaching. They should also make students understand the spirit and meaning of cooperative learning which is that each group member is willing to share their knowledge with others.

(3) Before performing Internet-based cooperative learning, teachers need to have a complete plan regarding the learning environment.

An effective cooperative learning relies on teachers' full preparation before the class, which includes: students properly divided into groups; teaching related material, such as web sites; increase initiation factor for cooperation; improve group members' contribution; develop students' ability to browse the Internet; and so on. These entire things require teachers to communicate with their students to reach a consensus before the class.

(4) Both teachers and students need to be aware of the roles they play in Internet-based cooperative learning process.

Though students learn by using Internet resources in Internet-based cooperative learning, the teacher still plays a crucial role. Like a navigator in a voyage, the teacher prevents students from being overwhelmed by the massive information on the Internet and guides them to reach their learning goal according to a series of stages. Students need to have the spirit of a trail-blazer in daring to make all kinds of trial effects. They also need to share the learning experience with others.

(5) During Internet-based cooperative learning, a teacher needs to increase students' consciousness on cooperation.

In cooperative learning, knowledge is obtained through cooperation between group members. Hence, group members should realize that the goal of the group is their own learning goal. Group power can be used to overcome learning difficulties, and develop a learning method that is suitable to the whole group. This allows each group member to experience the joy of learning.

5 Conclusions

This paper describes that cooperative learning and traditional learning can be combined with the Internet in an elementary school nature science course, and the learning efficiency will not be reduced. In addition, Internet-based cooperative learning is greatly superior to Internet-based traditional learning in learning efficiency. Since this paper is the plot study of Internet-based learning, we only focus on the learning efficiency of applying Internet on cooperative and traditional learning. It is likely that future replications of the study will in turn lead to discovery of comparison between other learning methods, such as cooperative learning, traditional learning, Internet-based cooperative learning and Internet-based traditional learning. Furthermore, we intend to develop different teaching strategic to lead students' interaction in the future.

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A Distributed Backbone System for Community-Based Collaborative Virtual Universities

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In this paper, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We discuss designing and prototyping of a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system as well.

Keywords: **Distance learning, virtual university, virtual community, MOO, software agent.**

1 Introduction

Information and network technologies have been changing how people work, live and learn. The so-called Internet revolution has brought great impact on the global society, and is greatly changing the educational systems. In recent years, distance education/learning and virtual universities have been attracting more and more attentions, and play an important role in the educational system revolution for the new coming century.

Virtual universities cover a very broad field. Many research works have been conducted in the domain [1, 2]. However, experiments and experiences have demonstrated that electronic communication in the networked virtual environment has some different characteristics from face-to-face communication in the real world [3]. Many studies have also shown that learning in the networked virtual environments involves approaches that are not typical of general classrooms [4, 5]. It is necessary for a virtual university to have general functions, utilities and resources of a physical real world university available on the networks. However, it is not enough and efficient only trying to move a physical university to the virtual world without considering on the fact that there are great differences between physical and virtual universities.

In this study, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We design and develop a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system (a networked computer and/or a software agent) as well.

2 Framework for Community-Based Collaborative Virtual Universities

The Internet provides a universal, free, and equal electronic communication environment for people of all ages with different education backgrounds, ability levels, and personal inclinations. It makes knowledge delivery, sharing and building possible among large and diverse groups of people across the networks.

The central purpose of community-based collaborative virtual universities is to provide a learning environment that widely opens to large and diverse group of people who have the will to learn and to share their knowledge with others across the networks. They are a networked virtual workspace with the time-independent and place-independent access, in which computation is effectively utilized to actively and properly support human-human communication, interaction and collaboration in addition to human-computer communication, interaction and collaboration, towards effectively assisting and enhancing learning activities in the virtual environments [6].

Community-based collaborative virtual universities are participants-driven. That is, participants or learners share a common interest in a topic or area, share a way of knowing and a set of practices [7]. Knowledge is not just delivered from teachers or experts, but also constructed by participants' team works and/or discussions. Community-based collaborative virtual universities support different ways for novices and experts to work in the same environment to accomplish similar goals. They may be large, the task general, and the communication open. Alternatively, they can be small, the task specific, and the communication close.

3 Design and Implementation of the Distributed Backbone System

3.1 Overview

The backbone system for flexibly supporting community learning has been designed so that a learner can navigate through it, select relevant information, respond to questions using computer input devices such as a keyboard, mouse, or voice command system, solve problems, complete challenging tasks, create knowledge representations, collaborate with others, or otherwise engage in meaningful learning activities.

Figure 1 shows an overview of the distributed backbone system for community-based collaborative virtual universities, which have been implemented in MOO (Multi user dimension Object-Oriented), well known as a text-based social virtual reality [8]. Human users and software agents co-exist and interact in the MOO based virtual community. Social interaction between users is actively mediated and facilitated by cooperative agents who support their learning activities in the virtual environments as well.

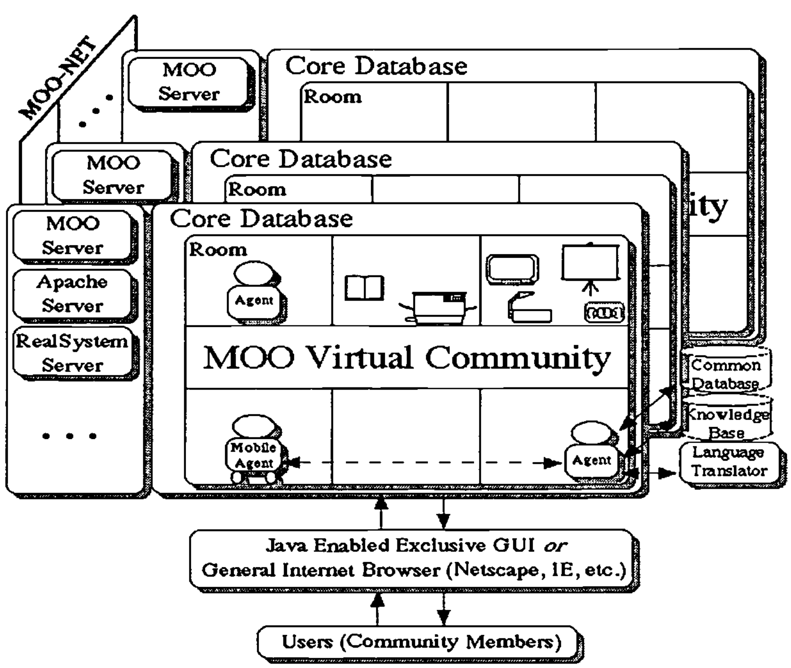

Figure 1 Overview of the MOO-Networked Backbone

3.1.1 Web and Multimedia Integration

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To fully utilize multimedia such as graphic images, sounds, and/or movies, we have integrated the MOO Server with the web server (e.g., Apache Server) and other servers providing multimedia services (e.g., RealSystem Server). Since the seamless integration of the MOO Server with the web server, technically, it is possible to integrate MOO with any types of server services and incorporate any type of multimedia such as MPEG1, MPEG2, and/or MP3 data in the MOO virtual environment.

3.1.2 Graphical User Interface

Java enabled exclusive graphical user interface specially designed for accessing MOO virtual environments has been developed. Consequently, MOO commands and verbs could be transferred to a hyper link. For example, users can go in or out of a room by simply clicking a corresponding hyper link that represents the entrance or exit; they may read a note by clicking the hyper link representing the note. Since it is constructed with Java language, it could be run with a general Internet Browser (e.g., Netscape, Internet Explorer).

3.1.3 Software Agent Support

To further provide flexible and proper support for communication, interaction and collaboration in the networked virtual environments, a multi agent paradigm has been adopted in this study. We have proposed a kind of software agents that adapt well to users' behavior and incorporated them both within the MOO environment and on the interface which we call interface agents, and integrate one interface agent for each user that bridges the virtual environment and the user to aid his/her manipulations and various activities.

Interface agents provide different ways of supports. They may provide suggestions, answer questions to a user. They can search something from an outside database or knowledge base for their owners by ``*wireless*" communication with the DB/KB agent to transfer their owners' request and obtain the search results. Interface agents may accompany a user to move around the virtual environment if the user requests so. They can also provide actively supports to a user once a problem occurs.

In addition to interface agents, there are also various types of software agents inside or outside the virtual community, which are called task agents. Task agents provide specific functions or resources available in the local environment or outside over the Internet to interface agents directly or indirectly. In the latter case, they are mediated by a so-called mediator agent.

3.1.4 Multilingual Environment with Language Translator Agents

Due to the diversity of the users in the community-based collaborative virtual universities, it has to encompass the needs of people of all ages, races, and nationalities with different education backgrounds, and ability levels. Consequently, this causes a language problem in knowledge representation and communication.

As described in the previous sections, integration of MOO environment with the web and multimedia service servers make it possible to play sounds and movies in any language, and display information and knowledge on the Java enabled graphical user interface or a general Internet browser in a language that the client program and browsers may support. However, the language has to be selected and specified by the users themselves. Moreover, it is impossible to conduct real time communication in different languages.

In this study, we have created a new kind of task agents (translator agent) that serves for each users and automatically select one suitable language for the user to communicate with others and browse the information and knowledge in the virtual environment according to the information given in a pre-defined property. The translator agent can also translate for the users from a non-native language to their tongue, even though they understand the non-native language. The agent may also display the original languages that other users speak in addition to the translated language.

3.1.5 Distributed Virtual Environments with MOO-net

To effectively provide general university functions, utilities and resources over the networks, we have designed the backbone system as a distributed one based on the MOO-net mechanism, which is a low-bandwidth information network for the MOO family and operates using a packet-switched model [9]. As a result, distributed virtual lecture could be delivered across the MOO-networked virtual environments using a special virtual lecture hall. Real time communication could be conducted between users in different MOO virtual environments. Further, agents may communicate with other agents in different virtual environments, and even search objects from there for users.

3.2 Prototyping Implementation of the Distributed Backbone System

The prototype system has been implemented in the three test-beds isMOO (available at URL telnet://n132.is.tokushima-u.ac.jp:6666 or http://n132.is.tokushima-u.ac.jp:6868), izMOO (available at URL telnet://pross50.u-aizu.ac.jp:8888 or http://pross50.u-aizu.ac.jp:7000) and vu21MOO (available at URL telnet://vu21.u-aizu.ac.jp:6666 or http://vu21.u-aizu.ac.jp:6868) which are running under the LambdaMOO Server with the Japanese patch and the JHCore and enCore Databases with MOO-net (http://www.cs.cf.ac.uk/User/Andrew.Wilson/MOO-net/), the RealSystem Server (http://www.realnetworks.com/ products/servers/index.html), and the Apache Web Server (http://www.apache.org/httpd.html).

The LambdaMOO embedded object-oriented script language has been used to construct programs for software agents within the MOO virtual environment, although it is possible and might be more *powerful* to create task agents outside the MOO virtual environment using a standard programming language. Our prototype translator agents support three languages: English, Chinese and Japanese.

4 Conclusion

This study aims at proposing and building an innovative educational system for the coming new century. In this paper, we have proposed community solution as an alternative for virtual universities, and described a new conceptual framework for community-based collaborative virtual universities. We have further introduced design and prototype implementation of the distributed backbone system for community-based collaborative virtual universities.

For future direction, we plan to improve the functions of proper communication support based on studies of natural human communication processes, and design and develop an educational information resource base with high quality multimedia. We will further develop mechanisms that facilitate mutual understanding beyond differences in place, time, language and culture, and make the virtual environments flexibly responsive to users' behavior.

Acknowledgments

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A European Learning Environment: Reflections on Teaching and Learning in a Multinational Virtual Learning Community

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This paper outlines the background to the development of a European Masters programme in *Multimedia Education and Consultancy.* The development arises from an Advanced Curriculum Development (CDA) Project supported by the European Commission under the SOCRATES programme, which involves nine institutions in seven different European countries. The aims and outline of the Masters programme are described together with the pedagogical approach adopted. A key feature of the latter is a virtual learning environment that is underpinned by the use of the concept of "metaphor". This is intended to convey how the technical construction of the pedagogical functions communicates the background theories of the learning environment to the users. A pilot unit/module on *ICT in Open Learning Environments* is outlined together with some of the key features of the learning environment. This was trialled by a group of students based at locations in Finland, Austria, the Netherlands and the UK during the second semester of the academic year 1999-00. Evaluations are provided by a participating tutor, an observer and from two participating students. Finally some reflections are outlined which focus on the innovative aspects of this learning environment and of our experiences as teachers and learners in a multinational virtual learning community.

Keywords: **Collaborative Learning - Web-Based Learning - Networked Social Learning - Teaching and Learning Processes**

1 Introduction

This paper reports on experiences as teachers and learners in a multinational virtual learning community, which have resulted from our involvement in a pilot unit as part of the development of a European Masters course. The pilot unit is entitled *ICT in Open Learning Environments* and our involvement has taken place between February and May 2000.

2 Background to the development

The background to the development is the Advanced Curriculum Development (CDA) Project *TRIPLE M: Masters in MultiMedia Education and Consulting* that is supported by the European Commission under the SOCRATES programme (29268-IC-2-97-1-AT-ERASMUS-CDA-1) over the period 1998 to 2001. The *TRIPLE M* project is co-ordinated by Pädagogische Akademie des Bundes in Öberösterreich, Linz, Austria and involves a number of departments and research units with experience and expertise in teacher education and the use of Information and Communication Technology (ICT). The current participating institutions in the *TRIPLE M* project are:

- Pädagogische Akademie des Bundes in Öberösterreich, Linz, Austria (Co-ordinating institution)
- Charles University, Prague, Czech Republic
- Hogeschool Arnhem and Nijmegen, Netherlands
- Liverpool Hope University College, United Kingdom
- Pädagogische Akademie Vienna, Austria
- Sheffield Hallam University, United Kingdom
- Umeå University, Sweden
- University of Oulu, Finland
- University of Santiago de Compostela, Spain

A sub-group of the TRIPLE M Consortium has formed the *European Association for Multimedia Education and Consultancy™ (EAMEC™)* with the intention of offering a validated Masters programme in for *Multimedia Education and Consultancy* from September 2000. Initially this will be offered as a part-time route with a plan to run the programme on a full-time basis from September 2001.

3 Programme aims and outline

The academic aims of the programme have been developed in response to the needs of the 'Information Society' phenomenon related to the rapid development of high technology use in all sectors of society. The programme aims to meet the needs of teachers in schools and further and higher education especially. Specifically the programme seeks to develop the profile of the 'problem solver'/team co-ordinator at the interface of pedagogical, technological and organisational/cultural dimensions of development. In summary the programme aims to support the development of individuals who are able to:

- demonstrate and communicate knowledge and critical understanding of pedagogical issues as applied to the use of multimedia in new learning environments
- critically understand the social, organisational and cross-cultural phenomena related to new learning environments in trans-national and cross-cultural contexts
- appreciate and be responsive to the social and cultural impact of the Information Society in relation to values and working practices
- act as effective mediators and facilitators at the interface between the needs of users and providers
- co-ordinate the efforts of multi-disciplinary teams in terms of problem analysis, design and implementation issues
- be aware of the staff development needs of new users and appreciate the support structures and strategies for continuing development
- demonstrate a critical understanding of (educational) research and its role in a context of rapid change
- remain open to critiques of the Information Society with particular regard to the social and cultural implications

The programme is made up of six units/modules that together make up 90 European Credits (ECTS). These are as follows:

- Open Learning Environments (*OLE* - 10 ECTS)
- Digital Media Applications (*DMA* - 10 ECTS)
- Communication and Consultancy (*CC* - 10 ECTS)
- Research Methodolgies (*RM* - 10 ECTS)

- Project Studies (*PS* - 20 ECTS)
- Dissertation (*DS* - 30 ECTS)

The four more structured units (OLE, DMA, CC and RM) all follow a common pattern of:
- Telematic-based Studies (50%) e.g. Web-based work and discussions, multi-point videoconferencing sessions, and
- Local and Independent Studies (50%) in national groups e.g. day workshops and tutorials plus independent study.

4 Pedagogical approach

The pedagogical approach involves Telematic-based Studies in Web-based work, discussions and multi-point videoconferencing sessions in multinational learning communities. It is seen as crucial that these studies are supported by Local Studies - in national groups e.g. day workshops, practical activity, project work, research activity and tutorials and Independent Studies including literature reviews, independent project work, research activity, writing etc.

The use of ICT as a medium for learning and communication is fundamental to the underpinning philosophy of the programme and is an integrated and all pervasive aspect of the pedagogical approach, both in terms of learning about it and as an essential part of the learning process. Students need to use the Internet as an essential part of the learning and communication process.

The platform for the net-based learning environment is *LC Profiler – Learning Community Profiler*. This is the product of *LCProf Oy*, which is a Learning Service Provider (LSP) and a 'spin-off' company of the University of Oulu. The services are based on the methodology and system developed at the University of Oulu in a range of domestic and EU R&D and education projects during the last 5 years (e.g. Telematics projects T3: Telematics for Teacher Training, SCHEMA: Social Cohesion through Higher Education in Marginal Areas). The implementation of the system is based on the principle of creating a distributed community of learners and supporting the tutors to enable them to create their own learning communities. This means that the tutors also belong to a unique learning community of their own, which aims to support ongoing professional development.

5 The role of metaphor

The concept of metaphor plays a fundamental part in the underlying design of the *LC Profiler* environment and also in signifying key functions to the user. In their paper Pulkinnen and Peltonen [1] use the concept of "metaphor" to "explain how the technical construction of the pedagogical functions communicates the background theories of the learning environment to the users". This paper is also one of the Core Readings for all students on the OLE unit/module. Their analysis combines ideas about knowledge, the structure of knowledge and learning with social aspects to do with the organisation of learning such as practical arrangements connected with "time, place and repetitive rituals". Their overall metaphor which captures the nature of the *LC Profiler* environment is of "a place of studying (virtual space) created with the help of ICT". The three "cornerstones" of their analysis of the learning environment are the individual whether as teacher or learner, the technology and the culture as fully outlined in Pulkkinen and Ruotsalainen [2]. They describe these as providing the "cross-disciplinary basis for the elements that are necessary for learning" and identify these elements as pedagogical functions, appropriate technologies, and the social organisation of education

6 The pilot unit/module

As part of the curriculum development process, two units have been piloted during the period from February to May 2000. These are *ICT in Open Learning Environments* (February to May) and *Digital Media Applications* (March to May). The former is based on an existing unit/module at the University of Oulu and forms the model for the development of the Masters programme as a whole. The full unit/module is worth 10 ECTS M Level credits for which 5 ECTS is available for successful completion of the telematics-based component. This was trialled as part of the TRIPLE M project with a group of about 25 Finnish, 9 Austrian, 4 Dutch and 2 UK students

The course outline is seen as one of the most important navigation tools, referred to as an "orientation metaphor". The introductory screen is shown below in Fig 1.

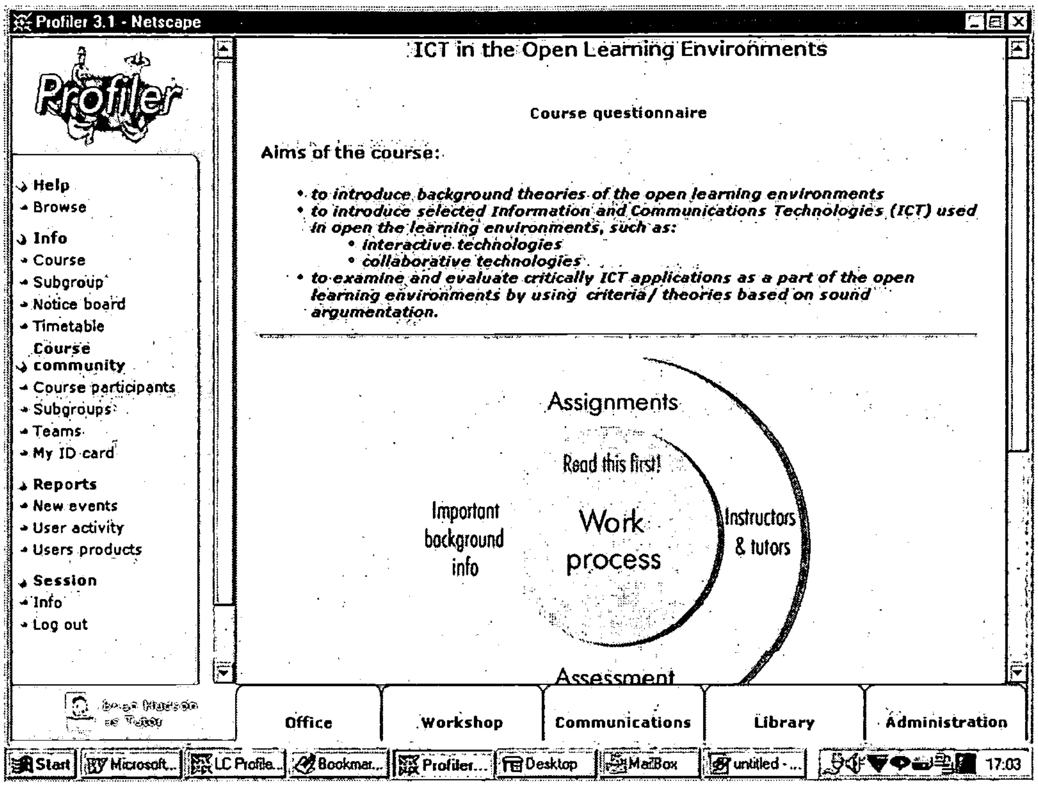

Figure 1

This screen includes a statement of the aims of the course and also conveys some of the metaphors that underpin the design of the system. (NB The use of the term "course" here is equivalent to the terms "unit/module" used previously and is a reflection of the diversity of the use of these descriptors across and within different systems) The most apparent metaphors are those which are to do with orientation to place or virtual working place. The Project Office, Workshop, Communications Centre, Library and Administration Centre refer to "working" and not to the technology and tools being used e.g. e-mail, chat, documents etc. This aspect is seen to be a particularly important issue in relation to signifying metaphors to users that refer to pedagogical practices. The metaphor of "project" is used to convey "the basic essence of learning" and the course flow orientates the user to time. This includes phases on the work process e.g. orientation, planning etc and also milestones, which are outlined in part in Figure 2.

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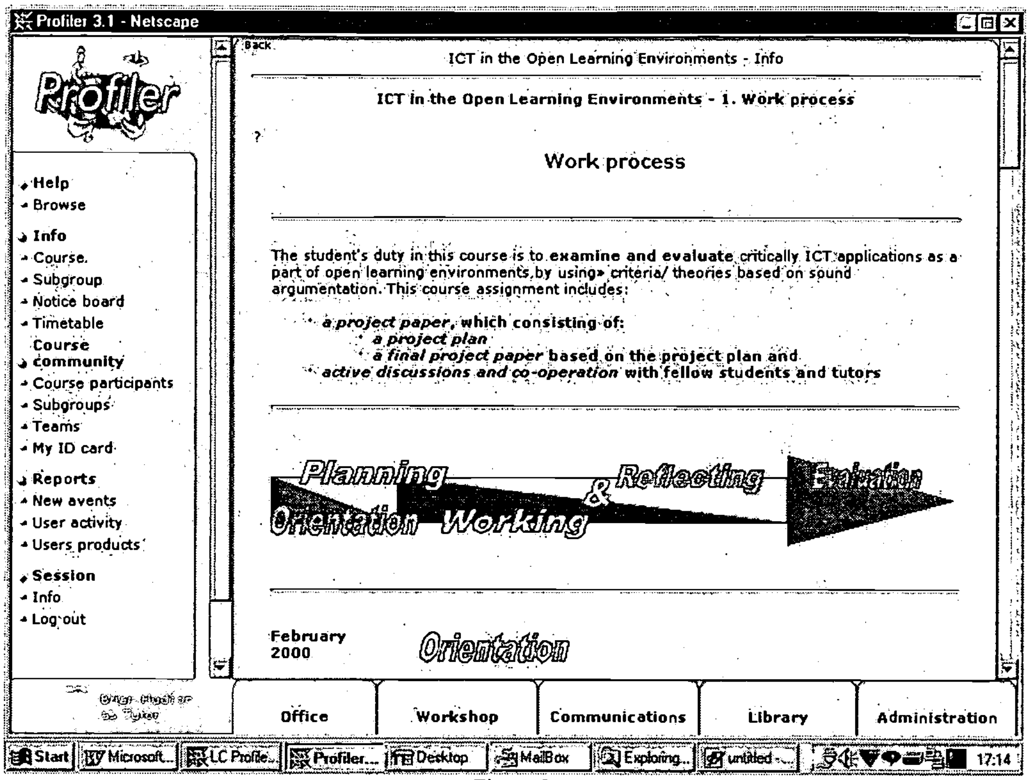

Figure 2

7 Experiences as teachers and learners

This section includes accounts and evaluations from a participating tutor (Brian Hudson), an observer (Ahmed El-Gamal) and from two participating students (Eric Knutsen and Amal Gouda).

As a particpating tutor I was immediately struck by the very clear sense of purpose that the course outline engendered with a very clear sense of the different phases, milestones and overall timescale. The active participation in discussions was not an option but a necessary requirement with comments being expected within fixed timescales and core readings, project plans of peers etc. As a result the level of communication on the course was very high - an analogy might be made with lighting a wood and coal fire - a little slow at the start but then bursting into flames from all sides!

Another key observation was of the role of the two main moderating tutors. Both could be characterised as being "on task" throughout the course of the unit/module. In general their responses to questions were very swift and they dealt with technical, pedagogical and social issues. The two tutors also interacted with each other in a very effective way by following up on each others comments, questions and prompts - so engendering a relaxed yet lively ambience around the discussions.

An example of the extent of the student discussions can be gleaned from the screen in Figure 3 below:

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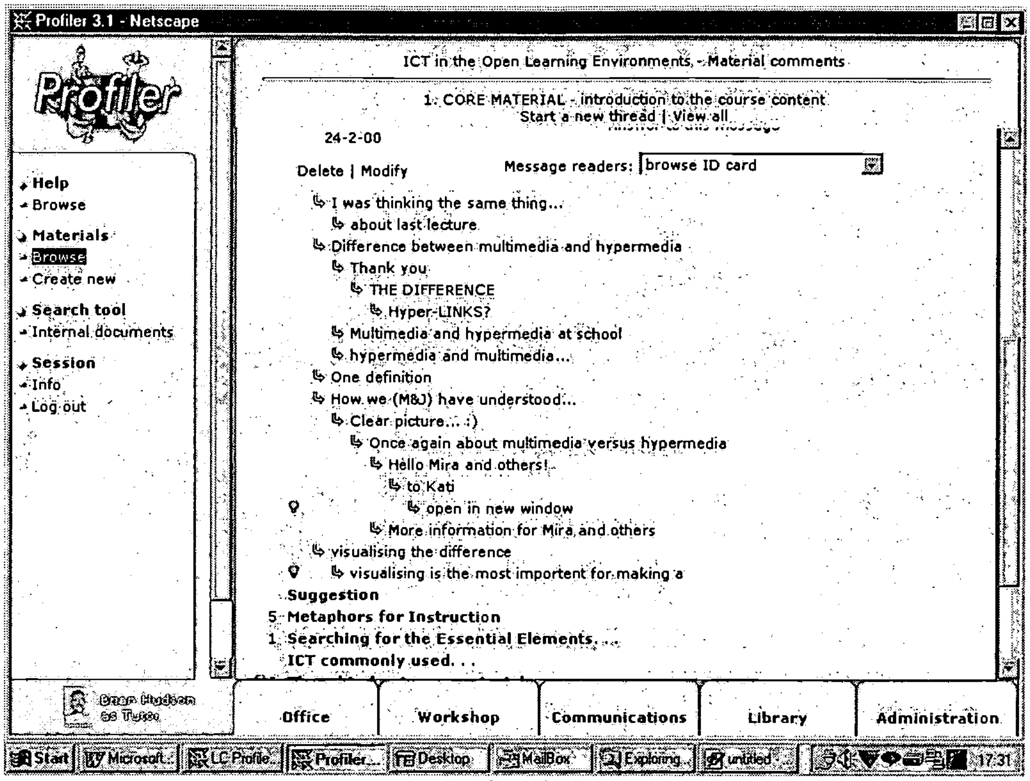

Figure 3

The particular thread started outlined above was started by student H on 24-02-00 with the comment:

Could some of you tell me what is the difference between multi- and hypermedia? Is there any difference, do they mean the same thing? The difference between these "words" was explained in the first core text but I just couldn't find the basic idea which might help to separate them.

These questions resulted in a rich, intense and well-informed discussion with around twenty contributions over a ten-day period, which seemed to conclude in an agreed consensus. Overall discussions were by no means restricted to technical matters but this particular thread was notable for its richness and intensity. A notable feature of this environment is the very clear way in which the threads are laid out and also the way in which the links are revealed when a thread such as the one above is opened.

Ahmed El-Gamal had the role of being a Local Tutor and was given access to *LC Profiler* as an observer. He is a staff member of Menofia University in Egypt on a PhD scholarship supported by the Egyptian Ministry of Education and Culture. He has chosen to cluster his comments around characteristics that he noticed about the learning environment in overall terms. This is a summary of his comments on these charactersitics:

Organization: The whole unit is well organized e.g. timetable, assignments, activities..etc. If there is any misunderstanding the student can post a question to the others.

Adaptability:Most of students adapted easily with this learning environment. Sometimes they have some technical problems e.g. the speed and the difficulty in using some tools, but they soon found assistace from the tutors and their peers.
Flexibility:It is a very flexible learning environment - students worked at different times in different countries, yet they have the opportunity to discuss the same topics.
Some students from different countries were able to create teams to conduct the same project.

Collaboration: Students collaborated with each other in solving some technical problems, clarifying some aspects in the references, developing teams and developing their project plans.

Conversation and discussion: Students were discussing different issues that were relevant to the course. All the participants have the opportunity to contribute to the discussion. They wouldn't end the discussion until they reached an agreement about the topic e.g. the discussion about the difference between Multimedia and Hypermedia was about 20 comments.

Social interactivity: Most of students have some social interactivity, by talking to the other students in the on-line café and by posting messages. Some friendships have been developed during the course.

Amal Gouda has studied to Diploma level in Educational Technology at Cairo University and is continuing her Masters studies at this time. She has chosen to group her evaluation around features of the studying process:

The studying process in OLE could be defined as an integrated process, which integrates the different resources and the different parts of the OLE to achieve the desired goals. The studying process in OLE is accomplished through the following parts:

Office: Every student can manage almost all his/her study through using the office and all the information about the course and other students are available on the office, in addition to the timetable and the framework of the course.

Workshop: Every student has developed his/her project plan and he/she has published it to the other course participants. This gave his/her opportunity to have the other students comments on it.

Communications: It gave the international students the opportunity to freely discuss different topics related to the course. It also allows them to discuss their project plans and the other students' project plans. Moreover, there are different categories for discussion e.g. questions and urgent message, general discussion about the study process..etc. In online café, the students can have a social chat with their peers.

Library: It has most of references that are related to the course, also it has a hyperlinks to enable students from browsing more materials. It was advised to write comments on these materials, in order to encourage the students to read them carefully.

Local studies: Every student met with his/her tutor many times to discuss the different topics and activities that seem to be unclear and to guide him/her through the course. The most important feature in the studying process in OLE is that it gave the opportunity to study and discuss different topics at any time during the day.

Eric Knutsen works in a secondary school and is in his first year of teaching as a teacher of ICT. He has chosen to respond to the aims of the course and to evaluate the extent to which these were met for him as a student:

- to introduce background theories of the open learning environments

This was done in a straightforward manner utilising the OLE of LC Profiler. It was useable as one would use a library in the traditional environment of a physical learning environment. The added value here was the amount of material referenced via the web. Using the expertise of the instructors on the course, I was able to make use of the varied written material and discuss other students' and my own opinions on the content. Being done in an asynchronous way, there was no need to be present physically or virtually for such discussion. Yet, I had the advantage of dozens of other opinions from which to draw my own conclusions. This took my learning beyond that previously possible via ..traditional learning ...

- to introduce selected (ICT) Information and Communications Technologies used in open learning environments, such as interactive technologies and collaborative technologies

One aspect of having been introduced to the background theory in the way it was done is the ability to review tens of project proposals and final project papers in light of the theory examined. This made the theoretical come to life, especially when undertaking my own individual work. This meant looking critically at the variety of components comprised with-in the environment being examined ...What made this a more lively introduction to the ICT was the regular use of LC Profiler and the success of the discussions taking place.

- to examine and evaluate critically ICT applications as a part of the open learning environments

by using criteria/ theories based on sound argumentation

Given the foundation above ... it was straightforward to see the relevance of the theory when examining the OLE at hand. Especially of interest was the use made of LC Profiler as an OLE by all members of the course and the social interaction made possible by all areas of LC Profiler, not isolated to the on-line cafe. This even fed the theoretical side to my thoughts about my assignment.

8 Conclusions

The experience of participating in this pilot unit has provided a real example of the transformative potential of the use of ICT. This is in spite of several years experience of using the *First Class* conferencing software which seems quite limited by comparison with *LC Profiler*. In McConnell's [3] terms *First Class* can be seen to be simply an example of "unstructured groupware" or an "electronic space". Some experiences result in real and lasting changes - for myself this experience has transformed my own pedagogical thinking and practice. Whilst being a vital component, the learning environment of itself is not the main ingredient for experiencing this transformation, although many people at this time are looking for the "quick fix" and simple solutions. However it has been the experience as a participant in a community of practice (Hudson [4]; Lave, [5] and Lave and Wenger, [6]) that has been fundamental. This process takes time and is about changes within (the person) and developing new ways of relating to other people. In general terms such high levels of on-line communication also necessitate the need to develop a more relaxed attitude towards committing ideas into print, for seeing such comments as transient and not permanent and being accepting of the need for "repairs" to communication as one would in more traditional forms of communication.

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A Flexible Transaction Model for Virtual School Environments

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Recent advances in Internet technologies have led to the advent of virtual schools. However, existing technologies have many limitations when applied to virtual school implementation. Especially, existing transaction models are not suitable for supporting virtual schools. In this paper, we present a new transaction model in order to support virtual school environments. First, we introduce the general characteristics of the virtual school environments. Then, we discuss transaction model requirements for virtual schools. Based on those requirements, we propose a new transaction model. We also show a locking-based concurrency control scheme for supporting collaboration works among students. Finally, we give conclusions and future research issues.

Keywords: **Collaborative Learning, Virtual School**

1 Introduction

Recently interests in virtual schools have been increasing due to advances in Internet technologies. The virtual school, which is based on distance learning, can overcome time and space limitations in the traditional schools. But, in order to complement lack of face-to-face communication in virtual schools, multimedia-based education is becoming popular. This multimedia-based education emphasizes the students' self-control. That is, multimedia- based education encourages interactions between teachers and students and also interactions among students. In the meanwhile, object-oriented databases become popular for supporting multimedia resources.

In the literature, many transaction models have been proposed for object-oriented database environments [5,7,8]. But, those transaction models have not reflected requirements in virtual schools. In this work, we propose a new transaction model that supports virtual school environments. The proposed model considers all those requirements.

This paper is organized as follows. In section 2, we discuss the transaction requirements in virtual school environments. Based on the discussion, we propose a new transaction model in Section 3. In Section 4, we present a locking-based concurrency control technique based on our model. Finally, we give conclusions and future research issues.

2 Transaction Requirements in Virtual School Environments

In this section we discuss transaction requirements in virtual school environments.

First of all, all transactions should maintain the correctness of database. One of the characteristics of database systems is manipulation of shared data. In this case, concurrency control technique is required to synchronize accesses to the database so that the consistency of the database should be maintained. Concurrency control technique requires an application-dependent correctness criterion to maintain database consistency while transactions are running concurrently. Serializability is a widely used correctness criterion [1,6]. But, serializability is too harsh for most applications so that we need user-defined correctness criteria, which is less restrictive than serializability.

Second, the length of transactions must be flexible. Usually, transaction length in virtual school environment is long since transactions are navigating on various multimedia information in database systems [2]. For long transaction case, the following problems might occur. That is, if locking-based concurrency control is adopted, long transaction blocks other transactions to run concurrently due to conflicting access. This will, in turn, degrade overall performance. Also, if a long transaction is aborted during its execution, it may waste execution time and resources it used.

Third, in virtual school environments, students' behavior is unpredictable. That is, since they are working in on-line way, it is hard to predict what kinds of actions they might take. Thus, they must be given some kind of self-controls.

Fourth, the transaction model reflects interactivity. Especially, it must support collaborative works between students and teacher or among students. Those collaborative works require common data to be shared among users in order to achieve common goal. In some cases, unlike traditional transaction model, uncommitted result by one student may be open to other students.

Finally, transaction model may need to support parallelism in order to reduce overall transaction response time. Especially, the parallelism can be used in object-oriented databases as follows. In object-oriented database, objects are accessed by means of methods. A method is nothing but a procedure to read or update attributes in objects. Two methods can run concurrently if they access different attributes in an object. Thus, transaction response time can be reduced by adopting parallelism.

3 The Proposed Transaction Model

Our transaction model reflects all requirements of transaction in virtual school environments as discussed in Section 2.

Our model is based on both Split/Join transaction model [4,9] and nested transaction model [7]. But, none of them support all those requirements of transactions in virtual school environments. Our model is to combine these two models. Our model also extends the previous model [3] so that we achieve higher parallelism as below.

The Split/Join transaction is summarized as follows. The Split/Join transaction is to restructure in-progress transaction dynamically so that it supports efficient resource management as follows. The Split transaction can be divided into two serializable transactions during its execution. In this case, two divided transactions can proceed independently with their own resources. Thus, the Split transaction model provides flexibility in resource management so that it can overcome the disadvantage of long transaction. On the other hand, the Join transaction can merge two on-going serializable transactions into one transaction. In this case, the transaction model is used to combine collaborating works into one in virtual school environments.

The nested transaction model is summarized as follows. A nested transaction consists of concurrently executable top-level transactions. In turn, a top-level transaction consists of one or more steps. Each step is either atomic operation or subtransaction. This subtransaction can run concurrently with top-level transactions or other subtransactions. In the meanwhile, a subtransaction can invoke another subtransaction. Thus, unlike flat transaction model, nested transaction model can exploit internal parallelism.

The basic structure of the proposed transaction model is shown in Fig. 1.

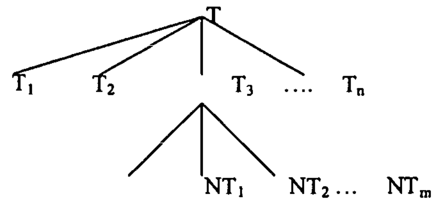

Fig. 1. The transaction model

T represents global transaction, which can be merged or split in various form during its execution. Also, depending on its nature, it can be committed without any restructuring. T_1, T_2, ,,,,T_n represent subtransaction or merged or split transaction. Also, NT_1, NT_2,,,NT_n represent subtransactions started by a nested transaction. In our model, we adopt open nested transaction [8]. In open nested environment, intermediate results of a subtransaction can be seen by other subtransaction as well as top-level transactions. This will increase parallelism further.

4 The Proposed Concurrency Control Technique

In this Section, we present a concurrency control technique based on our model. The proposed model is based on locking-based scheme. Our aim is to let two conflicting transactions go to negotiation stage if the lock requesting transaction requests a conflicting lock on a data item with a lock held by other transaction. In that case, the lock holding transaction and the lock requesting transaction can negotiate for conflicting lock types. If negotiation is successful by those two transactions, the lock requesting transaction can get a lock successfully and access the data. Otherwise, the lock request is blocked until the lock holding transaction release its locks. By doing so, the parallelism can be maximized among collaborating users. Assume that a transaction requests lock (L_R) on a data item already locked by other transaction with lock type (L_H), the following algorithm can be applied.

If L_R and L_H are compatible then grant L_R
    Else negotiate between lock requester and lock holder;
        If negotiation is successful then grant the lock
            Else block the lock request;

5 Conclusions and Future Works

In this paper, we first introduce the general characteristics for virtual schools. Then, we present all possible requirements for transactions in virtual school environments. Those requirements are user-defined correctness, flexible transaction length, the unpredictability, interactivity and internal parallelism. Based on those requirements, we propose a transaction model and a locking based concurrency control technique.

The immediate research issue is to apply real-time concept in transaction management. In that case, each transaction must have real-time deadline. Since all transactions are on-line based in virtual school environments, the transaction response time is very critical. Thus, we will develop the real-time priority assignment scheme and real-time transaction processing scheme for virtual school environments.

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A study of collaborative teaching for creative learning in an engineering class

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We synthesize a model for cultivating creativity that integrate the tasks of engineering design, and evolves four cognitive processes of creativity knowledge and skill via web courseware. This paper discusses three main themes of creative learning: 1) the effectiveness of collaborative teaching and course modules, 2) tools for fostering creative learning, and 3) interaction on the web-environment via creativity contest and design project. Several findings were observed based on qualitative evaluation of this class. First, the most rewarding course topics identified by the students is the creativity contest and design project because it provides ample opportunities to solve real-life open-ended problems, rather than to deal with dichotomous textbook problems. However, adapting dissimilar teaching style of our collaborative teaching generated anxiety to a number of students, which suggest the structure and sequence of the course development are need to be modified in order to fit students' level of capacity and readiness. Finally, we have demonstrated how problem solving and engineering design procedures can be closely integrated and taught, and what are the necessary knowledge and skills to enhance students' ability to become creative as well as effective problem solvers.

Keywords: **Collaborative teaching, Creative learning, Web-based learning**

1 Introduction

Creativity is inherent and a native intelligence. Many studies, show that the creative cognition can be trained and learned [1, 2]. Therefore, proper education and nourishing environment can foster creativity. *Creative problem solving* (CPS) is referring to use creativity or creative thinking for problem solving, which is a learning model being actively studied [3, 4]. It helps student use systematic method to solve a complex and realistic problem, possibly with multiple solutions. Students brainstorm to generate all possible solutions, categorize and evaluate solutions, develop implementation plan, and finally execute the plan [3]. CPS emphasizes the practice of creative thinking, implementation of creativity, and stresses on the creative leaning process. It can be regarded as a learning model for knowledge synthesis.

It is our responsibility and challenge as teachers to educate student who will be able to succeed in the high-tech environment. To educate students to cope with the rapidly changing world, they must not only to actively acquiring new knowledge, but also to have the skill of creative problem solving. In reflecting such responsibility and challenge, the course of "*Open-ended Creative Mechanical Engineering Design*" was offered in Department of Mechanical Engineering, National Central University for the last three years. The spirit of this course is asking students use their creativity to work as industrial engineers, form several mission-oriented teams, communicate and cooperate with other people, and deal with real industrial open-ended problems.

We wish to demonstrate how problem solving and engineering design procedures can be closely integrated and taught and what are the necessary knowledge and skills to enhance students' ability to become creative as well as effective problem solvers. Hence, we synthesize a model for cultivating creativity that integrate the tasks of engineering design, and evolves four cognitive processes of CPS knowledge and skill via web-based courseware. An integrated web-courseware [5] is constructed for above purposes. In the following sections, four main themes in our study will be introduced: 1) the collaborative teaching and course modules, 2) tools for fostering creative learning, and 3) interaction on the web-environment via contest and design project.

2 Collaborative teaching and course modules

2.1 Collaborative teaching

Based on the experiences for the past three years, we perceive the need for professionals from other disciplines to stress the importance of communication as well as teamwork skills for engineering students. More importantly, a scientific evaluation of the course and its effects on the students' learning of creativity must be done in cooperating pedagogical experts with engineering ones. The analysis of student outcomes can give information about the success of the innovative course in achieving our objectives.

But the question is: how can professors with engineering background to integrate their technical knowledge with an educational-oriented perspective? Engineering faculties may understand the cognitive and emotional conflict that students encounter, but couldn't verify their teaching approaches in order to take into account students' different learning styles. Besides, an engineering course taught by faculty of non-engineering background face a challenge of given students the new perspectives without accommodating the technology orientation of engineering students.

With above forethought, we propose and implement the collaborative teaching from four professors of interdisciplinary backgrounds: thermal/fluid sciences, mechatronics, education, and network-based learning. Collaborative teaching is a novel teaching approach, it allow teacher deliver lecture in a more efficient way and share mutual teaching experience, improve teaching deficiency, and understand learning difficulty of students. In devising the design-oriented courseware, besides compose the materials for hands-on creativity project, we also strengthen educational idea of cognitive psychology, learning strategy and learning evaluation. Such collaborative teaching team up with the expertise of education and engineering is hoping to build a nourishing environment for rising student's learning motivation, encouraging student to develop mature, diversified cognition and thinking, and then be able to perform higher level of creative thinking.

2.2 Course modules

The contents and modules (see Table 1) are designed to develop competence in mechanical engineering, creativity, and teamwork. Five major units are emphasized: 1) Introduction of creativity, 2) Basic principles of CPS process, 3) Hands-on learning activities to inspire creativity, 4) Engineering design process, 5) Creativity contest and design project. In the first one-third activities is centred on the development and inspiration of creativity and creativity education, and the next one-third of the units enable students to practice the creative mechanical engineering design. The last one-third of the activities finishes the implementation of creativity phase so as to show off student's imagination with the creativity contest and design project.

We use creativity contest and design project as a tool to enhance creative learning of students. One creativity contest is hold in every semester in order to incubate students' learning interest. It is all up to students to decide the material, procedures, requirements, and rules for the creativity contest with teacher's facilitation in order to develop the environment of freedom.

The design project could relate basic principles and concepts to real problems and to improve students' understanding, motivation and creativity [6]. Implementing a project is a way to encourage students to look deeply and laterally at individual topics and consider how they can be applied to real situation. They motivate students to confront both familiar and unfamiliar situations with confidence, providing a sense of achievement and satisfaction. Each team member is expected to be aware of the specific skills of others in order to achieve effective and collaborative working relationships. More importantly, each member needs to take other people's views into account.

3 Tools for fostering creative learning

We construct three tools to assist the creative learning process: 1) the creative activity board, 2) the search engine, 3) the engineering conrseware of domain knowledge.

The creative activity board, which is a web-BBS, is employed as the main interface for creative activity. Students are encouraged to actively utilize their own web-BBS for discussing their design projects with teachers and with classmates. They can announce important messages (e.g., resource acquiring) and post their current executing status of their project. More importantly, this board can be used to share their ideas and problem-solving approaches at any times with anyone who is interested in the topic. For convenient discussion of the creative ideas via network, particularly in the format hand-made sketches or the design charts, a FTP (download/upload) function is added in this board. Every user can participate the creative activity through web. The evolution and implementation of creativity can be recorded and exhibited. Properly application of this board can encourage students' morale for continually performing their design projects.

Students may encounter many problems when they execute the design project. The related information may be found in the courseware of domain knowledge or discussed in the creative activity board. Through the search engine, students can find useful knowledge and retrieve information from the integrated courseware more effectively by using appropriate keywords.

The creative activity cannot be successful without domain knowledge as its foundation [7]. When students are working on their team design projects, they need to integrate their domain knowledge based on the previous courses. There are four course modules materials are integrated: 1) Machine Design Course, 2) Electric Circuits and Electronics with Laboratory, 3) Innovative Application of Engineering Software, 4) Creative Mechanical Design. See [8] for detail description of content of these course modules.

4 Results: interaction on the web-environment

In the beginning whether students invest themselves in the class or not, depends on the development of the feedback from teachers. We use the web-BBS as the interaction interface with the students. After each team reported their project status, we will comment their idea and improvement of design prototype. Next, their status report will be upload in the creative activity board, and allow peers to review and comment. Encourage and endorsement from peers and teachers goes to those active teams. All interactions on the web are transparent and will inspire student if teachers can give feedback just-in-time, and guide each team to post their suggestion. In this way, both students and teachers will not be trapped in the classroom, and once the obstacle is encountered, it can be posted in the web and then exchange message. The more people to view these obstacles, the more possibility for the problem can be solved. Since not only teachers can help, peers can assist too. This is what we observed in this class when student performing their design projects. Positively and timely feedback from teacher and classmates enrich the value of the board.

We made surveys based on interviews, questionnaires, and articles of creative activity board. The most rewarding course content identified by the students is the creativity contest and design project because they provide ample opportunities to solve real-life open-ended problems, rather than to deal with dichotomous textbook problems. However, others are disturbed by the open-ended nature of the course materials. They claim that it is tiresome to cope with various teaching styles of four individual teachers. The evidence from our research also suggests that students' problem solving processes were affected by their understanding of the rationale of interdisciplinary course development. Therefore, teachers need to assist students to make their own links with the material they are engaging with in order to eliminate the negative impacts of the course content. For instance, increase the teaching topics involving mechanical hands-on activities might provide students more practice and appreciate the CPS process.

The issues of students' learning difficulties are complex and dependent on several factors, including course organization and development, the subject or topic being taught, teaching style, and students' expectations [9]. Although students see the new learning experience as an opportunity to broaden their scope, some others claim that the challenge of finding a design topic themselves was beyond their ability to manage. In order to set the stage for project design, our data showed that it is crucial that team members to accommodate each other and to devote their personal commitment. It is clear from our interview that failure to do so did influence the students' motivation to finish the project.

5 Conclusions

We have created a learning environment that facilitates students' development of problem solving abilities, enhances their confidence for cooperative creativity, and finally, provides students knowledge and skills for mechanical engineering design. The collaborative teaching is a novel experience to both of teacher and our student. Each member contributes their expertise and become the tutor to the other members. More importantly, the effort of compromising one another on the process serves as a role model for their students to work cooperatively.

The results of this study suggested significant concern for the students' anxiety created by the need to meet the special requirements of four individual teachers. It leads us to speculate whether the structure and sequence of the course development are appropriate to the students' level of capacities and readiness. Rather than viewing these problems as collection of obstacles and difficulties, we believe that we can make a difference in the learning of our students and chose to conceptualize those dilemmas and challenges in a constructive guide. Hence, we are currently adopting a new teaching approach by dividing the class into expert versus observer groups. The emphasis of the approach is to take responsibility as a learner and to develop the ability to ask questions about the projects done by other groups. We also conduct a peer-evaluation to encourage student to evaluate each other' s projects critically and objectively. We wish students to believe, as we did, that creative learning is within reach of anyone who is willing to exert himself and take responsibility.

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Content Outline	Learning Activities
Orientation to creativity	1. Introduce the importance of creativity to learning
Cognitive process of creative problem solving	2. Illustrate four stages of CPS skills
Thinking styles and contexts for developing creativity	3. Demonstrate pros and cons of various thinking style
Creative personality and teamwork experience	4. Film-viewing to illustrate the characteristics of creative people 5. Interview team members and identify their personality

Principles and strategies of lateral thinking	6. Analogy 7. Simulation activities
Conventional engineering design process	8. Discuss basic rules for invention 9. Apply rules to improve the design of commercial product 10. Brainstorm potential ideas for creativity contest via web
Problem solving in electric circuits and electronics (E&E)	11. Problem solving a case to illustrate the E&E concepts relate to project design
The creativity contest (by individual)	12. Peer-evaluate and select the top three most creative rubberband-powered vehicles
Research for proposal (RFP) of creative design project (by group)	13. Develop a RFP based on all information gathered 14. Oral presentation to class

Table 1 The course modules of the *CEdesign* web-class.

A Study on the Effectiveness of Web-based Collaborative Learning System on School Mathematics :Through a Practice of Three Junior High Schools

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The topic of Internet for educational purposes is currently hotly pursued but there are still not many observations on the effectiveness of it in school mathematics. In this paper, we discuss the findings of Web-based collaborative learning in school mathematics conducted with three junior high school in Japan, March 2000. Students performed asynchronous collaborative learning using bulletin-board type database installed in a Web server set at the Koshikawa laboratory in Chiba University. Students solved several mathematical problems presented on a Web page while discussing with other students in the database. In classes using the Internet, 3 or more methods of the problem solving emerged in the database as compared with a traditional class, and students could study many mathematical views and conceptions as a result of it. Moreover, a research of the student's opinions after the lessons indicated that students wanted to hear the other students' ideas and views and have collaborative learning, breaking down the traditional concept of the classroom wall barrier.

Keywords: **Web, Bulletin Board, Collaboration, School Mathematics**

1 The background and intention of this research

It is now believed that mathematical knowledge is created through collaborative learning, rather than something individual. This is based on social constructivism in recent years. And teachers have come to accept their new position of an advisor to the students as shown by Vygotsky's "Zone of proximal development".

Through using a distributed network such as the Internet, its very features are effectively utilized and allows the externalization of the student's knowledge. These knowledge can then be shared and this learning method is in accordance with the present idea of how learning occurs[4]. Thus, we have researched on web-based collaborative learning on school mathematics from 1998 focusing on this point[1][2]. With Web-based collaborative learning, it efficiently and effectively overcomes whatever physical differences the students may have and thus widely used for science and social studies lessons.

In mathematics, objectivity is the rule and therefore, there is no need for students to be able to express regional difference clearly and there are not many investigations into web-based collaborative learning of school mathematics. In this paper, we describe the qualities and reasons for conducting Internet based collaborative learning of school mathematics. We also describe the results of the questionnaire distributed to the students after the lesson.

2 The method of collaborative learning

In this research, we used the "bulletin board[1]" system that can be downloaded free from the Web site. As shown in Fig.1, the discussion progresses by entering in one's idea and posing questions to the others' idea or opinion. Students build their knowledge positively and share them in this process. The discussion is displayed by a tree structure whereby a reply to a question or comment is indicated with a new line, separated from the previous note with a slight space. Each new reply is so indicated, forming a tree structure. The symbol[2] is given to each utterance so that the kind of utterance may be understood. This database was installed in the Web server "Topo" at Koshikawa laboratory, Faculty of Education, Chiba University, and linked to the web page that we refer to as "The Page of Mathematics Teaching-Materials Research[3]". Students used this system for its school mathematicsFig.3. Fig.2 shows the notes which students have entered. Students study, choosing between the two screens, i.e. Fig.1 and Fig.2.

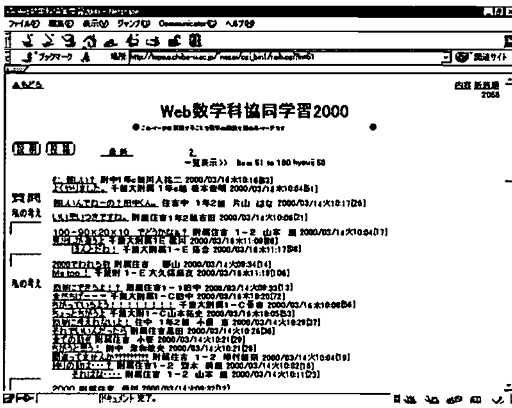

Fig. 1

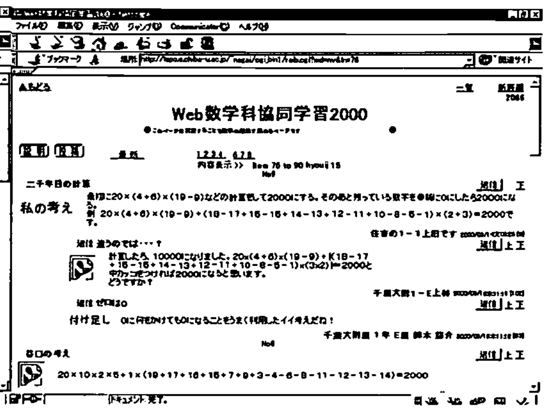

Fig. 2

3 The outline

The Web-based collaborative learning was performed as follows.
O Student participants
Nagaura Junior High School, 1st grade 2 class
Sumiyoshi Junior High School, 1st grade 3 class
Junior High School attached to Chiba University, 1st grade 3 class
O Term March 2000
O Instruction plan
Each junior high school had a 2 hours lesson.
The 1st hour ···Students read the problem and produce their own ideas.
And, they enter in their questions and opinions.
The 2nd hour···Students read the others input and enter in their ideas.
And they continue the discussion.

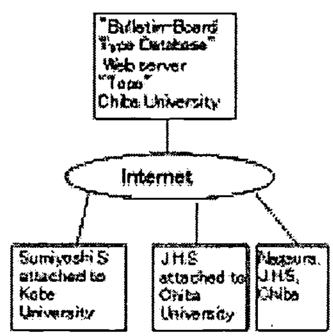

Fig. 3

3.1 Problems given to students

[1] raib-g 2.04 (wakatiai program)
[2] Question="質問"，My Theory="私　考　", etc.
[3] The author's page. http://www2.ak.cradle.titech.ac.jp/nagai/math_room/math.asp
The Grant-in-Aid for Educational Research, Chiba Prefecture(1997), and the Grant-in-Aid for Scientific Research, Japan Society for the Promotion of Science(Encouragement Research B, subject numbers 10913006,1998 and 11913005,1999) are granted to this page.

The two following problems were shown on the Web page at the beginning of the collaborative learning. Students solved the problem given to them with instructions from the teacher.

oProblem1
This year is A.D. 2000. Let's make the following formulas.
(1) The answer is set to 2000, using all the number of 1,2,3,4,~,19, and 20 at least once.
(2) Each number can be used only once.
(3) You may change the sequence of numbers.

oProblem 2
How to find, among a set of twelve balls, one which is lighter than any of the other equally-weighted eleven? You have only three chances to use a pair of balances. (Please also consider the reasons and enter it in.)

3.2 The student's activity

First, students read the given problem and create their questions and ideas about the problem. Next, they access the database and enter their notes. They read the others' writing, and if something attracts them, they will write a reply. The activity was performed over 2 hours and problem solving was carried out. A questionnaire shows that students participated in this collaborative learning positively. The teacher's role is only to support the computer operations of the students or problem solving when needed. In the beginning, although there were many students who took time in deciding what to enter or how to operate the database, they got used to it gradually.

4 Analysis and consideration of the collaborative learning

These were two problems and the students solved either one or the other collaboratively. Three junior high schools tackled the problem using the Web-based collaborative learning for 2 hours. Another class was asked to solve the problems not using the Web-based collaborative learning method i.e. traditional method. We describe the difference in the learning produced from the difference between these two methods of instruction. We also analyzed the results of the questionnaire.

4.1 Regarding problem 1

With problem 1, students find as many formula as they can whose answer is 2000 using all the integers from 1 to 20. In the collaborative learning using the Web, students invented 14 kinds of the following methods.

Formulas obtained from the collaboration using the Web (14 methods)

1. 20x10x5x2+(1+3-4)x(6+7+8+9+11+12+13+14+15+16+17+18+19)=2000
2. 20÷10x(19-9)x(18-8)x(17-7)x(16-6)÷(15-5)x(14-4)÷(13-3)x(12-2)÷(11-1)=2000
3. (1+19+2+18+3+17+4+16+5+15+6+14+7+13+8+12+9+11+20)x10=2000
4. (3+5+7+8+11+12+13+14+15+16+17+18+19)x(6-2-4)+20x10x(9+1)=2000
5. 10x20x5x2-(9+6)+(8+7)-15÷3+(1+4)-(11+19)+(12+18)-(13+17)+(14+16)=2000
6. (19-18+17-16+15-14+13-12+11-9+8-7+6-5+4-3+2-1)x10x20=2000
7. 20x10x(1+2+3+4)+(13-6-7)x(5+8+9+11+12+14+15+16+17+18+19)=2000
8. 20x10x5x2+(4-3-1)x(6+7+8+9+11+12+13+14+15+16+17+18+19)=2000
9. (1+3+7+9)÷2x(20+15+5)÷4x(6+14+12+8+11+19+13+17)÷10x(18-16)=2000
10. {10+(11-1)+(12-2)+(13-3)+(14-4)+(15-5)+(16-6)+(17-7)+(18-8)+(19-9)}x20=2000
11. {1+2+3+4+6+7+8+9+10+11+14+16+17+18+19-(5+12+13+15)}x20=2000
12. 20x10x2x5+1x(19+17+16+7+9+3+15-4-6-8-11-12-13-14-18)=2000
13. (1+2+3+4)x10x20+5+6+7-18+8+9-17+16+13-14-15=2000
14. {(11-1)+(12-2)+(13-3)+(14-4)+(15-5)-(16-6)-(17-7)-(18-8)-(19-9)}x10x20=2000

Next, in the traditional class, only four kinds of formulas appeared.

Formulas obtained by the ordinary class (4 methods)

3. (1+19+2+18+3+17+4+16+5+15+6+14+7+13+8+12+9+11+20)x10=2000

10. $\{10+(11-1)+(12-2)+(13-3)+(14-4)+(15-5)+(16-6)+(17-7)+(18-8)+(19-9)\}\times 20=2000$
15. $(11-1)\times 10\times 20+12-2-4-6+8-3-5+16-7-9+14+15+19-13-17-18=2000$
16. $(2\times 3+4+5+6+7+8+9+10-11+12+13+14+15-16+17-18+19)\times 20\div 1=2000$

4.2 Regarding problem 2

With problem 2, students find the lighter weight out of 12, using only a pair of balances and within 3 steps. The following four methods of solving the problem appeared in the collaborative learning using the Web. The notation shows how to divide the 12 weights first. For example, "4 4 4" means to divide the 12 weights into three groups containing four weights in each group first.

◇The first division found in the collaboration using the Web

(6 6) (4 4 4)
(3 3 3 3)(5 5 2)

◇The first division found in the traditional class

(6 6) (4 4 4)
(3 3 3 3) (5 5 2) (2 2 4 4)

As shown above, four kinds of methods appeared in the collaboration using the Web and five appeared in the traditional class.

4.3 Analysis and consideration of the data

In problem 2, the variety of methods for solving the problem did not differ much between the Web-based collaboration and the traditional class. However, in problem 1, the number of methods on collaborative learning using the Web was 3 or more times as compared with the traditional class(Exact Probability Test, $p<.05$). For mathematics problems with limited answers, there is not much difference seen between the two methods of instruction. On the contrary, for problems with many possible answer, students achieve better results when they can do the problem solving with the other students through the Web. We definitely believe that the students are able to solve problems by referring to the other student's notes. This can be seen from the student's interaction. For problem 1, five formulas generally represented as "$0\times m+2000$(m is an integer)" were produced in the collaborative learning using the Web. This is the formula not produced from the traditional class. We consider that the students become aware of this general formula by referring to the others formulas, and they utilize this general formula to solve the problem. Moreover, the students are also influenced by notes such as those below.

First, $20\times(4+6)\times(19-9)$ etc. is calculated, and it is made 2000. Then, it will be set to 2000 if the number which remains is set to 0. Example $20\times(4+6)\times(19-9)+(18-17+16-15+14-13+12-11+10-8-5-1)\times(2+3)=2000$.

2000/03/14 Tuesday 09:25 [9]

Although the formula of this student's example lacks a necessary "7", it is considered that the explanation which means 0xm+2000 was very helpful. This can be read also in the following response to the note " ".

This is a good idea. Every number which is multiplied with 0 is 0. 2000/03/16 Thursday 11:12 [93]

Such examples show that there were some students who didn't only enter their formula, but the strategy as well, and it became a support to other students.

As mentioned above, in collaborative learning using the Web, since the others idea remains on record and can always be referred to, students could utilize this and solve the problem. Problem 1 is asking for many possible formulas whose answers are 2000. That is, we claim that collaborative learning using the Web is effective especially with problems which demand exemplification. And students were able to access many mathematical views and conceptions. This appears also in the result of the questionnaire shown as "Many students' ideas can be known. 49 persons." and "Various methods and ideas which are easy to understand can be known. 36 persons.", and it turns out that the student's incentive and understanding can be improved. These educational effects are obtained by the realization of collaborative learning using the Web, and cannot be obtained in the class which is traditional. We emphasize that the effectiveness of the collaboration using the Internet on school mathematics is demonstrated.

5 Conclusion

In this paper, we referred to the educational effect and influence of the collaboration of three junior high schools using the Web. As we have shown, it has been indicated that students can utilize many mathematical knowledge and conceptions when we use the Web with due consideration given to the type of problems the teacher thinks can extract the most out of the students. This shows that collaborative learning using the Web is useful to train various views and ways of thinking currently emphasized by the Ministry of Education in Japan and National Council of Teachers of Mathematics(NCTM)[3],U.S.A. We emphasize that the database on the Web is effective as an environment where students can tackle open-ended problems in mathematics.Considerations for the future include the improvement of the student's computing skills, the improvement of the system with regards to numerical expressions and careful selection of the kinds of mathematical problems to be given to the students. After all, according to a questionnaire, since it is indicated that 70 percent or more of students are supporting collaborative learning using the Web from various reasons, we want to continue the research wholeheartedly from its educational perspective.

Acknowledgement

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Agent-Based Collaborative Learning Environment for Intelligent Tutoring System (ITS)

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This paper proposes a general architecture illustrating how students can learn through peer interaction in an interconnected environment. Three (3) predominant components comprise the architecture: *the student model*, *the tutor model* and *a pedagogical agent* known as *SPY*. The use of pedagogical agents is the essential part in the proposed architecture, in which information received from other students will be used as one of the tutoring strategies to assist students in learning. Collaborative/cooperative learning is achieved between students and the tutor, or among students, through pedagogical agent interaction. Moreover, the architecture supports a collaborative learning environment that helps improve students' comprehension.

Keywords: **collaboration, collaborative learning, agents, intelligent tutoring system**

1 Introduction

With the advancement in technology, computers have become essential tools in developing systems that cater to the different needs of users. Currently, many works have been done in the field of education. Systems known as *intelligent tutoring systems (ITSs)* were developed to teach students on specific topics, test their knowledge by giving exercises, and provide remediation on topics students did not perform well. An *intelligent tutoring system* is a computer program for educational support that can diagnose problems of individual learners. Such diagnostic capability enables it to adapt instruction or remediation to the needs of individuals [5]. Currently, the state of ITSs is focussed on one-on-one learning instruction. Specifically the kind of learning modality used is centered on *learning by being told* [2]. However, in reality, students can also learn through interactions with his/her peers or work in a team (or a group). The information students receive from his peers can help improve his comprehension on the topics at hand. A new learning paradigm has emerged aiming on this area and this new learning paradigm is known as *collaborative learning*. Collaborative learning emphasizes on how students function in a group and how the students' interaction with his peers or work in a team can help improve students' learning. This can be seen as either gaining new knowledge or verifying the correctness of what the students had learned so far.

Meanwhile, one of the major issues in Distributed Artificial Intelligence involves multi-agency. The agents in a multi-agent system are designed to solve a kind of problem. This is based on the fact that agents are autonomous and can recognize their own existence and the existence of other agents. Agents help each other in order to achieve a common purpose within a certain environment. Agents can assist each other by sharing the computational load for the execution of subtasks of the overall problem, or through sharing of partial results that are based on somewhat different perspectives of problem solving on the overall problem. Moreover, this form of cooperation addresses the nature of communication between cooperating agents.[1,6] Due to the social ability[1] and proactivity[2] of agents, many research, and works whether related on education (i.e., ITSs) or interface learning have been done with the incorporation of agents. Some works include defining software agents to analyze the collaboration in a virtual classroom [3]. [2] proposed a system that is a CSCW environment with

[1] Ability of agents to interact with other agents and human agents through some kind of an agent communication language. [3]

[2] Agents do not simply act in response to its environment, but they are able to exhibit goal-directed behavior by taking the initiative. [3]

artificial agents assisting students in their learning tasks. Furthermore, it uses a tutor agent partially replacing the human teacher. [4], on the other hand, showed that the tutoring knowledge in ITS can be designed and organized as a team of interacting pedagogical agents. These agents communicate with the student depending on the tutoring function they fulfill. Some tutoring functions include domain presentation, domain assessment, problem solving type of exercises, topic selection, problem-step solving, domain explanation, and the like.

This paper presents a new approach to collaborative learning using agents. The collaboration of agents is seen as sharing of information in the environment. The main thesis is that information received from other agents can be used as one of the tutoring strategies of other students learning in the network. The paper is organized as follows: Section 2 describes the general proposed collaborative learning architecture, the different components associated and their interrelations. Section 3 presents how artificial agents can support the learner and describes the kind of learning strategy each agent should posses in the system. The last section summarizes some issues that need to be considered in the proposed architecture.

2 Collaborative Learning Environment

The learning comprehension of a student on certain topics can be improved if the student is allowed to interact with his peers and not only with the tutor. This is because the way a student understands a topic can be applied as the same approach for other students who have difficulty comprehending the same topic. For example, two students (Student A and Student B) are studying at the same time on the same topic. They may be physically present but in different places. Student A is able to understand the topic well, but B is having difficulty with the topic. Instead of leaving the topic without fully understanding it (for the current topic may have an effect on the succeeding topics), B can either collaborate with his tutor or with A. Since B's tutor may use the same approach in explaining the topic as he did earlier, B "collaborates" with A. The collaboration may be in the form of using the same tutoring strategy used for A. With this, it is essential to develop ITSs that allows students' interaction that goes beyond the student-tutor relationship.

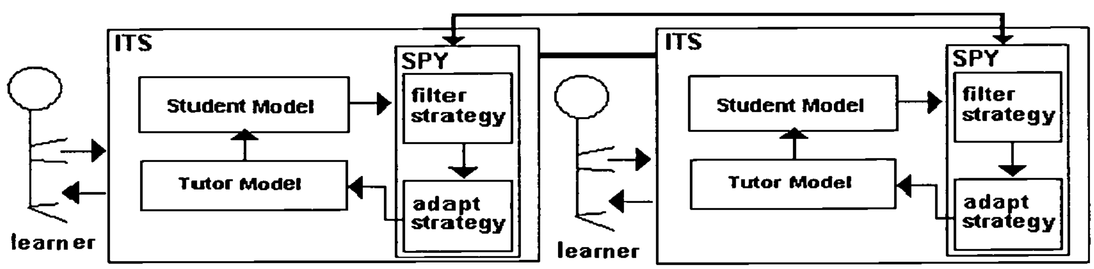

Figure 1: Agent-based Collaborative Learning Architecture

Figure 1 shows the proposed agent-based collaborative learning environment of an ITS system. The proposed architecture intends to illustrate collaboration that is not limited to student-tutor relationship but allowing students to interact directly or indirectly with his peers. In addition, this is done through interaction of the pedagogical agent SPY with the other agents of ITSs in the environment. It is assumed in the architecture that there can be several ITSs in the environment for a given domain. Though there may be the same set of tutoring strategies for the ITSs, it is possible that different tutoring strategies are used for the same topic. For instance, both student A and student B are currently studying lesson 1. However, the tutoring strategy used for A is presentation of lectures with illustrations, while B uses simple presentation of lectures. Furthermore, these ITSs are interconnected in a reliable network. The architecture can be implemented in either an Internet or Intranet infrastructure. Thus, it is good and useful for open and distance learning education.

There are three (3) main components in the architecture and these are the *tutor model, the student model* and *a pedagogical agent* known as *SPY*. Each of these is discussed below:

- ***Student Model:*** This module contains information about students' profiles and behaviors. Such information involves what the student has learned so far, has not learned, will be about to learn, and the possible misconceptions and their explanations on topics presented during the learning activity. Furthermore, the student model keeps track of the performance level of the students.

- ***Tutor Model:*** This module is responsible for the delivery of topics to students. Moreover, the tutor model also determines and delivers exercises to be solved by students. It is inherent in the tutor model that when presenting the exercise it considers student's level.

- *SPY*: Each student is assigned an autonomous agent in the learning environment. This agent is responsible for gathering information such as the tutoring strategy used, the topic where the tutoring strategy is applied and the performance of students during his interaction with the ITS. Furthermore, SPY collaborates with other agents in the environment, with or without the presence of the student and the tutor. This means that SPY persists even if the student is not using the ITS. The information gathered will be used to determine the appropriate tutoring strategy for a particular topic for a student.

Specifically, the student interacts with the ITS in order to learn new concepts or to verify the correctness of what he has learned so far. During the learning activity, the student model monitors the performance of the student, keeping track of what the student has learned and is currently learning and his performance during the learning session. Any misconceptions the student may have are also being monitored. The tutor model presents topics according to the level of understanding of the student. The same approach is done when presenting exercises to students. The student's level of understanding can be determined from the student model. Information stored in the student model is then passed to the agent SPY, which in turn uses the information to determine which students have similar profile as its human student (i.e. relatively same performance, same learning style and relatively of the same level). From this interaction, the agent will gather data such as how other students were able to solve similar problems and how the topics were presented to them (i.e. tutoring strategy used). Moreover, SPY will keep track of the topics where the tutoring strategy was used and the student's performance. The rational behind this is that it is possible for SPY to determine in advance the tutoring strategy used for topics that are not yet presented to its human student. Consequently, this will allow the tutor model to adapt tutoring strategies depending on the status of its student.

The architecture illustrates two (2) forms of collaboration. The first is where the student collaborates with other students through communication medium and tools provided by the environment. These tools include chat, exchanging of emails/messages, discussion groups, newsgroups and the like. In this way, students can get actual explanations of how their peers understood the topics, concepts and solutions of problems presented during the learning activity. The second form of collaboration is where agents interact with other agents in the environment. Such interaction is abstracted from the students. The collaboration seen here is the sharing of information among agents about the students they are associated with.

To illustrate the second form of collaboration in the proposed learning architecture, consider this example: Students may or may not use the ITSs at the same time and study the same concepts or topics. In either case, the respective agents of each ITS in the network will still have to communicate and obtain information from other agents. Assuming there are two students, A and B who are present in the network and are interacting with their respective ITSs. Student A is currently studying topic 1 and student B is studying topic 2. Any interactions both students do during their learning activity are being monitored by their respective student models. While A is studying topic 1, his corresponding SPY agent is interacting with other agents (including the agent SPY assigned to student B) keeping track of topics other students have learned or is learning, the kind of tutoring strategy used, and the students' performance. By the time A is about to study topic 2, the tutor model A will adapt the tutoring strategy used for student B. This is with the assumption that the tutoring strategy used in B is effective (i.e., student B was able to understand topic 2 well, as this can be seen by his performance on that topic). If the adapted tutoring strategy is not appropriate to A (i.e., the student did not perform well in the corresponding exercises) another tutoring strategy will be used or by default will use the tutoring strategy of the tutor model.

It can be seen from the second form of collaboration that adaptation of tutoring strategies exists. Moreover, it is possible for the tutor model to change the current tutoring strategy used depending on the performance of the student during his interaction. The first form of collaboration allows students to directly apply what he/she has learned from the interaction.

3 The Pedagogical agent SPY

The agent SPY is introduced in order to allow students to share to their peers what they have learned and how they have learned the concepts. Specifically, SPY continuously communicates with other agents in the network keeping track of the approach or strategy used by other tutor models in teaching the concepts. Once information is gathered, SPY will perform 2 main operations: (1) filtering the strategies acquired from other agents and (2) transform the acquired strategy into a representation that can be adapted by the tutor model. The filtering of strategies is done in order to choose the appropriate strategy that can be applied to the current topic or concepts the student is studying. During the agent interaction, each agent can gather more than one kind of tutoring strategy possibly for the same topic or concept. These strategies can be arranged in many forms or classifications. For instance, strategies can be arranged according to its effectiveness based on students' performance. This means the strategy with a student receiving the highest score will be adapted and used by tutor models of other students. If such strategy is not applicable to the current student, then the next highest scored student's tutoring strategy is applied. It is also possible for the agent SPY during the filtering of strategies to combine similar strategies into one strategy. Or better yet, arrange the different tutoring strategies according to the topics or concepts that have been presented or learned by students.

Once a strategy is selected, it will be transformed into a representation recognizable by the tutor model. This is done by following an adaption algorithm. The adaption algorithm should be flexible such that it can adjust to and apply any kind of strategies. However, it is possible that the adapted tutoring strategy is the same as the intended tutoring strategy of the tutor model. In this case, this will serve as a "confirmation" to the tutor model that the pre-planned tutor strategy is effective to its human student.

The objective of introducing a pedagogical agent in designing an ITS is to support the student in learning by adapting different approaches in presenting the topics. This is with the hope of improving students' learning comprehension. Furthermore, SPY assists the tutor model as to what kind of teaching strategy to use for certain concepts. In addition to being adaptive and reactive to the needs of students, SPY agents are proactive and goal-oriented in the sense that they act in the environment through its initiative.

4 Conclusion

In this paper, a proposed agent-based collaborative learning architecture for designing an ITS is presented. The architecture is general and at the moment no implementation has been made. The architecture has shown how a pedagogical agent can be used to model collaborative learning. There are three (3) main components in the proposed architecture and the predominant component is the inclusion of a pedagogical agent known as *SPY*. The agent *SPY* is introduced to assist the tutor model in determining which teaching strategy it will be used in presenting topics/ concepts to students. This also includes the presentation of exercises and possible remediation on topics students are having difficulty with.

This paper also showed a different form of collaboration that is not the same as the usual collaboration or teamwork that is seen in reality. The paper proposes a form of collaboration in which there is a sharing of information among the agents and students in the environment.

Certainly, much progress has to be made towards reaching the complete architecture in reality. Particularly, in-depth study and implementation of the said proposed architecture is needed to see if the architecture can provide improvement in student's learning comprehension. Moreover, there are several issues on the proposed architecture that needs to be studied carefully. Some issues include the learning capability of the tutor model to adapt new tutoring strategies from the SPY agent; representation and storage of strategies (i.e., how can strategies be represented in the form of rules and how to store them in each agent); filtering of strategies (i.e., how to determine which of the acquired strategies are useful and appropriate to the current performance of the students). In addition, a criterion needs to be defined on how to determine students with similar profile.

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Agent-oriented Support Environment in Web-based Collaborative Learning

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Currently, the web-based learning support systems are one of interesting and hot topics in points of the utilization of Internet and the application of computers to education. In particular, the web-based collaboration is very applicable means to make unfamiliar students, who are unknown with each other, discuss together in the same virtual interaction space. However, there are some problems derived from the gap between the real world and virtual environment: coordination for discussions, cooperative reactions, comprehension of learning progress, etc. These problems may be dependent on the fact that the actions of students cannot be influenced from the behaviors of others directly.

In this paper, we address a coordination mechanism to promote cooperative actions/reactions for progressive discussions. Our idea is to apply an agent-oriented framework to this coordination mechanism and introduce two different types of agents. One is a coordinator and the other is a learner. The coordinator monitors the learning progress of group and promotes the discussion, if necessary, so as to reach their common goal successfully. The learners are assigned to individual students, and act as interaction mediators among students in place of the corresponding students. Of course, the coordinator is a passive entity and learners are active entities in our collaborative learning space.

Keywords: **Collaborative learning environment, coordinator, learning situation, learner, personal learning history**

1 Introduction

The fast and world-wide enlargement of Internet/Intranet has made it possible that every person can interact instantly without depending on their physical locations. Also, various applications, which are available on the web environment, have been developed with respect to the content-based resource sharing, in addition to the traditional message exchanges. The web-based collaborative learning is one of applications, based on such a hot topic, and has been applied as computer-support for virtual learning space. If their computers were connected mutually through the web-based learning environment, students can discuss their common solving process successively and exchange various solving methods/ideas cooperatively. However, there are some problems to encourage activated discussions among students and make it possible that individual students should understand the correct answer and solving process effectively:

1) students may not participate into the discussion interactively because of their hesitation, derived from the fact that they are unknown with each other;

2) students cannot grasp the behaviors of others directly or indirectly because only the direct actions and reactions are observable through the interactive interface.

These problems are radical drawbacks for collaborative learning.

In order to solve these drawbacks effectively, we propose an agent-oriented support environment for collaborative learning. Of course, the agent-oriented frameworks for the construction of collaborative learning mechanism/environment have been already investigated until today. Florea[1] proposed a multi-agent collaborative learning environment in the web world. In this environment, three kinds of agents were introduced: personal agent which gets the information according to the requests of each student, tutor agent which generates advices when personal agents asked for the help, and information agent which acquires more information from Internet. Agents are activated by students' requests so that this system environment does not benefit passive students. Ogata, et al.[2] proposed mediator agents in the collaborative learning environment which assist students to find suitable collaborators. The mediator agent for each student holds the corresponding students' profile which indicates the understanding and interesting degrees about knowledge. When a student has problems, his/her mediator agent asks other mediator agents for the learning situations of their corresponding students and specifies appropriate students who may be able to help solving the problems. This research copes with the above problem 1) indirectly because this functionality supports to arrange appropriate learning group, but does not manage the progress of collaborative learning. Nakamura, et al.[3] and Liming, et al.[4] introduced respectively pseudo students which correspond to individual human students. These pseudo students have the same knowledge as the corresponding students and participate in the discussion in their ways if the corresponding students do not join in the discussion positively or cannot understand the discussion stage. These research viewpoints focus on passive students such as problem 1), but do not solve the problem 2). So, in spite of these various agent-based investigations, the previous drawbacks are not always overtaken.

In this paper, we address a collaboration learning environment, organized systematically under two different types of agents: coordinator and learner. The coordinator takes roles to monitor the discussion situation among students, grasp the learning progress and guide the learning process if necessary. The learners are virtual students corresponded possibly to individual students in our web-based collaborative learning environment. The coordinator and learner are complementary entities in the learning environment: the coordinator is a passive entity; and the learner is an active entity as the autonomy for practically participated student. In our investigation, we expect the collaborative learning of high school students who study mathematical exercises together, especially computation for the roots of equations. First of all, we show an overall framework of our collaborative learning environment in the web-world in Section 2. The functionalities about two different types of agents are stated in Sections 3 and 4, and then our prototype system is shown in Section 5. Finally, we conclude our paper in Section 6.

2 Collaborative Learning Environment

In the web-based collaboration learning environment, the actions/reactions of participated students are inherently different from their behaviors to be performed in the real world. Students in the physically constrained learning space can speak with each other by means of face-to-face, feel/recognize activities, occurred from the discussions of students, directly by various sensitive receptors and find out some new events/facts indirectly. Although these are not always implemented adaptively in the web-based virtual learning space, it is necessary to organize a collaborative learning environment in which the logical activities for support of interaction, discussion and comprehension can be implemented successfully and effectively.

Figure 1 shows our collaborative learning environment conceptually, which is characterized by two different types of agents: coordinator and learner. The coordinator places on the center of our virtual classroom (as a network server), monitors the interaction among students and generates advices if necessary according to the learning situation. This interaction is supported on the conversation means through the public communication line. The learner is a pseudo student in our virtual classroom and is assigned to the corresponding student one by one. The learner takes roles of the personal management of interaction interface for the corresponding student, the handshaking control of public communication line, the management of its own private learning history, and so on. In addition, the learner can communicate with other learners directly through the private talking line in order to exchange their personal learning histories.

Since students are studying with limited learning tools in the virtual web-based learning space, they sometimes do not able to communicate naturally. Furthermore, various students participate in the learning group and the learning process is not always completed successfully: i.e. some students are not able to solve the problem, some students are not able to understand the derived answering process after all, and so on. The coordinator solves such drawbacks in the virtual web-based learning space by managing the learning situation globally: the coordinator takes a place of teacher in our classroom activity. For the purpose of resolving inappropriate learning situation stepwisely and guiding

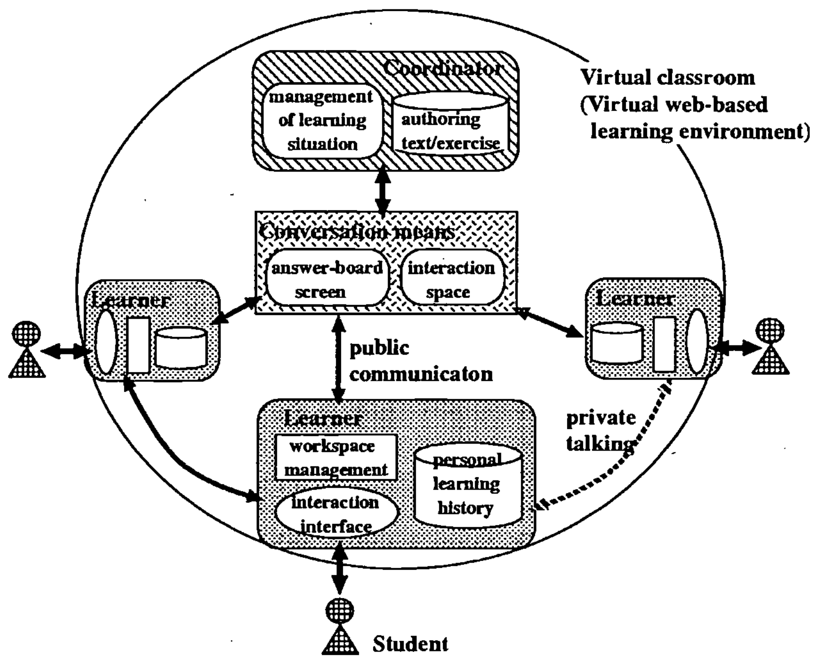

Figure 1: Collaborative learning environment

the learning group effectively, how to model and control learning situation is an important subject. If the coordinator grasps the learning situation appropriately, the advices which were generated from it may give appropriate hints in order for the learning group to proceed to the next phase of learning process. However, it is not always necessary to model the learning situation in detail precisely. This is, we think, because among the learning group students are able to help each other by discussion, so that the coordinator only has to detect the situation which the learning group cannot proceed the learning by itself.

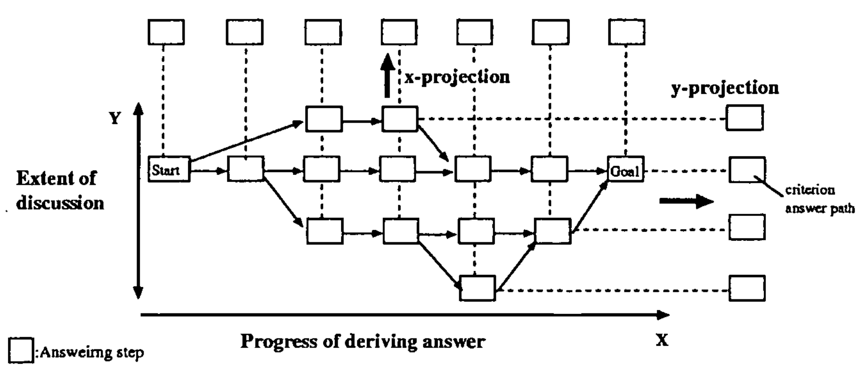

Figure 2: Answer space

The coordinator holds the right answer and the answering paths for an exercise as a knowledge to grasp the current learning situation. When the exercise has several answering paths for the goal, the answer space of exercise is expanded as 2-dimensional network structure, in Figure 2. In this figure, the learning progress along x-axis means the stepwise progress of deriving answer, whereas that along y-axis shows the extent of discussion. If the coordinator grasps the learning situation on the basis of the answering process of network structure as it were, it is very troublesome to manage the eventually changeable conversation stages successively. Therefore, our coordinator manages the learning situation with respect to the following two viewpoints separately: ratio of derived step for a whole answering process and extent of discussion. By monitoring the learning situation under these points of view, the coordinator is able to grasp the learning situation easier and generate advices timely. In particular, it is necessary and sufficient to manage the learning situation of group globally, but not individually do that of each student.

The learner acts as a network client in place of the corresponding human student in the virtual web-based learning space. This provides not only the interaction interface for virtual learning space attached to the corresponding student, but also the function of indirect interaction among students, so as to judge the understanding levels or personalities of them, which we call the focus function. According to the focus function, students select the opinions of particular students whom they evaluate as key students. In order to realize the focus function, the learner needs to have the knowledge about the corresponding student and exchange it with other learners. Therefore, the personal learning history is prepared for learner, which represents understanding level and personality of corresponding student. The learner constructs and maintains the personal learning history according to the current situation. Exchange of personal learning history is one-to-one interaction so that public communication is not necessary for the focus function. Therefore, we introduce mobile agents called mediators as children of the learner, that take responsibilities for the exchange of personal learning histories among learners. The mediator moves among learners by requesting/carrying the personal learning history on the private talking line.

3 Coordinator

The coordinator grasps the learning situation from two viewpoints: ratio of derived step for a whole answering process and extent of discussion. For the ratio of derived step, which corresponds to the x-axis of answer space in Figure 2, we have already proposed the resolution derivation scenario which represents the phases of deriving answer stepwisely [5, 6, 7]. The scenario is generated by means of projecting the answer space onto x-axis and consists of ordered states which correspond to individual phases of deriving answer. Grasping an approximate learning situation makes it possible that the coordinator generates advices timely and effectively because each state corresponds to the individual ratio of derived step. On our scenario structure, the current learning state is pointed by the indicator *current*, which points out the currently discussing stage. The coordinator infers the current state from student inputs and moves the indicator to the corresponding state. However, the utilization of only one current discussion indicator is not enough to manage the learning state of group sufficiently. In addition to *current*, indicators *upper* and *lower* are prepared for the representation of current understanding levels of learning group. *Upper* points out the state of understanding level which is estimated that best understanding student reached to and *lower* points out the state of worst understanding student did. The coordinator is able to grasp the learning situation on the basis of the relationship among these 3 indicators (Figure 3).

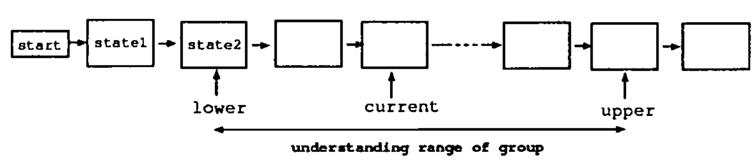

Figure 3: Resolution derivation scenario and indicators

On the other hand, the extent of discussion is estimated by the number of derived answering paths with different discussion viewpoints. The difference of discussion viewpoints among answering paths is defined as the ratio between common and uncommon answering steps. That is, if two answering paths contain large number of answering steps as common part, they are regarded as more similar paths; but if they have many different answering steps, they are judged as different paths. Common answering steps means that the answering methods which are used to derive those steps are the same. Once two answering paths were diverged, the following answering steps may be derived based on different answering methods so that they are regarded to be uncommon. From such viewpoint, the coordinator holds an answer tree which was transformed from whole answering paths as a tree structure. Figure 4 shows the construction of answer tree, derived from the answer space in Figure 2. The answering steps after the divergence are regarded as uncommon steps so that they are copied as different objects(Figure 4a). Then, the answer tree is transformed by means of collecting common answering steps for the purpose of grasping the difference among answering paths. The nodes in the tree are generated as a collection of answering steps that are common to particular answering paths and the path from root node to particular leaf node corresponds to each answering path. When the answer has been derived, the coordinator specifies derived/underived answering paths, calculates the differences between the derived answering path and other answering paths based on the answer tree, and estimates the extent of discussion.

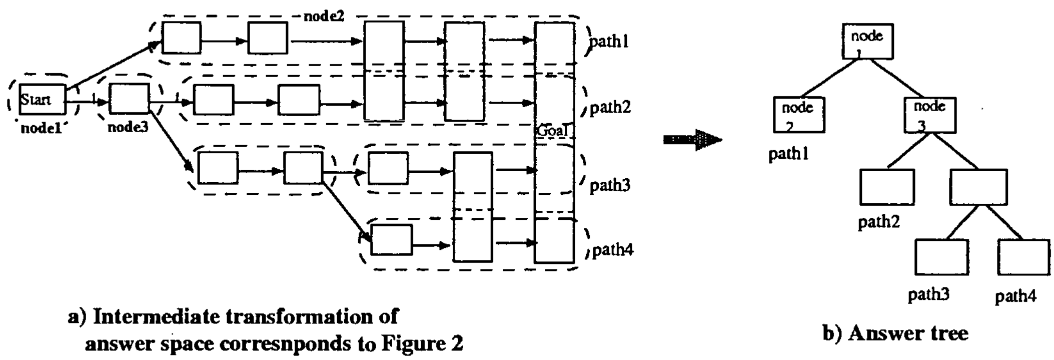

Figure 4: Construction of answer tree

By grasping the learning situation from these aspects, the coordinator is able to handle the changeable learning situation and generate appropriate advices at the right time.

4 Learner

The learner is situated on each student's computer and acts as a pseudo student in the virtual web-based learning environment. The learner provides the interface to the human student and controls the private talking among students such as focus function. Since the learner connects the private talking line according to only corresponding student's request, it behaves independently with the coordinator that manages the public communication.

A personal learning history is the model of corresponding student which is held by the learner. The personal learning history represents the understanding level and the characteristic of corresponding student. Some data of personal learning history are prepared by the human student beforehand and others are gathered by the learner occasionally through the learning. Currently, the picture and utterances of students are collected as a personal learning history. The feature of student does not change through the learning, so the picture is set by each student before the learning starts. Utterances indicate the understanding level of student and also attitude toward the learning; i.e. active or passive, understanding or not-understanding, and so on. They are gathered and added to the personal learning history by the learner when corresponding student send their opinions to the public communication line.

In order to exchange the personal learning history through private talking line, the learner generates mediators for each communication. The mediator is constructed as a mobile agent which processes its tasks while moving through the network autonomously[8]. Figure 5 shows the movement of mediator for acquiring the personal learning history of other students. When the corresponding student requests to get the personal learning history of particular students, the mediators are generated by the learner respectively. Once generated, the mediators move to the target learners through the network and ask for the personal learning history, attended inherently to the target learners. After the acquisition of personal learning history of target learner, the mediators move back to their original learner and disappear autonomously, since their roles are to acquire the personal learning history from target learners. Under such mechanism, students are able to know other students' characteristics even in our virtual web-based learning environment without any direct interaction.

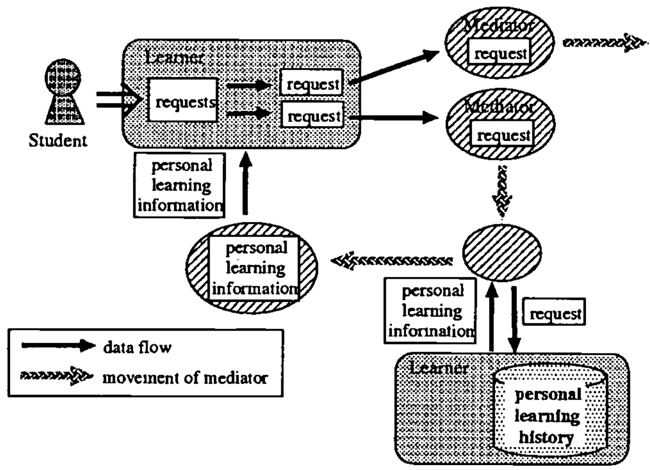

Figure 5: Mechanism for acquiring personal learning information

5 Implementation

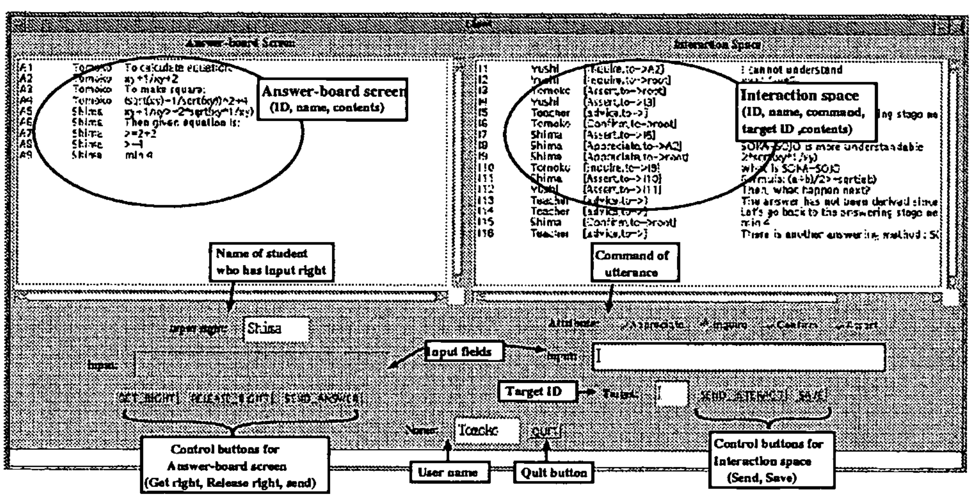

Figure 6: Interaction interface on student operation

We have implemented our prototype system on Internet using UDP protocol, since UDP protocol is suitable to control the frequent interaction of short messages. Figure 6 shows the interaction interface in our system. Two communication tools are prepared: answer-board screen and interaction space. The answer-board screen is a public communication tool which is used to arrange the group's answering process. Only one student is permitted to input on the answer-board screen at a time so that the input right is set. On the answer-board screen, ID, student' name, and contents of input is shown. The answer-board screen functions as a blackboard in our real world. On the other hand, the interaction space is prepared for free conversation so that all students are able to input freely. In order for the coordinator of our system to grasp the learning situation easily, commands that classify the opinions are introduced: Appreciate, Inquire, Confirm, and Assert. Students choose the commands when they input their opinions. In addition to the commands, students specify the target inputs which trigger off their opinions for the purpose of grasping the flow of conversation smoothly. Thus, in addition to the ID, student's name, and contents of input, command and ID of target input are also displayed on interaction space.

As for the coordinator, we prepared several advices which indicate the states of learning situation when the learning is proceeded inappropriately. Currently, the coordinator generates advices when it detects the following learning situation:

- learning situation has not been changed for a long time,
- some students cannot understand currently discussing stage, and
- students have not derived all viewpoints of solving the exercise.

The coordinator's objective is to activate the discussion, so the advices are generated on the interaction space as the same style as all other students' utterances. Figure 7 shows an example of advices generated by the coordinator. As for the advice, the speaker name is set as "Teacher", the command of advice is "advice", and the ID of target input is nothing because the advice is generated for the learning group but not for individual students.

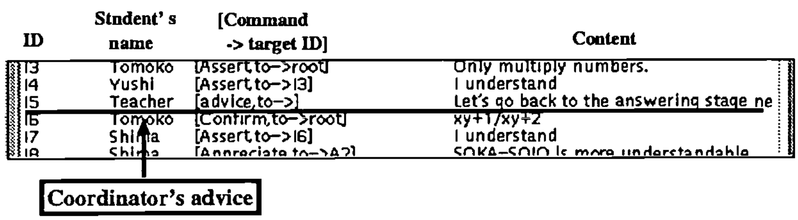

Figure 7: Advice example of coordinator on interaction space

The learners was implemented using AgentSpace[9] as a middle-ware to control the behavior of mediator. Figure 8(a) is an interface for generating requests. On the upper window, the causality of utterances on interaction space is arranged based on corresponding student's utterances. The arrangement of utterances on the upper window helps to decide the focusing students for generating requests. Once a student decides focusing students, he/she inputs IP addresses of focusing students, because mediators need IP addresses where they will work on beforehand in our current version. Then, he/she specifies the file name of focusing student's personal learning history. If a student wants to know only the particular utterances of focusing students, he/she sets the ID's of corresponding utterances shown on the upper window. Figure 8(b) is the result windows of requests for personal learning history. When requests have been completed successfully, the result windows are generated and the personal learning histories of focusing students are shown individually. Currently, the picture of focusing student is shown on the upper window and his/her utterances are shown on the lower window.

6 Conclusion

In this paper, we proposed a collaborative learning environment which contains two different agents: the coordinator and the learner. The coordinator monitors the public communication among learning group and generates advices so as to lead them to their learning goal. For this purpose, the coordinator grasps the learning situation globally from two viewpoints: the ratio of derived step for a whole answering process and the extent of discussion. Although the management structure of learning situation is simple, the coordinator may be able to find the most cases that students are not able to cope with inappropriate learning situation by themselves. On the other hand, the learner controls the private talking such as focus function. The learner holds the personal learning history of corresponding student as his/her characteristics and acquires other students' personal learning histories by generating the mobile agents called mediators. Currently, these agents function independently. However, for our future work, the interactions among coordinator and learners are necessary for the coordinator to generate more effective advices. In addition, the evaluation for the interaction interface of our prototype system and the preparation of more factors for personal learning history based on the result of the evaluation are also our future works.

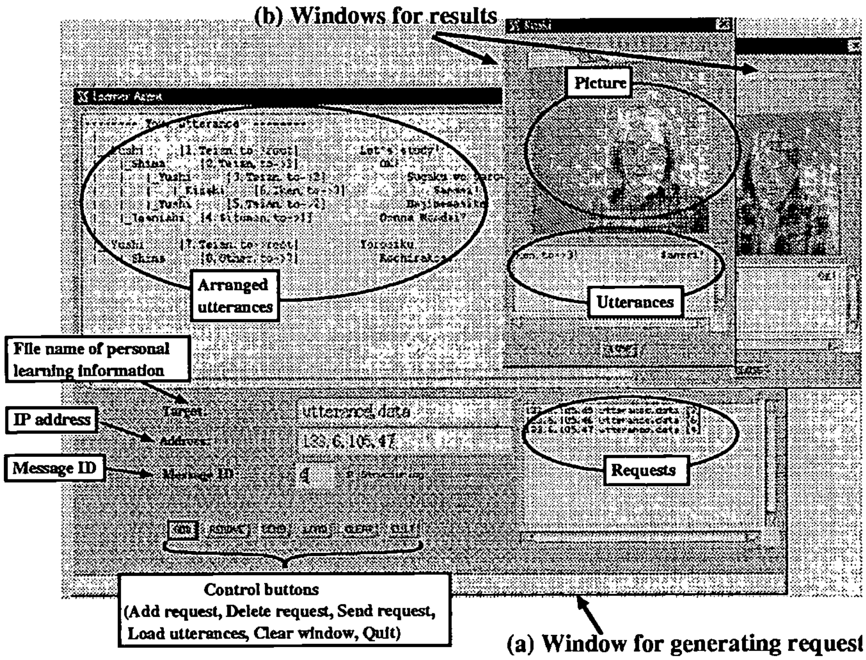

Figure 8: Interface for handling requests

Acknowledgments

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An Effectiveness Study of Web-based Application for Mailing List Summary and Review

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This paper reports an effectiveness research of e-mail discussion review support system with summary extraction method. The support system we have developed can automatically extract summary sentences from the normal conversational style language in e-mail messages using reference relationship of e-mails that participants have discussed. One could use the summary sentences for looking back on discussion, and use them as an idea database at a glance. Japanese natural language processing technology has been applied in the proposed method. In order to evaluate the effectiveness of the system, we conducted experiments using a questionnaire and protocol analysis. We compared the two system; the system with and without summary sentences in the table of e-mail content. As a result, following fact-findings were obtained. The system with summary sentences could promote reading strategy such as utilization of table of contents and comprehension of e-mail message structures. On the other hand, the system without summary sentence makes the reader pay attention to the detail information such as name of discussing member.
Finally, we concluded that the system with summary sentence is effective for understanding of relationship among various e-mail messages.

Keywords: **Mailing lists, Natural language processing, Distance learning, Learning environment, Summary sentence extraction, Collaborative learning, Factor analysis, Reading strategies**

1 Introduction

Collaborative learning support environments for network-based discussion appear to be investigated quite often [1][2]. For instance, e-mail is extensively used in the classes for learners' communication.

The research topic we reported here is collaboration support tools that intended for e-mail discussion. For the purpose of sharing of participants' activities on computer networks, we have proposed a summary extraction method along the development of mailing list discussions and an outline presentation tool for mailing list [3][4][7][9]. Japanese morphemes analysis system [8] is applied in our researches. This web-based tool supports reviewing the past discussion on the mailing list. As for results of the summary extraction method, we conducted comparative evaluation between the result of human summarization and of the method. The result suggests that the proposed method can detect major sentences in e-mail articles properly [4].

There is a number of preceding researches on the keyword and summary sentences extraction methods of documents [5][6][15]. But the most of extraction methods in preceding researches applied to well-documented text, like the newspaper manuscript or research paper. On the other hand, this research targets on the conversational style language in text form. For identifying the outline of e-mail discussion, there are many difficult problems in e-mail messages. These are:

- E-mail messages are conversational style language and many summary extraction methods using syntactic information could be not applied.
- The title of e-mail might not be changed as the discussion continues, if so, the title is not meaningful as the summary of documents.
- The method should identify the flow of discussion corresponding with e-mails in order to grasp the topic.

Besides, most of evaluation experiments in summary extraction method with natural language processing technology focus on the validity of algorithm, like adaptability or reproducibility. About analysis of reading comprehension when additional information, e.g. summary, is given, we could refer Ausubel's research on the advanced organizer model [10]. The paucity of reports on sentence comprehension process encouraged us to investigate it.

The purpose of the present paper is to analyze how the summary sentences accomplishes to an actual comprehension process. In this paper we describe an experimental study of e-mail message reading process with or without the extracted summary sentences.

In the first experiment, we investigated e-mail message reading strategies using responses of questionnaire. We conducted comprehension test and reading process analysis. In the reading process analysis, the result was divided into seven factors using factor analysis. The system with summary sentences could promote reading strategy such as utilization of table of contents and comprehension of e-mail message structures. On the other hand, the system without summary sentence makes the reader give attention to the detail information such as names of participating members.

In the second experiment, we analyzed peer discussion processes while reading e-mails on the World Wide Web (WWW) interface. We conducted the comprehension test of the e-mail messages. We also conducted protocol analysis of e-mail reading comprehension. Also hereupon, we compared the results with two conditions, one is a group to which the summary sentence of the e-mail messages was given, and the other is a group without summary sentence of e-mail messages. The results of protocol analysis show some difference in the number of utterance collected during the experiment.

2 Summary extraction method along development of discussion

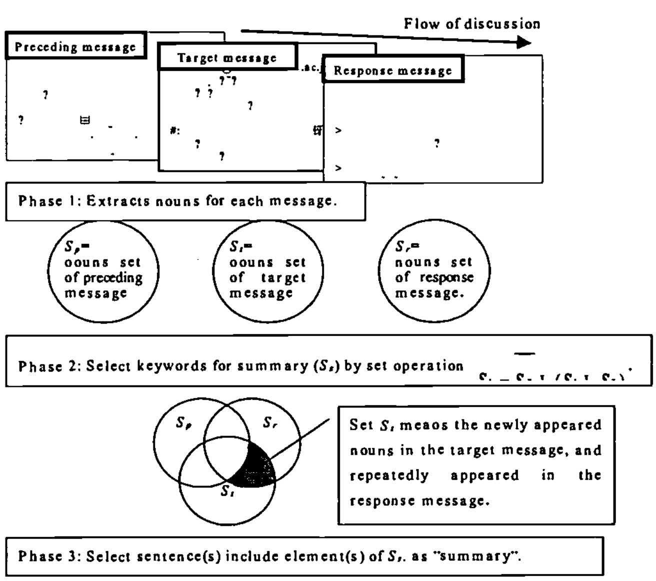


Figure 1: Flow of Summary Extraction Procedure from the target message.

The summary extraction method was discussed in our preceding research [3][4]. In this paper, we de-scribe the outline of the extraction method for better understanding by the readers.

2.1 Idea of the extraction method

We tried the extraction of keywords and summary sentences of the discussion from the document in the mailing list based on the preceding research [11] intended for the discussion such as Netnews. This key-word extraction method can be used in the discussion environment with the following features; (1) The change in the topic does not take place easily in a row. (2) There is a habitual practice that the participants do repeated revisions during the discussion, and uses the quotation appropriately. But although it is limited in our case, e-mail discussion might develop in many ways, and the topic is changeable. The relationship of e-mail message for the keyword extraction between the target message and the past messages is little in e-mail discussion.

Then, in this paper, we set up a hypothesis: Although there was a dependency on the topic, e-mail messages with new information are tempted to encourage responses later. That is, we can treat them as topic making messages in the mailing list. We proposed a summary extraction method that enables pick up those new information as keywords and summary sentences in the messages [3][4]. Figure 1 shows flow of keyword and summary extraction by this method from the content of the message of the mailing list.

However, this summary extraction method supposes both preceding and response messages must be consecutive in the thread. Therefore, we set some assumptions for these exceptions. When the target message is the beginning message in the thread, the title of the message is also used and extracts common nouns among the title of the target message and the body of related messages. On the other hand, when the target message is the last message in the thread, we choose keywords only from the preceding and the target message, and common nouns in both messages is treated as keywords for the target message. Moreover, summary sentences are regenerated when there is a new message in the mailing list.

2.2 Summary generation and WWW display tool

We implemented summary generation and display tool using the proposed summary extraction method. This can be operated on the World Wide Web (WWW) to refer to past messages of mailing list [7]. Fig-ure 2 shows the display of Web page with and without summary sentences. These Web pages fulfill the role of table of contents (TOC) of mailing list. Readers look for contents from the list view with tree structure along continuity of e-mails. They can trace the body of each message from Web link. TOC shows serial number, writer, date of issue, and the title of the e-mail. In Figure 2(b), under the link to the body, summary sentence obtained by the noun set is displayed. When more than one sentence is extracted by the method, it becomes so complicated that the implication of TOC is diminished. So we referred to the procedure widely used in full-text search system [6], the number of displayed sentence is trimmed off to only one sentence that include maximum different number of chosen keywords. We treat that sentence as important sentence for TOC.

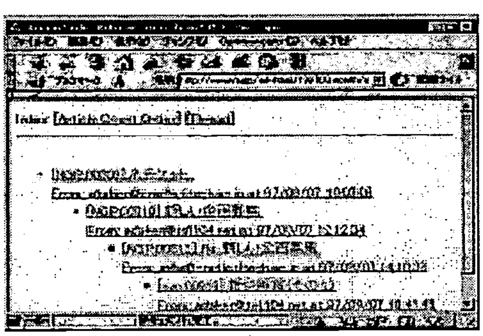
3 Evaluation experiment in the e-mail message comprehension

In this research, we carried out the evaluation experiment on effects of summary presentation while reading past e-mails on the mailing list. We conducted reading comprehension test and factor analysis of reading strategies.

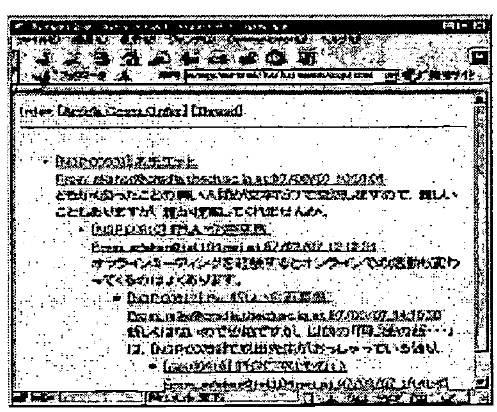
3.1 Methods

3.1.1 Subsubsections

In the experiment, we made the settings resembling the actual Web-based environment of the mailing list.



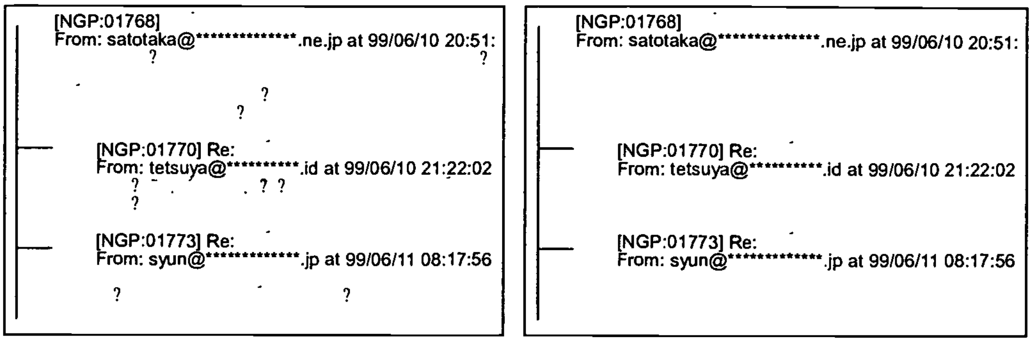
(a) TOC Web page without summary sentences



(b) TOC Web page with summary sentences.

Figure 2: "Table of contents" Web pages for review.

We printed out the several e-mail messages in a row, referred to as "thread", and the table of contents (TOC) for the e-mail messages in addition. Figure 3 shows the part of the experimental materials. To the semblance



(a) Printed TOC with summary sentences. (b) Printed TOC without summary sentences.

Figure 3: The part of the printed experimental materials

of Figure 2, the summary is generated from the proposed summary extraction method. It appeared in parallel beneath each entry in the TOC, or not appeared. E-mail messages for the summary extraction method consist of nine messages of mailing lists. The topic in the mailing list is the educational use of the Internet for foreign Japanese schools and domestic schools.

3.1.2 Procedures

Subjects of the experiment are 56 undergraduate students. None of the subjects know about the mailing list. The printed TOC as described above is affixed in front of the e-mail messages. The printed experi-mental materials were distributed to the subjects, and the researcher explained the experimental setting: "We are going to try to read past e-mails, and catch up with the exchange of the e-mail discussion." In addition, the participants were asked to use TOC positively.

The subjects read these documents for eight minutes. After the eight minutes, the researcher confirmed all the subjects had read the documents once. After that, the subjects were not allowed to read the docu-ments again, and they did the e-mail comprehension test. They had answered the following questions:
1. Write down the name of places which had appeared on the first e-mail as much as you remember.
2. Write down the episode of the first e-mail as much as you remember.
Later, they answered a questionnaire, which was consisting of 28 items with five-point rating scale and space for writing comments. The items were concerning the e-mail reading strategies. In order to make questionnaire, we referred the preceding research about sentence intelligibility [12] and our preceding researches.

3.1.3 Experimental Design

The factor of the experiment materials is presence of summary sentences in the TOC. We can divide the subjects into two levels. 56 subjects were randomly assigned to both two experimental settings of the materials, and were divided into the two groups of 28. Therefore, it is a between-subject experimental design with one factor.

3.2 Results

3.2.1 The comprehension test

In the question 1: "the name of places which had appeared in first e-mail", we compared the numbers of correct answers between two groups. We leave non-response persons off from the analysis. As a result of ANOVA, there was no significant difference in the number of correct answers

Table 1: Extracted factors and results of ANOVA

Name	Ratio	
1. Read the content in detail and memorize	21.5%	**p<.01
2. Use Table of Contents	10.5%	*p<.05
3. Think about the development of discussion	8.7%	
4. Combine their knowledge	7.1%	
5. Think about the theme of discussion	5.1%	
6. Read back and force	4.3%	
7. Write down a memo	3.9%	
Accumulated Explanation Ratio	61.1%	

(F(1,48)=1.065, p>.10).

In the question 2: "the episode of the first e-mail", we have chosen eight words from the message as answer words of the question beforehand. We compared the numbers of appeared answer words between two groups. We also leave non-response persons off from the analysis. As a result of ANOVA, there was no significant difference in the average number of the answer words (F(1,48)=.415, p>.10).

Table 2: ANOVA for Factor Scores

(a) ANOVA for Factor Score of factor 1.

Source	SS	df	MS	F	R^2
Factor	5.61	1	5.61	7.21	0.0098**
Error	38.11	49	0.78		
Total	43.72	50			

**p<.0

(b) ANOVA for Factor Score of factor 2.

Source	SS	df	MS	F	R^2
Factor	4.62	1	4.62	5.99	0.0180*
Error	37.78	49	0.77		
Total	42.39	50			

*p<.0

3.2.2 E-mail reading strategies

The factor analysis with major factor method and varimax rotation method was applied to the 28 questionnaire items concerning strategies of the comprehension for e-mail messages.

As we shown in Table 1, we sequentially named the seven factors. We extracted these factors from the change in the eigenvalue. The accumulated factor explanation ratio was 61.1%. Next, factor score of seven factors was calculated par subjects.
Table 2 shows results of ANOVA. As a result of ANOVA for seven factors, a significant difference was found in the first factor "Read the content in detail and memorize" (F(1,50) =7.212, p<.01) and the second factor "Use Table of Contents" (F(1,50)=5.988, p<.05).

In addition, we compare the score for each item in two groups.

As a result, the group with summary sentences could promote reading strategies such as "Usefully reading TOC help me to know the content of sentences" (t(51)=3.58, p<.01), and "Refer TOC to read the content in the messages" (t(52)=2.76, p<.01). Those who use summary sentences would have tendency that they try to know the relation between the content and the whole structure of the thread.

On the other hand, the group without summary sentences would take reading strategies such as "Pay attention to the participant's name or the name of places appeared on the e-mail while reading" (t(50)=2.34,p<.05), "Read the content carefully and memorize in detail" (t(51)=1.94, p<.10). Thus, they attempted to give attention to the detail information such as names of discussing members.

3.3 Summary of the experiment

In the experiment, there was a significant difference in the e-mail reading strategies while there was no significant difference in the recognition of e-mail contents. Our proposed method is a kind of new information presentation method for the support of e-mail reference. We might say our summary extraction method and display tool for mailing list could help readers to suppress consideration of detail information in the documents. On the other hand, these supports help to maintain the particular contents easier.

4 Protocol analysis of e-mail reading process

From the suggestion in the preceding section, adding summary sentences possibly provide a hint on the e-mail reading strategies. In this section, we examined changes of e-mail reading strategies when having the benefit of summary sentences using protocol analysis. To put it concretely, the subjects answer questions after reading the content of e-mail messages that is displayed on the WWW pages. We have observed the e-mail reading strategies while participants were reading e-mail messages.

4.1. Methods

4.1.1 Experimental materials

We have used 43 e-mail messages of the mailing list for the summary extraction method. Educational use of the Internet in foreign Japanese schools and domestic schools was focused in this mailing list.

the result of comprehension test does not show significant differences. We may con-clude at this point that the method of summary sentence extraction is effective in understandings of relationship of e-mail messages.

2. The influence of summary display on the e-mail reading strategies was examined from the analysis of utterance protocol. The use of Table of Contents WWW page along with e-mail summary sentences does not make a difference in the frequency of utterances, but preferential trend for the use of e-mail summary sentences was observed.

As a problem yet to be solved in the future, we are interested in examining the effectiveness of reading strategies when e-mail messages are posted and read in real time.

Acknowledgement

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An Implementation of Campus Distance Learning System Using Multicast

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A problem common to many universities is that thousands of students want to take some certain courses but only a few can actually take them owing to the shortage of teachers. The Campus Distance Learning System is an important way to solve the problem. This paper starts with an examination of some existing solutions, and then introduces the primary-secondary model multimedia network teaching system designed by researchers in the Computer & Information Management Center of Tsinghua University. The system is composed of three parts: the primary classroom system, the secondary classroom system, and the courseware management system. It fulfills real-time interactive teaching and learning, and multipoint communication, and at the same time records the teaching materials as courseware. The paper focuses on the constituents, structure and characteristics of the system, and expounds in detail the implement technology based on multicast. In the end, the paper points out some problems calling for further consideration.

Keywords: **Network distance learning; primary-secondary model; multicast**

1 Introduction

A problem common to many universities is that thousands of students want to take some certain courses but only a few can actually take them owing to the shortage of teachers. The traditional resolution was videoing and then broadcasting through CATV. This used to play an important part in television education, but it can not support the interaction between the teacher and the students, and the information that is limited by TV is not sufficient for lectures. With the network becoming more and more popular, network education instead of CATV is being received by more and more people. Many companies and universities have developed different network distance learning systems, the following are several famous systems.

Remote Education System of VTEL: This system is an application of the VTEL videoconference system in education. It adopts a complete set of software and hardware developed by VTEL and can implement mulitpoint bi-directional interactive network education.

IP/TV of CISCO: IP/TV is software developed by Cisco company, supporting video on demand and video broadcast. It adopts the client/server model and is mainly used for transferring high quality video, audio and data via computer networks. The system supports three ways of video transferring: live, on-demand and scheduled.

Multimedia Distance Education System of SATCOM: This system includes a program courseware generation system and a courseware on demand system.

2 Primary-Secondary Model Multimedia Network Teaching System

2.1 System Constituents

The primary-secondary model multimedia network teaching system is composed of three parts: the primary classroom system, the secondary classroom system and the courseware management system (See figure 1).

The primary classroom is where the teacher stays. In this classroom, the video and slide of the lecture are recorded synchronously. The video and slide information is broadcast live through multicast, and at the same time the information is stored in the courseware library for asynchronous use.

The secondary classroom is the classroom without the teacher, maybe a remote classroom. Students in this classroom can join the lecture by registering and playing the composite stream courseware synchronously with the primary classroom.

The courseware management system provides the directory service, user register management, asynchronous courseware on demand, and other management functions of the coureware library.

The free terminal can join the lecture from anywhere of the campus network through registering. It can also play courseware on demand from the courseware management system.

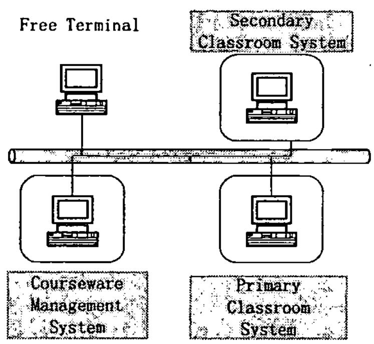

Figure 1 System constituents

2.2 System Structure

Figure 2 shows the structure of the primary-secondary model multimedia network teaching system. Its subsystems are as follows:

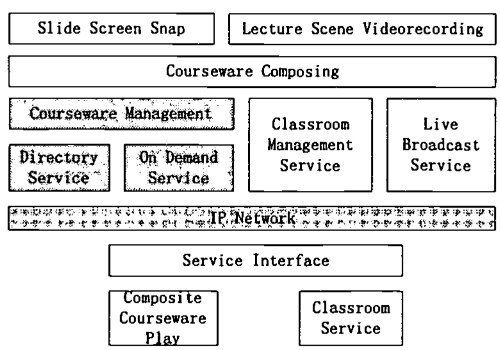

Figure 2 System structure

- Courseware synthesizing: The courseware synthesizing is the kernel subsystem of the primary classroom system. In this procedure, both the basic materials of the courseware – lecture scene videorecording and slide screen snaps are compressed into the composite courseware with synchronous timestamp. Afterwards, the courseware is stored into disks and multicast at the same time by the system.
- Lecture management service: The lecture management service is anther important subsystem of the primary classroom system, its main functions being registering new courseware in the courseware management system, requesting for the multicast address, configuring the multicast scope and lecture management.
- Directory Service: This is the kernel function of the lecture management system. It provides lectures and courseware lists and user management.
- On-demand Service and Live Broadcast Service: On-demand service is an asynchronous courseware service provided by the courseware management system while live broadcast service is a synchronous

service provided by the lecture management system. Both of them provide composite stream courseware to the user, the former using unicast and the latter using multicast.

- Lecture Service: This is an interactive supporting system provided by the secondary classroom system. With it students in the secondary classroom can participate in the discussion. The means of interaction may be keyboard typing, and speaking with a microphone.

2.3 System Characteristics

The main characteristics of the primary-secondary model multimedia network teaching system are the following:

1) It uses two streams to play the teacher's videorecording and slide screen snaps, and the quality of the slide screen snaps is the same as that of the slides in the primary classroom.
2) The lecture scene is kept in the archives in real time, and can be replayed at any time.
3) The teacher can discuss with students in remote classrooms through videoconference, and they can write on the same electronic white board.
4) The audience can have interlocution with the lecturer by text typing.

3 Implementing the System with Multicast

3.1 The Multicast Technology

By keeping routers informed about multicast hosts, multicast datagrams can traverse an internetwork and reach many hosts simultaneously. The ability to traverse an internetwork and reach an unlimited number of "member" hosts simultaneously without affecting others adversely is the linchpin of multicast. A Class D IP address in the range from 224.0.0.0 to 239.255.255.255 is a "multicast address." Each is also known as a "host group address," since datagrams with a multicast destination address can be received by all hosts that have joined the group that an address represents. Figure 3 shows the datagrams spreading abroad.

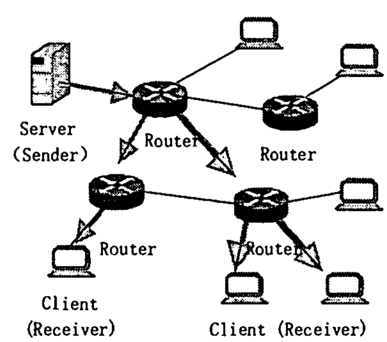

Figure 3 Datagrams sent only to hosts in a group

The mechanisms incorporated into WinSock 2 for utilizing multicast capabilities can be summarized as follows:

- Three attribute bits in the WSAPROTOCOL_INFO struct, which are used by **WSAEnumProtocols()** to discover whether multicast communications are supported for a given protocol;
- Four flags defined for the *dwFlags* parameter of **WSASocket()**;
- One function, **WSAJoinLeaf()**, for adding leaf nodes into a multicast session;
- Two **WSAIoctl()** command codes for controlling multicast loopback and the scope of multicast transmissions (SIO_MULTICAST_SCOPE and SIO_MULTIPOINT _LOOPBACK).

We can benefit from using multicast to implement network teaching system, which can be described as the following:

1) Because the member of a multicast group is dynamic, and no authority is requested, the terminal can join or quit a group at any time;
2) All hosts belonging to a multicast group have a clear physics network topology;
3) All users in one subnetwork that join the same multicast group share the same stream over network, and this can greatly lighten the network load.

3.2 System Implementation

In the practical system, we adopt the combinative way of multicast and unicast: using multicast to broadcast information from the primary classroom, and using unicast to implement the interaction between the primary classroom and the secondary classroom. Figure 4 shows the structure of the practical system in detail.

The primary classroom system is composed of a server, a teacher's PC, a video recorder, two overhead projectors and an electronic white board. The teacher's PC is used to play slide of the lecture, and it projects the slide to the electronic white board. If the teacher writes something on the electronic white board, the teacher's PC will capture the written information and combine it with the slide. At the same time, the teacher's PC compresses the slide/written information and sends it to the server. The server takes charge recording the video/audio information, receiving the slide/written information from the teacher's PC, and broadcasting the information with multicast. At the same time, the server stores all information into special type file, which is the composite courseware.

The full function secondary classroom is made up of a server, a video recorder, two overhead projectors and an electronic white board. The server receives the video/audio and slide/written information from the primary classroom, and projects the video information on the white wall, the slide/written information on the electronic white board.

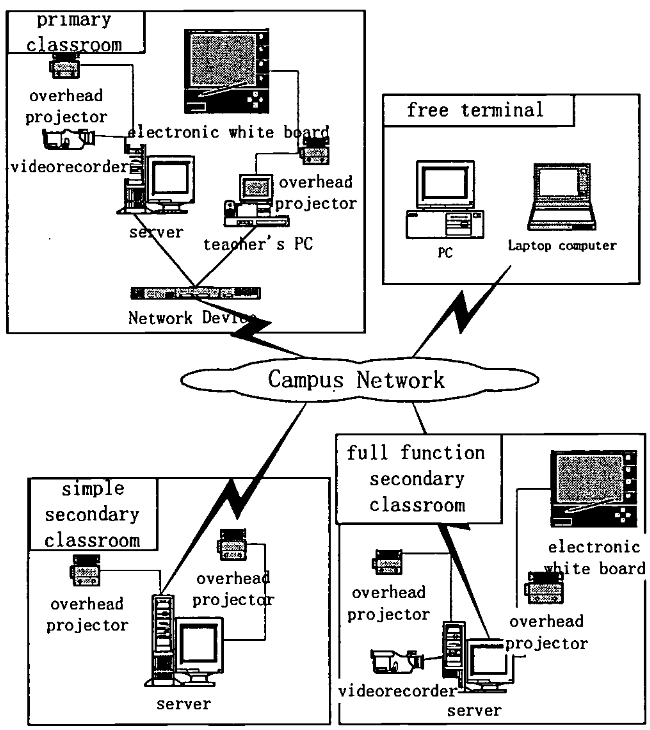

Figure 4 The topology of the primary-secondary model multimedia network teaching system

The simple secondary classroom is made up of a server and two overhead projectors. The server receives the video/audio and slide/written information from the primary classroom, and projects the information on the white wall separately.

The free terminal may be any PC connected to the network. It receives the video/audio and slide/written information from the primary classroom and displays it in different windows.

The teacher in the primary classroom and the students in the secondary classroom can discuss with each other. This is implemented with unicast. During the discussion, the server in the secondary classroom records the information of the students and sends it to the server of the primary classroom. The server of the primary classroom receives this information and projects it on the white wall. If students in the secondary classroom write something on the electronic white board, the servers will transmit the written information, which will be shown on the electronic white board of the primary classroom at the same time.

4 Conclusions

In our experiments, we use lossless a compression algorithm and the slide screen snaps can be compressed to 1%~2%, it means that the slide screen snaps will take up 100~200Kbps bandwidth. In another side, the video information can be compressed into 128Kbps by MPEG-4 and all the information of this system can be fit in a 384Kbps channel. This system is available for long distance learning and of course for campus distance learning.

The primary-secondary model multimedia network teaching system has built a virtual network classroom system. It will play an important role in making better use of teaching resources and improving teaching efficiency.

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Analyses of Cognitive Effects of Collaborative Learning Processes on Students' Computer Programming

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The purpose of this study was to clarify the cognitive effects of collaborative learning on Junior high school students' Logo programming. Two experiments were implemented: *Experiment1* was an analysis of the relationships between interaction in pair activities and students' reflection. The effects of pair learning on students' promoting abilities of programming were analyzed in *Experiment2*. As the results of *Experiment1*, students' self-monitoring and self-control were supplemented each other through the interaction. Results of *Experiment2* suggested that the effect of collaborative learning on students' programming abilities were developments of debugging ability against syntax error and coding ability of lower students, which was obtained the cognitive strategies for task division through the interaction.

Keywords: **Collaborative Learning, Junior High School Students, Cognitive Effects, Logo Programming**

1 Introduction

In Japan, education about computer programming was placed in *Fundamentals of Information* of *Industrial Arts* at junior high school level from 1989. From 2002, programming, sensing and control will be placed in *Information and Computer* of *Technology* as an elective learning content (*Course of Study* published in 1998)[5]. Many technology teachers in Japan thought that teaching programming was not only for professional higher education. They didn't made points of understanding the function of software upon a computer system, but acquiring the problem solving skills through the programming activities.

Historically, many researchers suggested that one of the methods for acquiring the problem solving skills was collaborative learning. It was necessary for students to communicate and interact with someone who had same goal in collaborative environment (Deutsch 1949)[1]. In the recent past, it was supported that the experiences of solving the problem through the interaction made the processes of planning and decision making clearly each other, and would promote their self-control and self-monitoring when they would solve another problem all by themselves (SATOU 1996)[3]. In the case of learning about programming, KAGE (1997) suggested that 12-year old pupils showed vigorous verbal interaction, which led them to more sophisticated problem solving [4].

From these findings, it was predicted that acquiring the problem solving skills brought to promote students' programming abilities as a result of cognitive effects of collaboration.

The purpose of this study was to clarify the cognitive effects of collaborative learning on students' programming. For this purpose, two experiments by using Logo programming (Japanese Edition) were implemented. The aim of *Experiment1* was to clarify the relationships between interaction of collaborative learning processes and learners' reflection. The effects of collaborative learning on students' promoting abilities of programming were analyzed in *Experiment2*.

2 Methods

2.1 Experiment1

2.1.1 Subjects

Twelve 3rd grader Jr. high school students (6 males and 6 females) were divided into 6 pairs.

2.1.2 Instruments

"The Reflection Scale of Thinking Process on Computer Programming: RSTC"(MORIYAMA et al 1996) [2] and the modified LUTE (Link-UniT-Element) model (MORIMOTO et al 1997) [6] were used for measuring the level of reflection and analyzing the interaction, respectively. The RSTC was constructed from 4 factors as in Fig.1. Factor1 was the reflection of understanding the problems and enterprising how to make the program adequately. Factor2 was the reflection of designing the program and coding. Factor3 was the reflection of self-monitoring on each parts of the program on the local level. Factor4 was the reflection of self-monitoring on the whole program and renewal of problem representation.

Factor1 (6 items)	**Factor2** (6 items)	**Factor3** (5 items)	**Factor4** (3 items)
Semantic understanding of the problem	Setting up the keywords	Predicting the result of running	Analyzing the bug
Imaging the command and grammar	Division of the program	Testing walk through the list	Renewal of problem representation
Comprehending the image of program	Setting up the functional unit	Checking the clerical error	Seeking the bug
Rhetorical understanding of the program	Connecting the functional unit	Checking the syntax error	
Seeking the semantically-related knowledge	Coding the functional unit	Checking the logical error	
Seeking the rhetorically-related skill	Checking the sequences of each commands		

Fig.1 The Reflection Scale of Thinking Process on Computer Programming: RSTC

The modified LUTE model was shown in Fig.2. There were categories for analyzing interaction of collaborative learning in this model, and this model had three abstract levels: element, unit and link level. The items of element level were categories for functions of protocols. The unit and link level categories were for phases and contexts in their programming activities.

Element Level (5 categories)	Unit Level (6 categories)	Link Level (6 categories)
Proposed	Phase of Analysis	Link for Formation of plan
Agreement	Phase of Plan	Link for Modification of plan
Question	Phase of operation	Link for Implementation of plan
Opposition	Phase of Edit	Link for Check of Implementation
Supplementary explanation	Phase of Checking the program list	Link for renewal of plan
	Phase of Checking the result of running	Link for renewal of implementation

Fig.2 The modified LUTE (Link-UniT-Element) model

2.1.3 Procedures

Subjects were asked to make the Logo program which draw the "*House*" constructed from triangular shapes, square patterns, circles and lines in pair. Their activities were recorded on a VTR. After they finished the task, they answered RSTC individually. Their protocols were extracted from the VTR and were categorized by using modified LUTE model. The level of reflection and the relative interaction in the collaborating pair were analyzed by ANOVA on mean scores of frequencies of link level categories and Coefficient of Correlation (r) between the RSTC scores and frequencies of the element and unit level categories.

2.2 Experiment2

2.2.1 Subjects

Sixty 3rd grader junior high school students (30 males and 30 females) were divided into 2 groups learning Logo programming. One was collaborative learning group (pair), and the other was individually learning group.

2.2.2 Instruments

The achievement tests and the RSTC were prepared. The achievement tests included both the coding test and the debug test. The coding test asked to make a program drawing "*Scarecrow*" on an answer sheet. The debug test asked to find three types of error, clerical error, syntax error, logical error from the program list which drew "*Spaceship*".

2.2.3 Procedures

The procedure was shown in Fig.3. At first, subjects had a coding test which draws the easy "*flag*" as a pre-test. Next, subjects were asked to make the program, which draws the "*House*" such as *Experiment1* and answered RSTC in every group as a middle-test. Finally, they had the achievement tests and answered RSTC individually as post-tests. The effects of collaborative learning on students' promoting abilities of programming were analyzed by using ANOVA and Coefficient of Correlation (r) between the RSTC scores and the Achievement tests' scores.

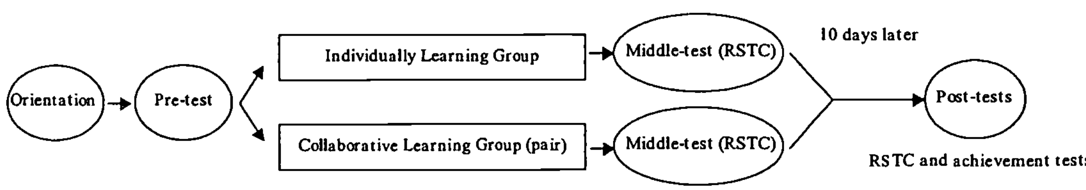


Fig.3 The procedure of *Experiment2*

3 Results and Discussion

3.1 Experiment1: Students' Reflections and Collaborative Programming

3.1.1 Contexts of Collaboration in the Pair Activities

There were differences of period of keyboard operation time in pair activities. In this analysis, long-operated learners were called *Learner A*, and the others (short-operated) were called *Learner B*. Mean scores of frequencies of link level categories were shown in Table.1.

Table.1 Frequencies of link level categories

Link Level Categories	Mean Score (S.D.)				ANOVA
	Learner A to B	*Learner B to A*	*Learner A to A*	*Learner B to B*	
Link for Formation of plan	1.75 (1.04)	2.00(1.77)	1.63(1.41)	3.50(2.73)	*n.s.*
Link for Modification of plan	3.35(2.12)	2.50(1.93)	0.25(0.46)	0.13(0.35)	F(3,24)=8.397, p<.01
Link for Implementation of plan	1.88(2.70)	15.63(5.80)	5.88(3.40)	2.75(2.49)	F(3,24)=21.732, p<.01
Link for Check of Implementation	3.75(1.49)	1.13(1.36)	1.00(1.07)	0.13(0.35)	F(3,24)=13.055, p<.01
Link for renewal of plan	0.38(0.52)	0.38(0.74)	0.13(0.35)	0.63(0.52)	*n.s.*
Link for renewal of implementation	0.63(0.92)	1.25(1.28)	0.25(0.46)	0.00(0.00)	*n.s.*

Results from Two-way Repeated Measures ANOVA showed that there were significant main effects of Links for Implementation of Plan from *Learner B* to *A* [F(3,24)=21.732, p<.01], and Links for Check of

Implementation from *A* to *B* [F(3,24)=13.055, p<.01]. Also, Links for Modification of Plan with interaction (*B* to *A* and *A* to *B*) were increased than that of individually links (*A* to *A* and *B* to *B*) [F(3,24)=8.397, p<.01]. These data indicated that the role of operation (*Learner A*) and the role of planning (*Learner B*) were shared in pair activities. However, it was suggested that consensus decision making through the interaction was important for building up their programming plans.

3.1.2 The Relationships between the Interactions and the Reflections

Coefficient of Correlation (*r*) between the RSTC scores and frequencies of element level categories were shown in Table.2. According to these data, when *Learner A* (operator) proposed something to operate, the reflection of designing the program (Factor2) was promoted in own thinking process [*r*=0.88, p<.01]. However, when *Learner B* (planner) proposed, the reflection of self-monitoring on each parts of the program (Factor3) was promoted in *Learner A*'s thinking process[*r*=0.88, p<.01]. Furthermore, opposition by *Learner A* correlated the reflection of self-monitoring (Factor3) in *Learner B*'s[*r*=0.71, p<.05]. Also, *Learner A*'s reflection of designing (Factor2) was promoted by the opposition of *Learner B*[*r*=0.77, p<.05]. These results indicated that the verbal communications on their interaction brought out their self-monitoring and self-control each other.

Table.2 Coefficient of Correlation (*r*) between the RSTC scores and frequencies of element level categories

Element Level Categories		Factor1		Factor2		Factor3		Factor4	
		Learner A	*Learner B*	*Learner A*	*Learner B*	*Learner A*	*Learner B*	*Learner A*	*Learner B*
Proposed	*Learner A*	0.41	0.26	0.88**	0.41	0.52	0.13	0.06	0.06
	Learner B	0.04	0.45	0.37	0.25	0.88**	-0.33	0.50	0.31
Agreement	*Learner A*	0.00	-0.10	0.31	-0.34	0.52	-0.66	0.26	-0.20
	Learner B	0.44	0.35	0.67	0.55	0.28	0.08	0.36	0.07
Question	*Learner A*	-0.32	0.56	0.27	0.28	0.56	-0.11	0.78*	0.23
	Learner B	0.40	-0.52	0.56	-0.29	0.00	0.02	0.03	-0.31
Opposition	*Learner A*	0.03	-0.30	0.27	0.08	0.13	0.71*	0.42	0.19
	Learner B	0.12	0.19	0.77*	0.23	0.52	0.27	0.68	0.00
Supplementary explanation	*Learner A*	0.72*	-0.35	0.61	0.13	0.03	0.40	-0.15	-0.01
	Learner B	-0.01	-0.34	0.32	-0.13	0.14	0.40	0.45	0.08

n=8, df=6, **p<.01, *p<.05

In addition, Coefficient of Correlation (*r*) between the RSTC scores and frequencies of unit level categories showed that, operation by *Learner B* as a planner conduced to *Learner A*'s self-monitoring on whole program[*r*=0.85, p<.01]. Also, task analysis by *Learner A* as an operator encouraged *Learner B*'s designing of the program[*r*=0.75, p<.05]. It was evident that one's reflective thinking was precipitated by the observation of the other's behavior which was supposed to be his own behavior.

These results of *Experiment1* suggested that students' meta-cognition (self-monitoring and self-control) were supplemented each other through the interaction of collaborative pair learning.

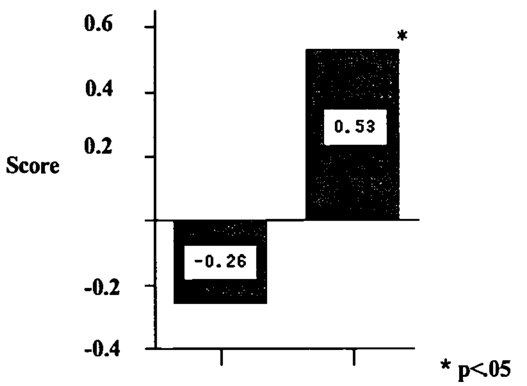
3.2 Experiment2: Effects on students' promoting abilities of programming

3.2.1 Acquisitions of Programming Abilities

In the pre-test, there are not significant differences between the pair learning group and the individually learning group [F(1,56)=0.65, *n.s.*]. Students who could get high scores were called ***higher students*** and the others were called ***lower students*** in this analysis (both 50% and n=30). In the middle-test, mean score of RSTC in the pair learning group (0.77) was higher than that in the individually learning group (0.56) [F(1,56)=32.40, p<.01]. This result supported findings of *Experiment1* because collaborative pair learning could promote students' reflections of thinking processes.

Mean scores of debug test were shown in Fig.4. Results from the ANOVA showed that the debugging scores of syntax error in the pair learning group was higher than that in the individually learning group [F(1,56)=4.75, p<.05]. But, there were not significant differences on the debugging scores of clerical and logical errors [F(1,56)=2.06 and F(1,56)=0.89, both *n.s.*]. These results indicated that collaborative pair learning could form students' debugging abilities against syntax errors, at least.

Mean scores of coding test were shown in Fig.5. The result from the Two-way Repeated Measures of ANOVA showed that there was significant interaction between *High-Low student* condition and *pair-individually* group condition [$F(1,56)=10.46$, $p<.01$]. Furthermore, from the results of Simple Main Effects Tests, the score of *lower students* in the pair learning group was promoted to the same level as *higher students* in both groups [$F(1,56)=12.56$, $p<.01$]. These results indicated that the coding abilities of Low-Ability students could be pulled up through the interaction with High-Ability students.



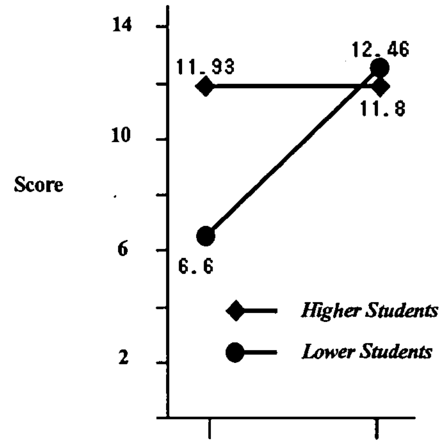


Fig.4 Mean scores of debug test (syntax error)

3.2.2 Acquisitions of Cognitive Strategies

Coefficient of Correlation (*r*) between the RSTC scores and the achievement tests were shown in Table3. According to these data, there were significant correlation between the coding test and the RSTC items: "Division of the program"($r=0.31$, $p<.05$), "Coding the functional unit"($r=0.41$, $p<.01$), "Connecting the functional units"($r=0.40$, $p<.01$) and "Selecting the commands for each functional units"($r=0.40$, $p<.01$) . Also, There were significant correlation between the debug test and the RSTC items: "Division of the program"($r=0.29$, $p<.05$), "Checking the sequences of each commands"($r=0.33$, $p<.01$). It was indicated that promoting these reflections were responsible for the development of the programming abilities. Furthermore, these items suggested the reflections of cognitive strategies for task division.

Table 3 Coefficient of Correlation (*r*) between the RSTC scores and the achievement tests

Items of RSTC	Achievement Tests	
	Coding Test	Debug Test
Division of the program	0.31 *	0.29 *
Coding the functional unit	0.41 **	
Connecting the functional units	0.40 **	
Selecting the commands for each functional units	0.40 **	
Checking the sequences of each commands		0.33 **

**p<.01, *p<.05

Results of *Experiment2* suggested that the effect of collaborative learning on students' programming abilities were developments of debugging ability against syntax error and coding ability of lower students, which was obtained the cognitive strategies for task division through the interaction.

4 Conclusion

In this study, it was clarified that students' meta-cognition and cognitive strategies could be acquired through the collaborative learning at junior high school level, also that the RSTC was useful for measuring students' reflections in their programming activities. These findings will contribute to the researches of developments of collaborative learning systems.

For the future, learning processes and cognitive effects of more widely collaborative learning environment, for example, distributed programming by using CSCL system or long distance education for programming by using Internet, must be analyzed.

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Note:

This study was revised and enlarged version of the following papers published in Japan:

Jun MORIYAMA, An Analysis of Collaborative Learning Process on Students' Computer Programming, *Journal of Japanese Society of Technology Education*, 41-4: pp.187-196, (1999) (In Japanese)

Jun MORIYAMA et al, Development of the students' abilities for Computer Programming through the Collaborative Learning, *Proceedings of the 42nd Annual Conference of Japanese Society of Technology Education*: p.21, (1999) (In Japanese)

Building Mathematics Collaborative Learning Web Sites

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How to make a good use of the Internet in teaching has become a kernel question for educators recently. Surveying research findings and exploring existed related web sites, we suggest three cornerstones of such kind of web site: usage of multimedia, online collaborative courses, and automatic material submitting system. Taking mathematics as our target subject, we build a mathematics collaborative learning website prototype.

Keywords: **Web-based collaborative learning, multimedia, constructivism, submitting system**

1 Introduction

The Internet has greatly changed the way of learning and teaching. For example, teachers and students now can communicate with each other by sending E-mail. They can access learning material and resources through the World Wide Web. Students can even complete a project by cooperating with other people form all over the world. The Internet has becoming the main medium to acquire and share educational information. [6, 12] However, difficulties do exist while applying the Internet toward education. One of the main difficulties is the lack of online resource. Because of the limited educational resource, students usually simply surf the Internet rather than learn knowledge from the net. [14]

This study intends to find some feasible ways to enrich the educational resource that suitable for the Internet. Each of the following three sections focus on one of such ways: (1) using multimedia learning resources, (2) embedding collaborative learning spaces, and (3) gathering web-based learning resources. In each section, we first survey related research findings and existing educational web sites. Our analysis induces important factors of a successful web-based learning space. Applying these suggestions, we build a prototype web that help elementary school students to learn mathematics.

2 Multimedia learning resources

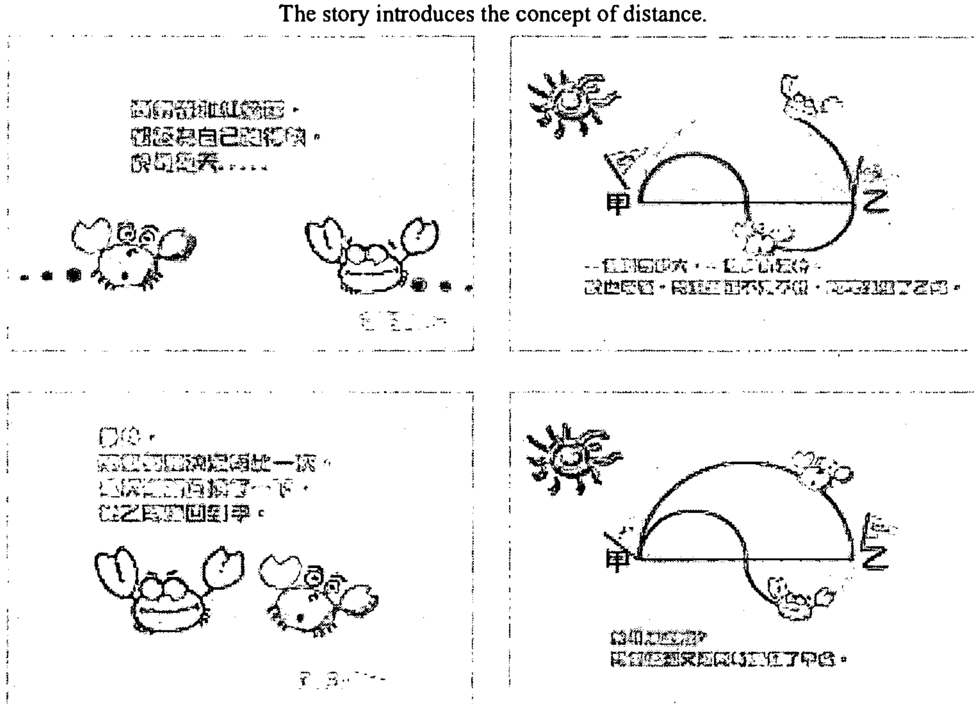
Many researches showed that learning material should be demonstrated by multimedia to achieve better learning effects. C.S. Lin [7] indicated that online courses should be presented by multimedia like visualization, auditory, and even three-dimensional virtual reality. Such multimedia courses make students understand knowledge in a correct manner. Furthermore, multimedia courses often enhance user's long-term memory due to its elaborated and organized information. Blake and Sekuler [1] claimed that visual stimuli usually play an important role for providing various resources. Especially for mathematics and science subjects, combination of texts and images can effectively demonstrate the concepts to be learned. Paivio [10] proposed the Dual Coding Theory suggesting that peoples' memorization systems include verbal and non-verbal system. L.J. Lin [8] further showed that the knowledge encoded by both verbal and non-verbal system could be memorized easier than the knowledge encoded simply by verbal or non-verbal system alone. Y.R. Chen [2] argued that background music presented in computer-aided learning affects the feeling of the learners.

Many mathematics web sites provide mathematics related stories. However, based on our experience on the web sites listed on Table 1, most of them use only texts to present the stories, which is not coincidence with the research findings discussed above. In our web site, we composed mathematics stories by using animations. The animations contain voice, background music, images, and texts. Each of the stories demonstrates a mathematical concept, question, or mathematician biography. As an example, Figure 1 demonstrates screen snapshots of a multimedia mathematics stories.

Table 1: List of some mathematics web sites.

Web site	Web Title
http://dns.eses.tnc.edu.tw/	The WWW of Er-shi elementary school
http://www.netvigator.com.tw/~goodmath/	Funny Mathematics Web
http://www.tacocity.com.tw/ghsghs/	The home of Su-Horng Math prince
http://www.enc.org/classroom/claslinx/nf_resmath.htm	Classroom Links-Math
http://www.mathpro.com/math/glossary/glossary.html	On-line Mathematics Dictionary
http://www.cut-the-knot.com	Interactive Math Miscellany and Puzzles
http://www.c3.lanl.gov/mega-math	Mega Mathematics
http://math.rice.edu/~lanius/frac	A Fractals Lesson
http://ois.unomaha.edu/drfreemath	Dr. FreeMath
http://group.estmtc.tp.edu.tw/math/	A Math amusement park on Internet
http://acorn.educ.nottingham.ac.uk/cgi-bin/daynum	About Today's Date
http://www.eduplace.com/math/brain/	Brain Teasers
http://www.cs.yale.edu/homes/tap/past-women-math.html	Past Notable Women of Mathematics
http://math.rice.edu/~lanius/frac	A Fractals Lesson
http://www.ed.gov/pubs/parents/Math/index.html	Helping Your Child Learn Math

Figure 1. Screen snapshots from a mathematics story named "A Strange Competition." The story introduces the concept of distance.



3 Embedding collaborative learning spaces

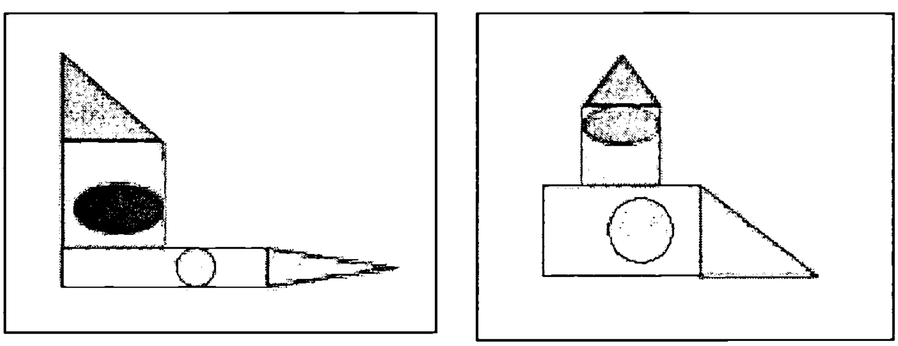
Intensive researches have recently focused on how to use network to assist students' collaborative learning. Ho and Kuo [5] divided network-based learning into two models: collaboration and competition, since the Internet allows many people to use the net simultaneously to achieve a common goal. Chou and Sun [3] summarized advantages of collaborative learning over the Internet as following. (1) Students can learn different opinions and ideas, so that they can understand the topic in different viewpoints. (2) Collaborative learning encourages communication and sharing of personal and team experience and knowledge. (3) Students need to demonstrate and explain the contents and knowledge that they have learned. Through this articulation process, old and new knowledge would be integrated and new knowledge can be expended to other applications. (4) Collaborative learning promotes the feeling of participation and identification. On the other hand, their paper also showed that competition style computer-assisted instruction systems motive students' learning better than traditional computer-assisted instruction systems. But the competition mode causes higher anxious feeling.

Since current curriculum in Taiwan emphasize learning in a group collaboratively, rather than to compete with each other. Research findings shown above also support collaborative learning over the Internet. We design a collaborative learning model on the Internet. Our model encourages collaboration but try to avoid unnecessary competition. Following example explains the model in detail.

This example helps students to learn colors and shapes. Learners can plot various shapes like triangles, squares, rectangles, and circles on the computer. He or she can then color each shape that just drawn. While the shape is drawn and color is chosen, their names are shown and read by the computer. In this way, learners learn the names of shapes and colors. After drawing the graph, learners may write a detailed description of what he or she just finished. The description is then sent it to his or her partner by E-mail. The partner then draws the graph according to the description. Due to the difference of reading and writing skills, two graphs may be in large diverse. Such differences also generate a lot of fun. See Figure 2 as an example. The system also provides synchronous and asynchronous communication tools. Synchronous tools are message passing and chat room; asynchronous tools are discussion board and E-mail. Learners can choose an appropriate way to learn.

During the learning process, learners should describe the picture in words, which means the learners must know the names of colors and shapes. This activity of learning on the Internet not only achieves the goal of collaborative learning, but also trains the ability of communication. It also develops learns' creation and thinking abilities. Furthermore, it makes learners get along with their partners better and happy.

Figure 2. Screen snapshots of the graphs that different learners drawing.



4 Automatic mechanism for gathering web-based learning resources

We have suggested composing multimedia mathematics stories and collaborative project on the web. To accomplish these tasks, however, can be very time consuming. Single person can produce very limited material and thus resource sharing becomes important. As suggested by Engkavahnish and Sujira [4], information exchange and resource sharing is very important nowadays. Vaughan and Sandrairene [11] also indicated that the society today usually share the resource to save precious timing and money.

Therefore, we construct a mechanism allowing people to submit their learning material to the mathematics learning web site. In this way, rich resources may be created quickly and then be widely shared. One of the important functionality of the system is to allow people to submit their works of multimedia stories or learning material. People can upload related files to the server via web browsers. The developer also needs to fill out simple forms, like subject of the work and type of the files, to assist classification of their works. The files will be stored and put online based on their properties. Such automatic process to classify works systematically not only save a lot of manpower, but also greatly increase the accuracy of classification. Once the classification is done, learners can search the whole site in a systematic way to find what they want easily.

Classification is important for a database and automatic document classification is a kernel problem for improving the accuracy and efficiency of searching. Consider three ways to explore information from the Internet (surfing, browsing, and searching,) two of them (browsing and searching) need the data be organized first. Our system adopts Extensible Markup Language (XML) to implement the classification of the web pages. See [9,13] for more information about XML. Tags of classification fields are defined in the XML clip. Such technology improves the efficiency of data exchange and provides a metadata (data of data) of each of material web page.

5 Conclusion

Rapidly changes of technology affect each of us in all aspects. These changes affect students and their future significantly. In this study, we have suggested three essentials of a successful mathematics collaborative learning web site. We have implemented a prototype of elementary mathematics learning web using these three factors. We hope these suggestions may benefit the education community for building more and more better educational web sites.

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Collaborative Learning using GSS on the Internet

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In Collaborative Learning, students learn in a team and play a good roll in the. We use the GSS (Group Support System) to improve the efficiency of learning on the internet. This paper also introduces the implementation of a collaborative learning game on the Internet.

Key word: **Collaborative Learning, Group Decision System, Team-game.**

1 Introduction

Collaborative learning focuses on the function of the team to inspire the learning motivation and improve the learning performance. Many social psychology mechanisms of cooperation and competition are used in Collaborative Learning to achieve learning goal of a team. Collaborative Learning has been regarded as a positive way of teaching. In our Internet Collaborative Learning model, we use the GSS to improve the efficiency of learning. These systems were all proofed to be efficient on communication, task performance and process completion.

2 The Collaborative Learning on Internet

Slavin considers that Collaborative Learning as to put the learners into the team' s missions, offer the reason of cooperation and the motivation of group, and the collaborative behavior as a result.

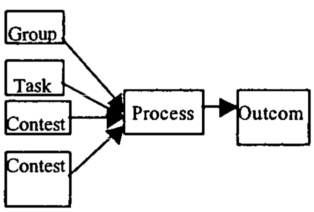
The team of Collaborative Learning has five characters (Johnson,1994): (1)The positive dependence relationship (2)Personal responsibility (3)The skill of cooperation (4)Face-to-face interaction (5)Student' s reverse thinking. Usually, there are two ways to classify students in a team: (1)Student with the same ability in the same group (2)Student with the different ability in the same group.

Traditional Collaborative Learning was restricted by time and distance. It can' t satisfy student' s abundant demands gradually. Collaborative Learning on the internet has various merits at traditional learning could not complete. Learning and communication on the internet is so popular that the internet become another fabricated society. According to the internet' s characters, the merits of learning on the internet are: (1) The users are the central of the Internet environment (2) More convenient and simple (3) The users can control the process by himself (4) Resources can be get and absorbable quickly (5) The content of course should be renewed and exchanging information quickly (6) Promoting users contract technology and using it to learn (7) In anonymous way to heave problem, and it can be answered by the other users (8)It offers new and interesting system.

As now the Internet technology, people can accomplish communication through CMC (Computer Medium Communication). According to Walther(1992) definitions that CMC is a computerized communication tool to proceed communication by synchronous or asynchronous. In a synchronous communication, users have to connect Internet in the same time. They can meet each other on the Internet through texts, pictures or voices such as Video Conference System. It' s not necessary for people to present on line in the same time when they do asynchronous communication. The asynchronous communication tools are quite popular such as E-mail, electronic board or news-group. The collaborative learning can be classified into two kinds when we consider the communication way that group member used. There is no limitation both in time and space for internet communication. The scholars always look forward to doing the collaborative learning actives on the internet. Now it can realize on the Internet and also can practice diversely and exquisitely.

3 The study of GSS and Collaborative learning

Group support systems(GSS) is the information system that contain communications, technology, computer science and decision model. By lowering the communication problem between the members and guided group discussion systematic to improve the efficiency and functional of group missions. GSSs is based on the environment of information technology to support any kind of times, places and mission association of group meeting proceed. The definition of information technology environment contain many different kind constitution of software hardware degree, model any kind of group mission, including communication, plans, brain arousing, solving problems point discussing, negotiator discussion settling conflict and the other kind of group actives.GSSs have five characteristics: anonymity, parallel communication, group memory, coordinate function and medium effect.



The structure of GSS : Nunmaker brought up the the structure of GSS. Group communication interface: With information technology developing, communication can use many different kinds of media, for example letters, oral conversation have different support effects. It also means that different GSSs characteristics need different medium.

In collaborative learning environment, it provides anonymity. The user can show his opinion without explore his ID, therefore he is no need to worry about others view and concentrate on discussion. During these years, the study of GSSs assist collaborative gradually attracts scholars interesting, but the result is not complete. If students using a GSS assist collaborative learning system , they will find it' s better than tradition collaborative learning.

Our system is basically a jungle game. It contains Astronomy and science, Land-organism, Ocean-organism, and Common sense of nature. The system interface include (1) Registration area (2) Role Selecting area (3)Game area (4)Score List (5) Public discussion area (6)Team private area.

4 Conclusion

In the collaborative learning environment, the strategies of GSS can help students improve their learning, the cognition of knowledge, and the ability to deal with problem. The GSS has been proofed to be a useful tool for the teamwork to smoothen the task. It provides a good environment where users can communicate with group efficiently and anonymously. The users can gather more useful information than ever. The information technology has made a lot of progress in these few years. If the characteristics of information technology can be well used by the educators, the students can also learn how to cooperate with each other while they accumulate knowledge.

In the collaborative learning, there is cooperation among members and competition between groups. The members of same group had to learn to solve problem together and get a high score together. The only way to defeat other groups is to stimulate one' s ability and to unite the whole team together. We hope that one day there are full of CAI games of collaborative learning on Internet. Then the children have chances to make friends and to do entertainment while they learn.

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Cooperative Monitoring System using Mobile Agent

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This paper is a study on the design and implementation of the cooperative monitoring system using a mobile agent for an educational portal site. Generally educational portal sites have many addresses of teacher's homepage related education. Therefore, portal site has a very difficult task with maintaining a consistent address of site as well as it is impossible that administration of portal examines all dead sites in searching education site and DB. In order to solve this problem, we designed and implemented a mutual cooperative monitoring system to filter off dead site using a mobile agent. This monitoring system applies to the Korean educational portal site (KEPS) for elementary students and teachers. For efficiency this system, we made an experiment that compared a cooperative monitoring agent system with a stationary monitoring agent system.

Keyword: **Education Portal Site, Cooperative Monitoring System, And Mobile Agent**

1 Introduction

Today, the advent of the web that can easily be connected through the "Internet" is known to be an easy and popular method for teaching and learning. Web-based educational homepages are used in many computer assistance medias and also the numbers of educational sites are on the increase extremely.

An extremely increase in number of homepage raises a question whether a student can search appropriate homepage for learning. In case of finding educational contents using a general searching engines, the searched site can exist an irrelevant contents against a student's request. Moreover the result of searching content fell into learning confusion, because the contents are difficult to apply at learning intact.

In order to overcome this problem, an educational portal site was constructed to gather only educational homepages that had been made several times before. An advantage of educational portal site is that content is used correctly and rapidly in learning because searching site is well constructed. In addition student can easily get suitable contents. For gathering of an educational homepage, an educational portal system, called KEPS, was constructed by the EDUNET and Inchon National University of Education.

While walking past a type of the gathered homepage in KEPS, it can be seen as to make not by an expert institution or a special company but by a teacher and a private person. As a result, characteristic of the homepages have to be petty and is frequently updated. Because the educational homepage can disappear easily, portal site faces difficulty to maintain consistency of the site address. If a hyperlinked address of a portal site is not connected or the retrieval site is disappeared to user, then this portal site may bring discredit to student. In order to maintain consistency of portal, the administrator of portal site must validate all addresses of site. But this examination is impossible work that man completely manages and finds. Consequently, a monitoring of a site address for finding the dead site can be process by an intelligent agent instead of human.

A single agent needs comprehensive amount of time required for the monitoring of a portal site. If a single agent examines extremely a many site addresses, the monitoring work may be inefficient. Because a mobile agent is possible with decentralization and a parallel processing, the monitoring works using a mobile agent can be process effectively [5].

Accordingly, this study designed and implemented a mutual cooperative monitoring system to filter off dead site using a mobile agent. In the following section, the mobile agent and monitoring scheme will be surveyed and the overview of the structure of monitoring agent will be designed. And the next section will be focused on implementation and experimentation of monitoring agent system. Finally the conclusion and future works will be described.

2 Mobile Agent and Cooperative Monitoring

The agent is a program with intelligent characteristics to help the users with the use of computers and take the user's place. The intelligent agent perceives any dynamic stimulation or condition and interprets the data collected for a solution to the problem and exercises reasoning for a final decision. It also acts to change the conditions within its environment in order to perform assigned duties. It has autonomy, social ability, reactivity, pro-activeness and a cooperative relationship, learning, mobility, and so on [9].

Generally an agent divides a kind of two by the mobility, a stationary agent to be executed roles in single system, while the mobile agent is executed at various systems after moving through the networks. An execution example of the mobile agent is shown in figure 1 and the mobile agent based environment is viewed figure 2. The mobile agent server must be installed to act a mobile agent as figure 2.

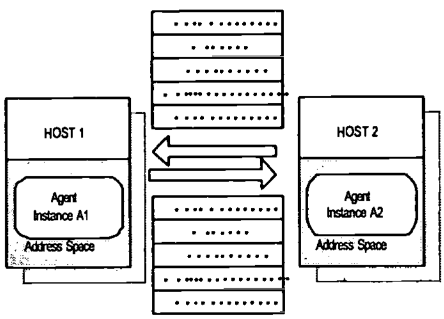

Figure 1. Execution of mobile agent

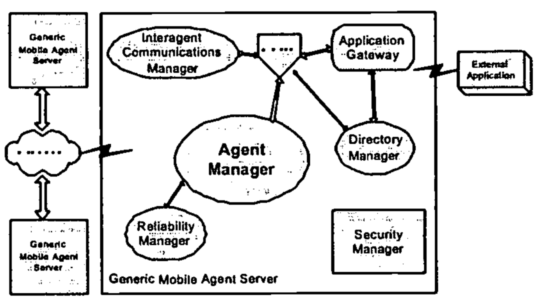

Figure 2. Mobile agent based environment

The mobile agent has a specific characters listed below compared with a stationary agent [5][6].

- The mobile agent reduces the network load.
- The mobile agent overcomes network latency.
- The mobile agent encapsulates protocols.
- The mobile agent executes asynchronously and autonomously.
- The mobile agent adapts dynamically.
- The mobile agent is naturally heterogeneous.
- The mobile agent is robust and fault-tolerant.

In the information retrieval, a monitoring work ascertains a state of gathering sites for the maintenance of data consistency. Generally, because the information of the web is changed frequently, a monitoring job by human is an impossible or inefficient work. This monitoring job can be processed by intelligent a computer program instead of a human. Such a program is called the web robot or an intelligent agent system [10][11].

In case of examining many sites in the monitoring work, if a single agent of the only server processes monitoring work, then the monitoring work may be needed long time and overloading of a monitoring server. The mobile agent has made possible cooperative and speedy monitoring job from distribution and parallel processing [8][11].

3 Cooperative Monitoring System

3.1 Overview of System

Overview of the KEPS system, including the temporary monitoring agent system is shown figure 3.

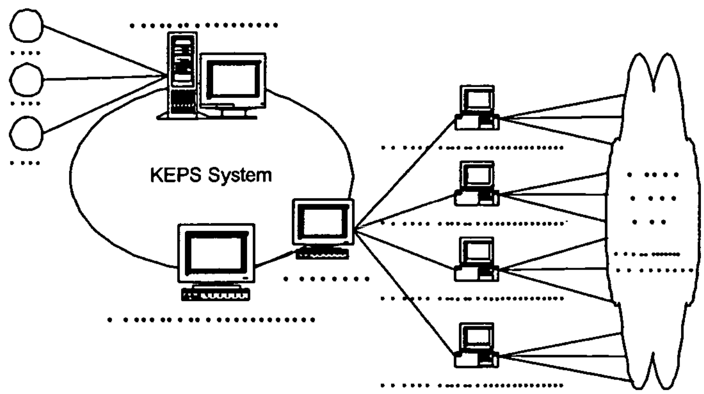

Figure 3. Overview of system

The portal system is consisted of four parts. There are the portal web server (PWS) and the monitoring agent server (MAS), the temporary monitoring server (TMS), a mediator. For using educational portal service, user must be connected with the Portal web server. Gathered address of an educational homepage is supported searching service of an education contents to user through the Portal web server. The Portal web server has searching engine, site DB and a query processor. The monitoring agent server has a stationary monitoring agent and a cooperative mobile agent, error DB, a mobile agent server. Also the monitoring agent server performs works as a creation and an allocation, a control, a gathering of the monitoring mobile agent. For the mobile agent perform it's task fully, each server is installed the mobile agent server necessarily.

The temporary monitoring servers are in existence out the KEPS system. In order to process a fast monitoring work, the TMS have function of distributed and parallel processing. The number of TMS is not fixed but dynamic by amount of monitoring job. Furthermore the TMS is used in temporary palace which mobile agent examines each a state of the registered site. At ordinary times, the TMS is not used usually for examining a state of the registered site. However the TMS can be only used when is requested by the mediator agent server.

The mediator is situated between the monitoring agent server and TMS, and acts as the role of mediation with the mobile agent and servers. All agents and agent servers must be registered in the mediator.

3.2 Design of KEPS System and Cooperative Work

The structure of the KEPS System is detail shown figure 4. The portal web server is consisted of searching engine and query processor, is shared the gathering DB of portal site. The searching engine provides searching service about education content and the query processor is shown the result searching at DB. The monitoring agent server is consisted of inference engine and agent manager, error DB. The monitoring system in monitoring agent server has a stationary agent and a mobile agent for distribution and parallel working. A stationary agent examines the state of gathering site and the confirmation of HTML documents through HTTP connection. After a failure sites are saved at temporary error DB, these will be deleted from site DB of portal web server. A permanent deletion of fail sites is executed by inference engine of the monitoring agent server.

When a monitoring agent server is overloaded or the stationary monitoring agent has difficulty processed by examination with many site, the monitoring agent server requests to the mediator about information of the registered TMS. If the number of the TMS is lacking, the monitoring agent server waits until the TMS becomes sufficient. Having sufficient number of the TMS, the mobile agent is created to divide as a suitable size of address by inference engine. And then the mobile agent has been created by a monitoring agent server, will be cloned with suitable number. Each mobile agent is allocated a monitoring work and will be dispatched to the TMS through ATP connection. The mediator agent can grasp each work states of an agent by using the agent finder.

Each agent is moved to temporary monitoring server and examines the allocated addresses of sites through HTTP. When a mobile agent is finished all checking of sites, it sends to the monitoring agent server with the result of observation. If the job of the mobile agent is occurred some problem, monitoring agent server creates a new mobile agent and re-dispatches to the TMS. All results gathers, result of examination saves at site DB and error DB. Finally, dispatching the agents retracted by the monitoring agent.

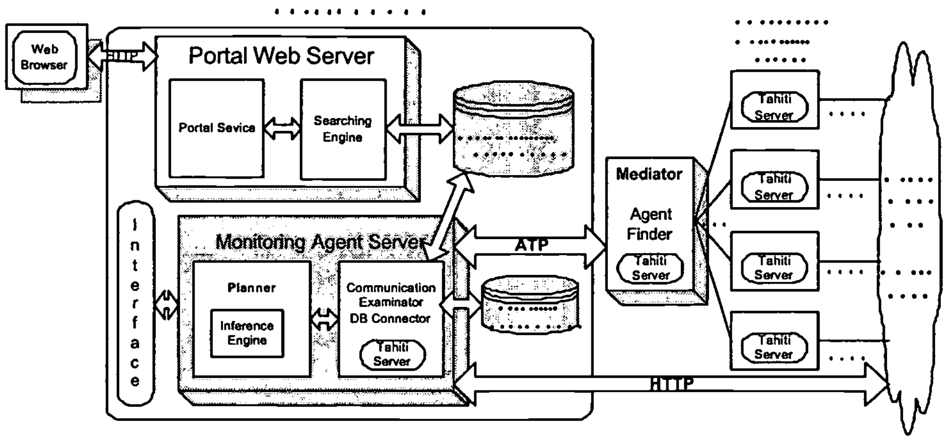

Figure 4. Structure of the KEPS system

The processing algorithm of execution about monitoring working is shown figure 5. The job of monitoring using the mobile agent has advantages that prevent an overloading of a single server and lessen monitoring time by distribution and parallel processing. Because agents are not used stationary server but are dynamically used in other servers, all servers performed share resources of monitoring system. Accordingly, each agent can do cooperative parallel processing using autonomous and society properties of agent.

4 Implementation and Experiment

4.1 Implementation and Application of System

The monitoring agent system proposed in this study was implemented two types. The stationary monitoring agent was implemented by using VC++ and CLIPS. Also the mobile monitoring agent system proposed in this study was implemented using JAVA based Aglet API and JESS. Aglet is the java class library for that can easily design and implement all the properties of the mobile agent. Moreover the Aglet provides with the Tahiti server and Agent finder for helping research of users.

The stationary monitoring agent interacts with the mobile agent of Tahiti server based environment. Inference engine of the stationary monitoring agent was used the CLIPS dynamic linked library and the mobile monitoring agent system was used the JESS class library. The CLIPS and JESS are rule based inference engine and was used to infer planning and allocation of the mobile agent. SQL was used for the gathering DB of portal site. ODBC and JDBC were used to connect the monitoring agent system and the gathering DB of site.

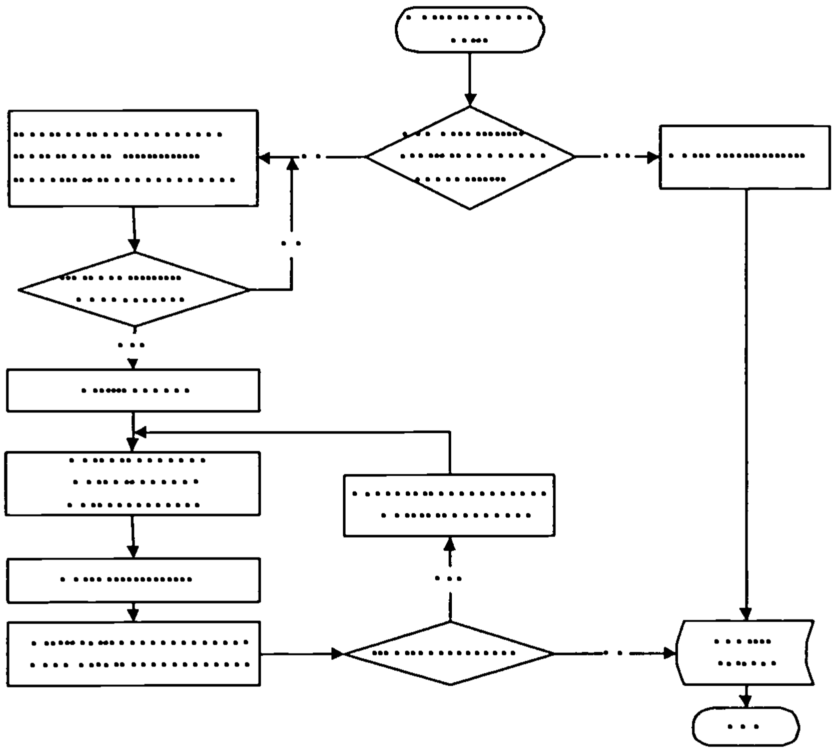

Figure 5. Algorithm of monitoring procedure

Figure 6 below is image of the interface of the stationary monitoring agent by making VC++. Figure is shown that the single monitoring agent is examining each site. The stationary monitoring agent was consisted of three parts mainly. The left screen of figure is represented list that the agent will examine site of DB. Also the center of screen is viewed results of a successful site and the right screen is represented results of a failure site.

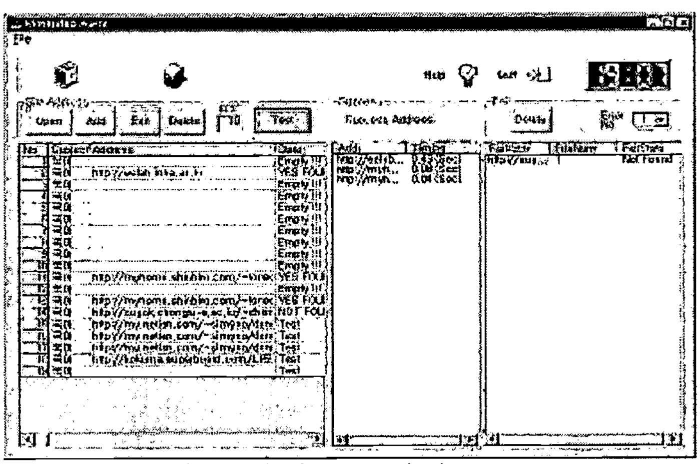

Figure 6. Stationary monitoring agent

Figure 7 is shown screen that the mobile monitoring agent is examining each site with distribution and parallel processing. If the numbers of sites are many in existence, the stationary monitoring agent executes the mobile agents to interact with the Tahiti server as followed image. Above window of figure is represented the stationary monitoring agent. Black screen below is viewed that mobile agent sever is executed by the stationary monitoring agent. Small screen below is shown the Aglet viewer. The Aglet viewer perform an important role as a creation, dialog, dispose, cloning, dispatching, retracting of a mobile agent.

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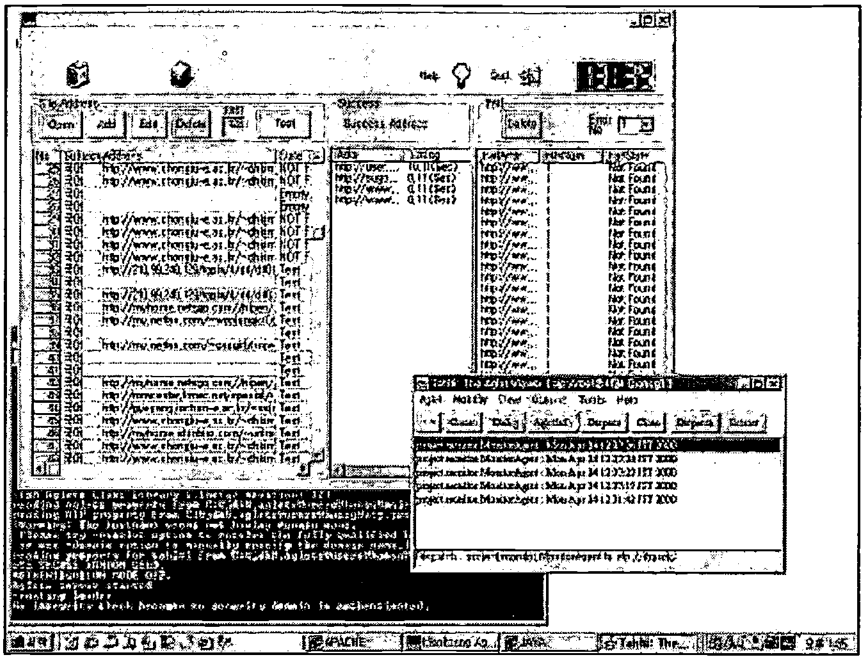

Figure 7. Interaction between stationary monitoring agent and Tahiti server

In order to use the implemented monitoring system in this study, we applied at the educational portal system and the KEPS system in the EDUNET server. Figure 8 is shown the searching screen of the web browser using KEPS system. This portal site in the EDUNET was constructed for the Korean elementary student and teacher. Also this site contains all contents about the curriculum of the Korean elementary school.

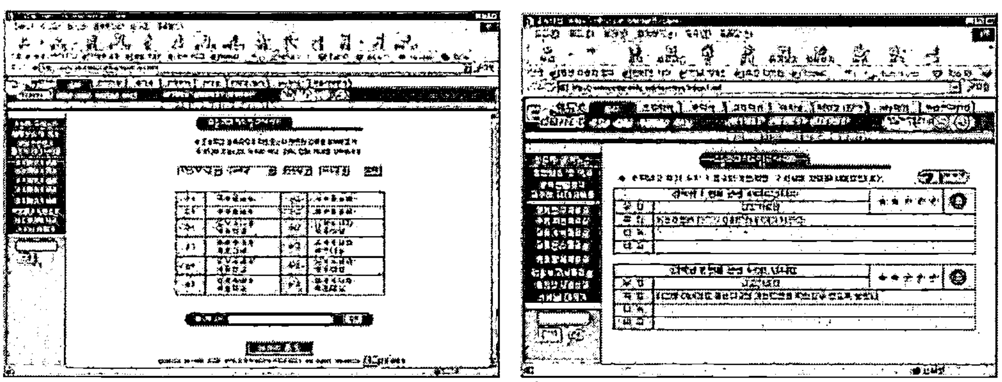

Figure 8. Searching of KEPS system

4.2 Experimental Results

For examining the efficiency of the cooperative monitoring system using the mobile agent, we compared and evaluated a monitoring time of each agent system. A comparative and estimative items listed below are as followed.

- Comparative item
  - *The single stationary monitoring agent vs. the cooperative monitoring agents.*
- Estimative items
  - *The monitoring time of the single monitoring agent*
  - *The monitoring time of the cooperative monitoring agents(3)*
  - *The monitoring time of the cooperative monitoring agents(7)*
  - *The number of sites: 10,30,50,70,90,110,130,150,170,190 ..etc.*

The experiment measures examination time of sites using a comparative and estimative items above. The estimative result is shown Table 1 and is represented figure 9 with form of graph. The horizontal axis of graph is represented the number of site and the vertical axis of graph is represented monitoring time of each agent.

In case of the number of an examine site is small, the result of experiment is viewed that the single stationary agent is faster speed of examination than the mobile monitoring agent. Also, when mobile agent is dispatched to three servers, speed of examination is faster than is dispatched to seven servers. The reason is caused by overtime occurred because the many mobile agents are created, allocated, gathered.

However, the more the number of site increases, the faster the mobile monitoring agent gets speed of checking than the single stationary agent. In particular, when the cooperative monitoring system using many agents, experimental result is shown that a speed of examination is very fast. If a single stationary agent processes very many sites, the result of execution can be useless though the result is very accurate.

Consequently, the cooperative monitoring agent can become higher execution speed by distributed and parallel processing and an overload of network by using a mobile agent can be decreased. If a server has an active environment of the mobile agent, the servers can be used with an active space of a searching agent and a monitoring agent.

Table 1. Result of monitoring time

Number of Agent / Agent Type	10	30	50	70	90	110	130	150	170	190
Stationary Monitoring Agent	42	137	201	261	374	412	518	592	645	743
Mobile Monitoring Agent(3 Servers)	120	132	143	165	221	253	262	282	316	335
Mobile Monitoring Agent(7 Servers)	130	121	124	122	148	143	147	183	186	182

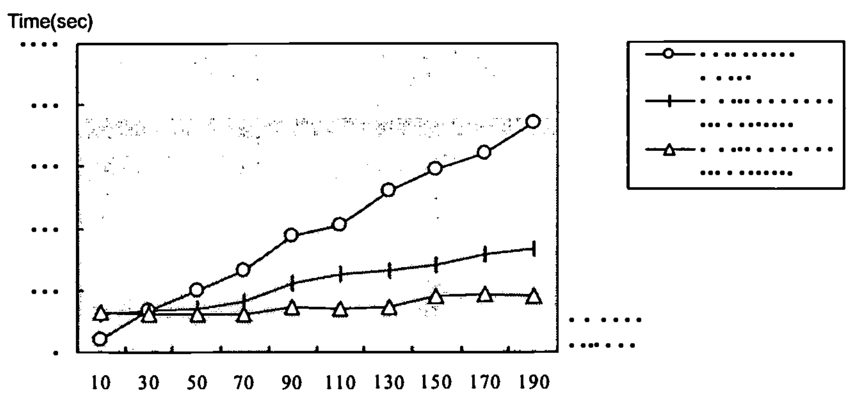

Figure 9. Graph of monitoring result

5 Conclusion and Future works

This study is on the efficiency of cooperative monitoring agent using mobile agent for educational portal site. The monitoring job has been getting difficulty processed by human. Thus, an intelligent agent can process the monitoring of the portal site instead of human. A monitoring work by using a single stationary agent needs long time for checking of many sites.

In order to overcome the problem in this study, the mobile agent is used in monitoring job. The monitoring job of educational portal site can be processed by collaborative method of decentralization and parallel using the mobile agent. The monitoring system was implemented by using the Aglet and Tahiti server. This system could execute cooperative monitoring job through an intelligent interaction between the stationary agent and a mobile agent. Also the KEPS system is possible with the mediation and the registration of agents by using the mediator agent between the monitoring server and the temporary agent sever.

The temporary agent sever is not fixed with the number but can be dynamically changed. Therefore all servers are by resources of monitoring job and each server can exe cute its role by inference.

More studies are required on research that constructs knowledge base for inference engine of the mobile agent. For effective portal site constructed, future work needs researches about not only intelligent monitoring but also intelligent searching and gathering of educational information. In order to interact between the mobile agents, we require research about KQML, language for sharing and exchange of knowledge between agent and agent.

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Designing Extensible Simulation-Oriented Collaborative Virtual Learning Environments

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Theoretical understanding that learners acquire is concretized through exploration and collaboration with other learners as they articulate their understanding and knowledge of the learning domain. Recognizing that knowledge building is a dynamic process that requires learners' active participation, there has been a shift from traditional teacher-centered instruction towards interactive, peer tutoring, as well as simulation-oriented collaborative group learning. Systems that allow users to engage in such activities are increasingly interesting to scientific communities and learning organizations.This paper shows how our system's design leverages off the Model-View-Controller (MVC) architecture to allow developers to share the behaviors and interactions of virtual objects. We also present our approach to partitioning different parts of our system's virtual environment as well as storing and synchronizing virtual worlds such that our system can support unlimited interactivity with virtual objects and encourage user interactions in quasi-immersive online learning communities.

Keywords: **Collaborative learning, virtual reality in education, simulation, experiential learning**

1 Introduction

Constructivist theory, based in part on the results of Piaget's research, is the most widely accepted pedagogical standpoint adopted among teachers today. Constructivism emphasizes the careful study of the learning processes and leverages learners' active participation in problem solving as well as in learning activities that promote creative and critical thinking. Rather than memorizing concepts through iterative rote learning, learners internalize new concepts through exploratory learning and develop their own understanding by integrating newly acquired knowledge with prior knowledge and experience. Peer tutoring among learners and interactions with experts facilitate such learning processes where "knowledge [is] directly experienced, constructed, acted upon, tested, or revised by the learner" [10].

The pedagogical consequence is that learning environments should support and stimulate further growth and development of learners' minds while encouraging learners' autonomy and initiative. This constructivist orientation requires a fresh perspective on the roles of technology in learning. Instead of viewing computers solely as a knowledge presentation device, we can also view them as tools for supporting a pedagogical focus on communications in collaborative learning ventures [4]. Suppose we are able to bring a group of people together to interact in a model of a real environment, then we also have a tool for constructivist learning. Imagine students steering ancient battleships and firing cannon balls at one another in order to explore the concepts of relative velocities and projectile paths. Or perhaps a chemistry class where students can mix and test chemical reactions in the safety of a virtual chemistry laboratory.

A successful Constructivist Learning Design (CLD) should provide familiar environments that reflect the thinking processes of the participants; in such environments there must be trust and public sharing of knowledge in this environment [14]. Moreover, the Across-Schools Pedagogy Issues group [4] endorses the "necessity of large-area networks for particular contexts, instructional goals, and learner characteristics." Injecting constructivism into the educational system culminates in a revolution, from planning for teaching to designing for learning [14] and the "key to reinventing our educational system . . . lies in what our teachers believe about the nature of knowing" [1].

Increasing interest in virtual environments coupled with a recognition of their potential benefits from the use of simulation, experientially-grounded learning, and socialized learning have led to the development of many virtual reality (VR) systems. Working within the constructivist paradigm, we have developed a system that creates virtual collaborative learning environments. Our system supports user interactions that facilitate mutual tutoring and knowledge sharing. The system can be used by academic institutions that offer courses through distance learning, or it may be used as a complementary form of on-line collaborative learning. In particular, these institutions can conduct laboratory classes with visual demonstrations, simulations, and presentations. The system can also be used to create virtual towns where users can interact with one another and coordinate online meetings.

In subsequent sections of this paper, we critically evaluate related applications, present our research focus, and describe one of the virtual worlds in our system to demonstrate how users collaborate and interact in virtual environments. After the virtual world description, we discuss our approach to system design such that it is easily extensible by future developers. Next, we present the basic mechanisms used to implement our virtual environment system. The discussion on system architecture is followed by the conclusion and intended further work for our system.

2 Critique of Related Applications

There have been several attempts to create similar VR environments. *VR for Learning* [6] is based on Couch's multi-user virtual reality system. It is limited in that it does not store its data in a database. Moreover, avatars in the virtual environments are static. They do not adhere to any common structure, and they *float* in the virtual worlds rather than *walk*.

Active Worlds is a proprietary-standard virtual world browser that provides game-like 3D rendering of the world with user-selectable (first-person or third-person) views. In addition to the browser window, *Active Worlds* also comes with a chat window that supports user communications. Mouse- and keyboard-based navigation through virtual worlds is remarkably smooth. However, the joints of *Active Worlds* avatars have far fewer degrees of freedom than that possessed by humans. Hence, the avatars are capable of a smaller repertoire of actions compared to avatars that model humans more accurately.

Community Place, developed by Sony Corporation, is designed to be scalable and to support many "geographically dispersed users, interconnected through low bandwidth, high latency communication links" [5]. However, the chat and whiteboard windows are separated from the navigation window. This increases the semantic distance between the different components of the system.

blaxxun, by blaxxun interactive, has the advantage of using Humanoid Animation 1.0 (HANIM) [13] compliant avatars. However, *blaxxun* lets avatars float instead of walk. Avatars move very quickly, but realism is compromised.

3 Research Focus

In order for our system to benefit as many users as possible, our work is implemented using non-proprietary technology. We developed the system's virtual world browser using Java3D and implemented the other components in Java. Hence, our system is portable to hardware platforms that support Java3D and Java Virtual Machine (JVM). Moreover, the system is designed to support a large number of users while maintaining reasonable performance.

Considerable effort was devoted to designing an engaging interface so that the system is pleasurable to use. This is pertinent because the objective of our system is to help users actively participate in learning environments and not in learning how to use the system. This will encourage users to engage in experiential learning and increase their familiarity with the learning context.

In order to support collaborative learning and to enhance learning experiences, interactions between users and virtual world objects must be supported. Moreover, each object should have unique behaviors and properties, or they should be able to share behaviors and properties with other similar objects in an Object Oriented (OO) fashion. In our system, virtual object states are modified by manipulating components of these virtual models directly. The system processes new object states and updates virtual worlds as well as a database of virtual world states. By storing virtual world states, users can collaborate in discussions that span several login sessions. Similar to most virtual environments, avatars are pertinent for promoting user interactions because they allow users to establish their presence in virtual worlds by creating sensations of "being there."

4 BattleShips World Description

One of the virtual worlds in our system is the *BattleShips* world (Figure 1). This world allows users to explore three physics concepts:

- the time taken for free-falling objects to reach level ground is independent of the objects' masses
- the relative velocity between two moving objects creates the illusion that the objects are moving at different individual speeds
- the trajectories of projectiles are parabolic

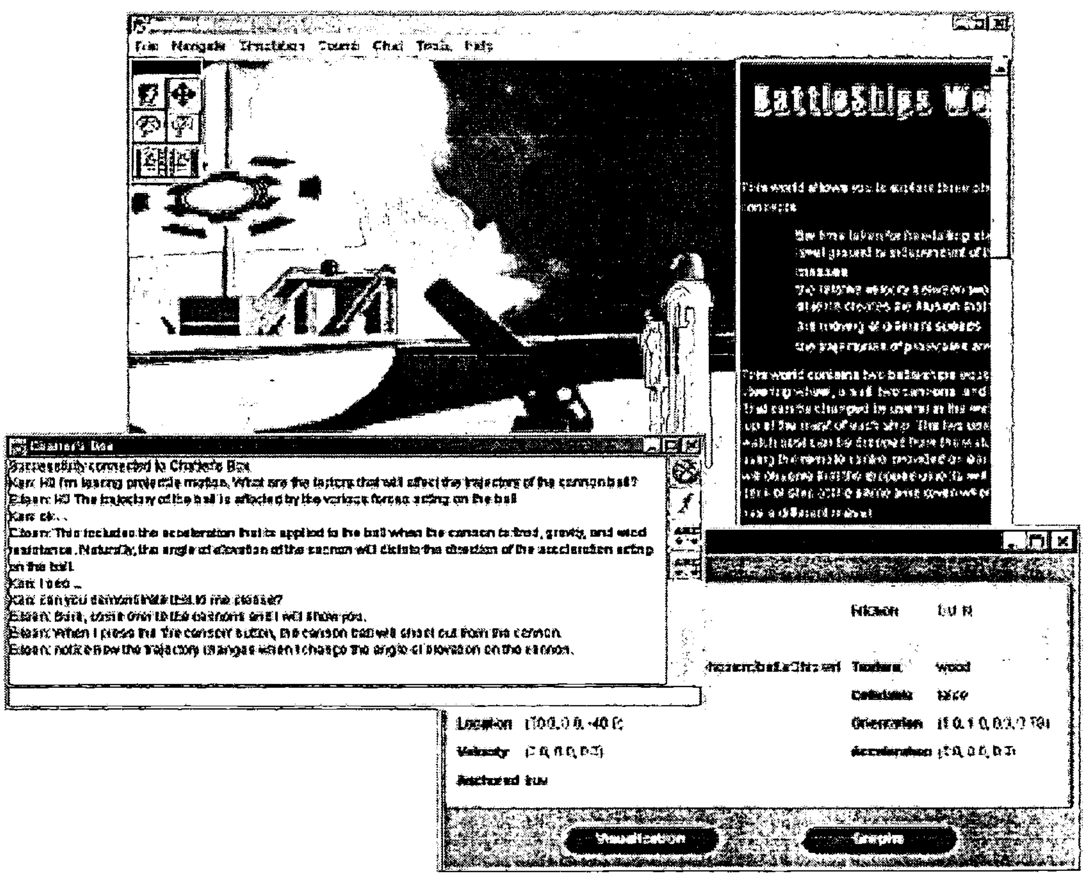

Figure 1 A screen capture of the *BattleShips World* with two cannon balls of different masses falling down towards the cannons

This world contains two battleships equipped with cannons on both sides of each ship. By default, cannon balls from each cannon have different mass. Users can change the mass of a ball by selecting the *Examine* mode on the floating toolbar palette followed by the ball of interest. The system will pop up an *Inspector* window (where users can enter a new mass for the ball) at the position of the mouse click.

One of the battleships has two user-selectable objects in the crow's nest on top of the mast. When users activate the trapdoor at the bottom of the crow's nest by clicking on the remote control button provided, the selected objects will start to fall to the deck of the ship. Users are asked to find the object that will reach the ground in the shortest time given that each object has a different mass. (The heaviest object will reach the ground fastest due to air resistance. This is contrasted with the *VacuumChamber* virtual world where the time taken to reach the ground is independent of the mass of free-falling objects due to the absence of air resistance.)

Users can collaborate in controlling a ship. For example, one user may be navigating the ship to place it in a more strategic firing position (with respect to the other ship) while trying to stay out of the other ship's line of fire. Another user (on the same ship) may control the firing of cannons and the angles of elevation of the cannons. Users can engage in mutual tutoring and knowledge construction by communicating with one another using our system's text-chat facility.

Because both ships are moving, it is necessary to consider the relative velocity between the two ships when navigating and firing the cannons. In addition, trajectories of cannon balls in this virtual world illustrate that projectiles trace a parabolic path in contrast to the early intuitive (but mistaken) belief held by many novices that cannon balls drop vertically near the end of trajectories [7].

5 System Design

Our system is designed to be easily extensible by developers so that virtual worlds supporting new learning activities can be created more efficiently through reuse of existing implementation. Its design adheres to the MVC architecture, hence providing minimally coupled yet cohesive subsystems. In this section, we describe the Model, View, and Controller portions of the system. Following that, we discuss how we use a database to store virtual world states persistently and how events are propagated to other clients in order to maintain virtual world consistency (across different clients).

5.1 Model

In our system, the Model is represented by the *vtalk* package. *vtalk* models virtual objects (*VObject*), virtual worlds (*VWorld*), and laws that can be applied to each *VObject* and *VWorld*.

5.2 Virtual Object

Every virtual object (*VObject*) in our system is modeled as an OO class. This design allows virtual objects to inherit and share properties as well as behaviors easily. In this manner, objects can be placed in new virtual worlds and behave according to the conditions of the new worlds. For example, consider a virtual world where users are placed on a planet with lower gravity (compared to the Earth). Users can choose to insert a cannon into the virtual world (even though there are initially no cannons in this virtual world) and fire the cannon to observe the trajectory of the cannon ball. The main challenge, however, is to classify a potentially infinite number of objects into an extensible taxonomy. Our approach to the taxonomy is to categorize objects into *Living* and *NonLiving* things. The taxonomy for *Living* things is well defined by Parker [8].

On the other hand, the taxonomy for *NonLiving* things depends on the context in which the objects are placed. As such, *NonLiving* objects are classified according to generic behaviors (such as moving when a force is applied to it) and properties. For example, billiard balls, golf balls, bowling balls are placed as subclasses of the *Ball* class. This classification of *NonLiving* things is developed in the context of the scope of our intended experiments and is not meant to encompass all possible scenarios.

In order to minimize coupling, the Model communicates with the other parts of the system via messages encapsulated into events. Consequently, behaviors of each object generate events (such as velocity changed) that are propagated to the virtual world that contains the object and other Views (typically represented by a virtual world browser) rendering the object.

Virtual worlds (*VWorld*) are managers of *VObjects*. A virtual world delegates events generated by objects that the world contains, responds to events using implemented laws (such as Newton's Laws of Motion), and routes events to affected *VObjects* as well as the network component of the system. Each *VWorld* presents a rich set of cohesive simulations where users can modify attributes of virtual objects and observe the effects. For example, when users change the texture of a billiard table, a billiard ball on the table will be observed to roll at a different speed (compared to the speed before the change) when the users hit the ball with a cue stick.

5.3 Laws

Laws are implemented separately from *VObjects* and *VWorlds* because different laws are applicable to *VObjects* depending on the learning objectives (determined by *VWorld*). The consequence of incorporating laws in virtual worlds is that laws cannot be shared across virtual worlds. On the other hand, embedding laws within *VObjects* may result in ambiguity of applicable laws as well as prohibit sharing of laws. Hence, the separation of laws from *VObjects* and *VWorlds* allows *VWorlds* to determine applicable laws and the priority of laws to resolve conflicts.

5.4 View

A View denotes the portion of the system that listens for events. This approach allows the system to present different representations of the same model, for example a 3D virtual environment and a 2D plan view of the 3D environment. Currently, our system has one View component, *VBrowser*. Consider a cannon ball fired from a cannon, the ball will generate high-level events that inform *VBrowser* that its velocity and acceleration have changed. Subsequently, the view will apply Newton's Laws of Linear Motion at every uniform interval to compute the new location, velocity, and acceleration of the ball. The laws can be applied independently of the world containing the virtual objects.

Collision detection is necessary for most virtual environments especially in simulation-oriented systems. Ideally, collision detection should be implemented in the Model. However, only *VBrowser* has access to geometric data of all virtual objects necessary to compute collision accurately. For these reasons, our system detects collisions by leveraging off collision detection mechanisms available through the graphics engine of *VBrowser* [12]. When *VBrowser* detects collisions, it generates events of the collisions and routes them to the virtual world where the collisions occurred. Virtual worlds would then handle the collisions according to the implemented laws of each world.

5.5 Controller

Users generally interact with the Model using a Controller. Because users interact with virtual objects through direct manipulations, the Controller's interface is part of *VBrowser*'s interface. For example, users navigate through virtual environments by dragging the mouse across *VBrowser* (representing the View). However, the engine that handles the mouse movements is part of the Controller. In this case, the Controller updates the Model, and the Model, in turn, generates events that are received by *VBrowser*. *VBrowser* would then update the View presented to users.

Our system supports direct manipulation of objects such that users interact with the objects they see in virtual worlds directly. Because the types of possible (and logical) object interactions depend on the virtual world containing the object, introducing the allowed interaction types into the Controller or View would couple these two components undesirably to the Model.

In view of this, Controllers convey user intentions of manipulating objects to the Model which then decides the appropriate interaction types and pops up a toolbar containing valid actions that can be taken next to the object of interest. Users can then select the desired action (from the toolbar) to perform.

5.6 Network

The network component of our system propagates events from virtual worlds in order to synchronize worlds on different clients and to update the database storing virtual world states. However, if all virtual world events are propagated to other clients, the events will be "bounced" from client to client indefinitely. For example, when client A sends an event denoting that the location of object 1 is changed, this event will be sent to client B. Client B updates its copy of object 1, thus triggering off another location changed event. This event would then be propagated back to client A, and so on.

Although this event looping situation can be circumvented by tagging every event with the originating client, a better design is to send only high-level events that result directly from user interaction. For example, a user moves a stick to strike a ball. The location changes of the stick (as the user manipulates it) are sent to all clients in the same world. However, events of collision between the stick and ball as well as subsequent location changes of the ball due to this collision are *not* propagated. It is not necessary to propagate such events because every client is able to detect the collision and handle the subsequent ball movements locally. This is similar to the dead-reckoning technique. As a result, bandwidth requirements are reduced because "update packets can be transmitted at lower-than-frame-rate frequencies" [9].

5.7 Database

The relational database in our system is used to store virtual world states and other data necessary to facilitate restoration of virtual worlds. Using the Java Reflection API and object serialization [11], we designed the database to handle objects of new virtual object classes without requiring any modification in the database code. As a result, other developers can create new virtual objects, by extending available virtual objects, without implementing ways to store the new objects.

In interactive collaborative virtual environments, two or more users may attempt to grab the same virtual object at the same time. By leveraging off concurrency control mechanisms of the relational database, our system prevents concurrent attempts by multiple users to grab the same virtual object through the use of "ownership" data in every virtual object's database tuple. A user who holds an object is considered to be the "owner" of the object until the user releases the object [9].

On the other hand, a user may attempt to grab an object that is already held (virtually) by another user. However, this scenario is unlikely to occur with the exception of virtual worlds where such actions are appropriate because socially acceptable norms discourage users from "snatching" other users' objects.

5.8 Flow of Events

Figure 2 illustrates a typical scenario representing the flow of control and events when the system is running.

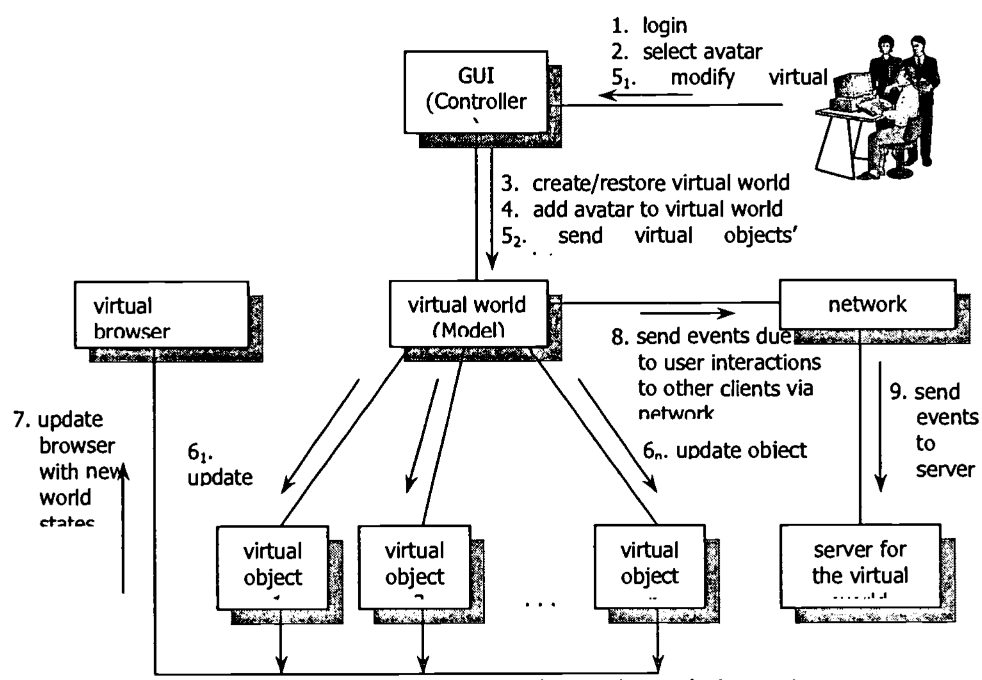

Figure 2 Flow of control and events in a typical scenario

When users interact with the objects in virtual worlds (Model), the Controller sends events to notify the associated virtual world of attribute changes. At the same time, the Controller also sends these events to other client machines via the network in order to synchronize virtual worlds on all clients. Every event is tagged with the time that the event occurred so that the order of events is preserved and consistent across all client machines. Because each client may have a different local time (such as in the case of client machines in different time zones), our system synchronizes the time of an event with the server's time.

The virtual world on every client machine will propagate the events encapsulating the changes to the virtual objects concerned. Upon receiving such events, the virtual objects will process these events representing the necessary updates and route the events to event listeners; that is objects that indicate interest in receiving virtual object events.

Finally, the View will interpret the events it receives from the Model and render the necessary changes by updating the geometric representations of all affected virtual objects.

6 System Architecture

In this section, we describe the basic mechanisms that we used to implement our system. We adopt a client-server architecture where there are multiple servers, with each server catering to several client machines (Figure 3). Although the system's server programs currently execute on one Sun workstation only, these programs can potentially reside on different physical workstations to support scaling beyond the processing power of one workstation.

Our system architecture is similar to the RING system [2]. Unlike the RING system, however, the servers in our system do not communicate directly with one another (although they share the same repository for virtual world states) because each server in our system handles only events from client machines in the same virtual world. Moreover, server programs may be hosted on different machines to distribute workload. When a user logs on to the system, the Controller retrieves the current states of the virtual world where the user is located from the database using JDBC. Using these states, the Controller instantiates the Model to represent the virtual world and all objects within the world. The Model then generates events to the listeners. One instance of a listener is the View (or *VBrowser*) that renders the virtual world as an interactive 3D environment on the monitor.

If the current states of the virtual world into which a user has entered are not available either due to a disconnected network or the fact that the world is newly created, then the virtual world is built locally according to the default layout of the world. If the world is new, then the Model will update the database with the default states of the virtual world. On the other hand, if the network is unavailable, the system is still functional because *vtalk* package's virtual network (*VNetwork*) is able to simulate the existence of a network connection. Hence, users can still engage in learning activities in virtual worlds in single-user mode. Changes made to objects in this mode are, however, not saved.

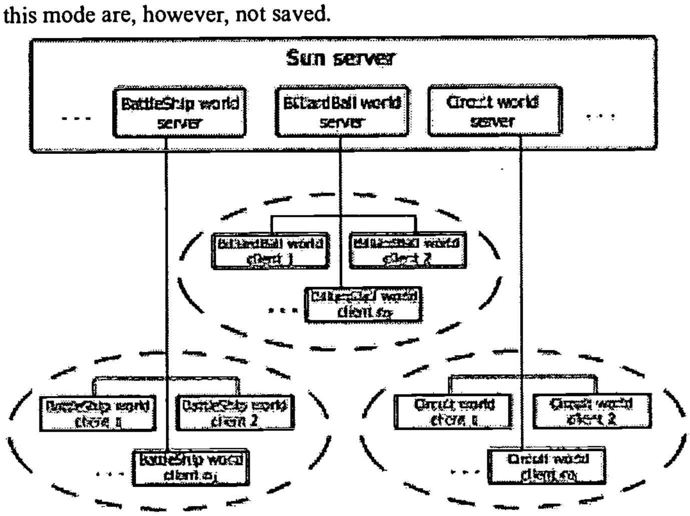

Figure 3 System architecture showing connections between virtual world servers and clients

The View of our system's virtual environment is generated using Java3D while the interfaces are created using Java Swing. The View is driven by events that are generated by virtual worlds and objects. Typically, these events are generic attribute changes (such as change in velocity) that affect the rendered view directly.

A possible event generation implementation is to use the Java Observer/Observable classes. Although these classes resemble the example code written by Gamma et al. [3], the Observer/Observable approach has the following disadvantages [15]:

- In order for event listeners to make use of the Observer/Observable classes, the classes modeling the event listeners have to be subclasses of the Observable class. However, it is usually difficult to meet this requirement because Java does not support multiple inheritance and the listeners may be subclasses of other classes already.
- Programmers need to understand details of how the update handler methods work.

Hence, the event generation mechanism of our system is based on the MVC architecture instead. Using this mechanism, each object that generates events stores its own list of event listeners [15]. When the attribute of an object changes, the object generates an event and routes it to every event listener in its list of listeners. Event listeners can be added and removed dynamically at run-time. As such, our system can create multiple views of the same model simultaneously. For example, it is useful to represent virtual worlds as 3D environments and also as a 2D plan view to aid navigation through large virtual worlds.

7 Conclusions

In this paper, we have explained the design of our simulation-oriented collaborative virtual environment based on the MVC architecture. We presented a description of our system's *BattleShips* virtual world where learners can explore physics-related concepts in an engaging and immersive fashion through interaction with objects in the world. Moreover, learners can participate in constructive online discussions as part of a learning community using our text-based chat facility. We further showed how different behaviors and laws can be shared and extended among virtual worlds and objects in an OO fashion. We also explained how our system is designed to support the addition of new virtual objects with minimal changes to the network and database. Finally, we presented the underlying system architecture of our current system to support collaborative learning distributed over geographic locations.

Our future work will include letting users see the actions and gestures of other users so that less time and effort is spent on prefatory remarks in online discussion (using text-chat). We will explore network topologies that afford greater scalability. We also intend to implement automatic distribution of load among several workstations and conduct formative and summative user evaluations.

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Development of the Web-based classroom system to be implemented by the teachers

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The Japanese ministry of Education made an announcement that a new curriculum "Information and Computer" will be introduced nation-wide in Japan from the year 2002. Accordingly, all the schools have been rushing to deploy the personal computers and prepared to connect to the Internet through 2001. While the scope of this project aims at covering 40000 or more schools, there exists the two major problems: 1) The number of teachers who have expertise in handle the PC and the Internet, are too far short in proportion to the number required. 2) Dial-up networking prevents the students from having access to the Internet any time when they want. With a view to overcoming these problems, we have designed and developed the Intranet system or "micro Internet for classroom: mIc". The "mIc" is developed and designed to incorporate the various functions such as web-mail, electronic bulletin board "BBS", mailing list, search engine, web video conference and etc. Since "mls" consist of Microsoft Active Server Pages (ASP), it can be used from Web browsers and custom-tailored at ease.

Keywords: **Intranet, Collaboration, Video-conference, BBS**

1 Introduction

The Japanese ministry of Education made an announcement that a new curriculum "Information and Computer" will be introduced nation-wide in Japan at both the elementary school and the junior high school in 2003 and at the high school in 2002 respectively. Accordingly, all the schools have been rushing to deploy the personal computers and are prepared to connect to the Internet through 2001. While the PC have been gradually and extensively, it seems quite obvious that far small number of the teachers can handle the PC and the Internet to the contrary.

The Minister of Education has been sending the computer engineers or other computer technical personnel to school since 1994 with a view to training the teachers about the computer and the Internet. They are also required to see to it that both the teachers and the students can implement the PC and the Internet smoothly without any problems. Additionally, The Ministry has been initiating their own training programs for the teachers as well. While the project is supposed to cover 40000 schools or more, it has been experiencing the extreme difficulties of the shortage in the engineers and the technical staffs to reach out all the teachers in 4000 schools or more. It has been experiencing the difficulties as well as that Dial-up networking prevents the students from having access to the Internet any time when they want.

Despite these difficulties, it seems quite viable that all the students will get accustomed to the computer and the Internet at the earliest convenience. We, therefore, have designed and developed the Intranet System(micro Internet for classroom: mIc)

2 Design of mIc

This system "mIc" is developed and designed for both the teachers with least knowledge about the PC and the Internet, and the students as well to learn the various functions.

(a) Simulation of the Internet.
We are of an opinion that the E-mail and Electronic Bulleting Board shall be viable tools for "collaboration" among the students. Should the students require any information from the Internet, the search engine shall be inevitable to learn as well. We, therefore, have designed to incorporate these functions in the system. The teachers simply use the system without any other programs and the students can experience those functions as if they were connected to the Internet.

(b) Web-based easy operation.
The teachers can use "mIc" from Web browser. Therefore, should the teachers use the system, they can create new BBS, mailing list and registration of the students on Web based. As far as the teachers will use solely "mIc", the profound knowledge about the Internet server and the program of CGI is not necessary.

(c) Customization.
The curriculum of "Information and Computers" varies depending on the computers deployed ,the network system applied, and the objective of the education for PC & the internet in each school respectively. The system "mIc" can be customized by merely changing the text-files.

3 Structure of mIc

Considering the Standardizing the server of the average school environment, "mIc" will be installed in WindowsNT server or Window98. Please take note that less than 10 people can work with Window98 simultaneously.

3.1 ASP and COM

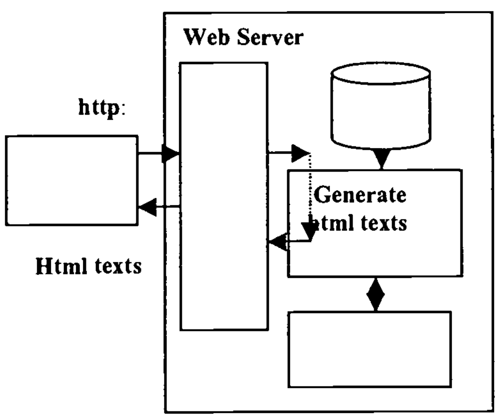

Figure 1: The Action of ASP

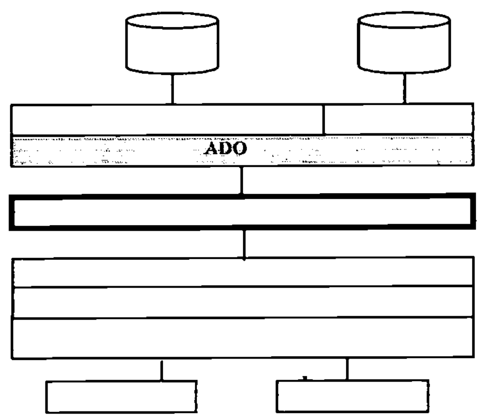

Figure 2: The structure of mIc

The system "mIc" consists of Microsoft Active Server Pages(ASP) which is the server-side execution environment. The ASP can run scripts and Component Object Model(COM) on the server . It can also easily create the dynamic contents and the powerful Web-based applications. The COM is the Microsoft software architecture that allows application to be built from binary software components. Windows itself and many other applications such as WORD, EXCEL and etc. are consisted of the COM.

Figure 1 shows the process of "mlc". ASP files appears to be the same as the HTML files but it includes additionally VBscripts or Javascripts, which call COM. At first, a browser makes a request to the server to send an ASP file in such a manner as to the HTML file. Secondly, the server executes ASP file and Bvscripts or Javascripts At last, the server send these to a browser. By using ASP, a browser only interprets common HTML without executing scripts in the client environment. Figure 2 shows the structure of "mlc". We have applied to some COM, which have access to a database, a browser, files, and a mail server. ADO is the database access COM and the system uses Microsoft Access or SQL Server.

3.2 Setup of mlc

The system "mlc" can be easily installed by simply copying the ASP files in such a manner as for HTLM files .The teacher will be required to edit the "mlc"' configuration file which contains such information as URL, the install path and etc. Should a teacher wish to display some comments enabling the students to take note for their reference, he simply input the comments in the text-file corresponding to the exact page. The "mlc" can build more than one system in one server by creating more than one data base file.

4 System function

The functions of "mlc" will be detailed as follows;

4.1 Registration

The teachers can register the students with the use of browser. They can register even many number of students at once with the use of EXCEL or ACCESS. If the teachers will use BBS and E-mail via other programs than "mlc", they will be required to register newly each time they change the application.

4.2 System Menu

Three different user modes are available in the menu , one for a teacher , one for students and one for a guest respectively. The teacher can customize the menu for each mode. Should the teacher not use the mailing list, he can simply edit the configuration file to turn off the flag of the mailing list and the menu eventually will not display the button of the mailing list.

4.3 Web mail

The system "mlc" has two different Web mail modes whose user interface are the same , the one simulation mode and the other SMTP/POP3 mode. While the simulation mode will not actually allow to send or receive mails via the Internet, it will allow to simulate the mail functions without the mail server. Should you have the mail server and use the SMTP/POP3 mode, it will allow to send or receive mails via the Internet as the regular web mail.

4.4 Electronic bulletin board (BBS)

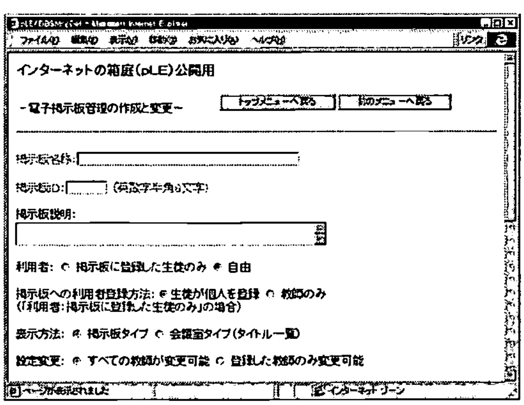

Figure 3: Screen image of Defining BBS

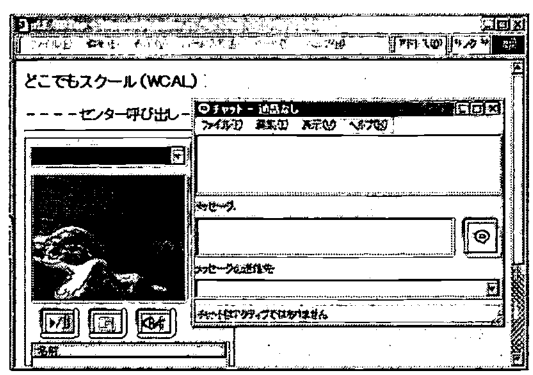

Figure 4: Screen image of Video conference

The system "mlc" allows to set up more than one bulletin board. Should the teacher wish to create a new BBS, he will be required to simply define the BBS on the browser and no new program will be necessary(Figure 3). "mlc" allows to set up the users' list covering the users who can have the access only in the BBS. The users' list can be selected in accordance with the student attribution such as Class , Group and etc.

4.5 Mailing list

The operation of the mailing list will follow the same manners as mentioned above for BBS.

4.6 Search engine

Since "mIc" has a directory service like "YAHOO" , the teachers and the students can add any new URL to the directory for their reference. If "mIc" is installed in WindowsNT server with Microsoft Index Server, the text-matching search engine can be used. The attention is drawn that "build-up of HP" has become one of the most important curriculum in Japan . The student can register their own HP's in the directory of "mls" and can subsequently search them in the classroom.

4.7 Web Video conference

Since the Video conference is very efficient and effective tool in term of the international communication, we have designed to incorporate the function "Web Video conference" in the system so as to suffice in this respect(Figure 4). A student can communicate with other students and visualize them via web video conference and refer to the data interactively via web data conference. Data conference allow the students to collaborate on "chat", "whiteboard" and "program sharing" without Video and Audio. Since the web videoconference is based on Microsoft Netmeeting 3.0 Active X, the multipoint data conference is possible and thus more than one student can participate the meeting simultaneously.

4.8 Generator of the questionnaire

Understanding strongly the importance of the questionnaire so as collect of the opinion from the students for various topics, "mIc" is designed to generate automatically the questionnaire in the form of HTML and ASP files. The teacher can easily make these files by filling in to the points raised as question on the web pages . The form filled in by the students can be saved to the text file in the form of the spreadsheet such as Excel.

5 Further development(future work)

We have already started to introduce the system"mIc" at schools ranging from the junior high school through the university . Having learnt from the experience, it seems very obvious that the teachers can make BBS and use search engines at ease. Through the continued experiments, we are prepared to improve the system further.

mIc Web Site (In Japanese)
URL www.jona.or.jp/~gohome

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Do they do as they say? An exploration of the gap between the discourse and the application of socio-constructivist principles of pre-service teachers using ICTs.

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The purpose of this short paper is to present the preliminary results of our exploratory research concerning the impact of information and computer technologies (ICTs) on students' perception about their role as future elementary school teach ers. More specifically, we are trying to determine which factors, when ICTs are used as instructional support, are likely to facilitate the shift from a teacher-centered approach to a more genuine learner-centered approach. Using student interventions in telediscussions and the pedagogical scenarios as data sources, we outlined two general trends. First, students who demonstrate critical thinking abilities in telediscussions are more likely to apply successfully their constructivist values and beliefs in their productions of integrative scenarios. Secondly, students who do not support their opinion in the telediscussions will be less able to apply constructivist principles to their productions, where the learners are truly at the centre of their learning.

Keywords : **On-line education, teaching and learning processes, pre-service teacher education, socio-cons tructivism**

1 Introduction

The purpose of this short paper is to present the preliminary results of our exploratory research concerning the impact of information and computer technologies (ICTs) on students' perception about their role as future elementary school teachers. More specifically, we are trying to determine which factors, when ICTs are used as instructional support, are likely to facilitate the shift from a teacher-centred approach to a more genuine learner-centred approach. To do so, we are using, as data sources, the student interventions in telediscussions and the pedagogical scenarios (hereafter integrative scenarios) that were produced on the web.

2 Context

Students registered in our teacher education programme have to take a minimum of two courses about the integration of ICTs in the classroom. The first course (ETA1700) is a general overview of the various technologies that could be integrated in a given learning environment. The final assignment consists of producing, as a team, a complete and fully working integrative scenario that will be available on the Web, for the benefit of their colleagues and the teaching community. To develop their scenarios, the students have access to our instructional model that favours a scaffolding strategy. The creation of the scenario includes the following steps : needs analysis, development of the content, selection of a learning approach and the development of a lesson plan. In a socio-constructivist approach, students are free to choose the subject-matter, the grade level, the pedagogical approach, the teaching tools and medium. As the teams develop their integrative scenarios, individual members are invited to participate in telediscussions. For the course ETA1700, four themes are provided : the impact of ICTs on society, the effective use of ICTs in educational settings, the changing role of teachers and learners and continuing education of teachers. Since learning to use the technology is a sub-goal of the course, students are requested to make at least one contribution for each theme, as well as offer one reply to one of their colleague.

The second course, PED2000, is a full year course, offered to second or third year students and mostly at a distance. Team members are free to meet as they please. Using the same scaffolding approach, students have to produce a more comprehensive scenario for a situation of their choice. However, prior to designing their scenario, students have to contact an in-service teacher who will let the students conduct their intervention in his or her classroom. The field experiment allows the teams to conduct a formative evaluation of their project. PED2000 students also have access to electronic forums of discussion, with the difference that no themes have been pre-determined. It is the students who create and launch topics of discussion. An on-line tutor is available to guide the students in their creative process.

3 Description of the project

3.1 Object of research

As we mentioned earlier, our goal is to understand better the perceptions that students might have about the impact of technology on their future role as elementary school teachers. Ultimately, the research results will be used to improve an to enrich our scaffolding approach, in order to help the students not only discuss the socio-constructivists principles but adopt them in practice. To do so, we explored the links between the discourse held in the telediscussions and the application of the principles in the integrative scenarios.

3.2 Sampling

For this paper, we used only the one of the multiple sections of the ETA1700 course. We selected four integrative scenarios representing 18 students, who contributed 80 messages on the two relevant themes (perception about the role of the teacher and effective use of ICTs in the classroom). Since our goal is to explore the factors influencing the application of socio-constructivist principles, we retained the projects that demonstrated some interdisciplinary and collaborative flavour.

3.3. Criteria for analysis

3.3.1 Integrative scenarios

To assess the students' perceptions about their changing role as teachers, we referred to some of the criteria described in Viens (1993) [1], as well as the general constructivist principles (Lave & Wenger, 1991; Brown, Collins & Duguid, 1989) [2] [3]. Even though we used a Likert scale to evaluate each criterium, our intention was not to cumulate frequencies. We rather used the scales to guide our critical analysis of the constructivist aspects of each scenario. Consequently, the results are more descriptive in nature.

The criteria are as follows :

Learning strategies . Notwithstanding the specific learning strategy to be used, we assessed whether the learner's during the instructional strategy was « directed », « guided », « rather guided », or «free ».

Team work. We examined whether the students planned to have their learners work individually, in teams but to conduct a fragmented task, or in teams to conduct a collaborative and collective task.
Content. Did the students determine a specific content or did they leave it completely opened for their learners to decide of their subject, as it is usually done in project-based learning?
Pedagogical goals. Aside from the usual well-stipulated instructional goals, did the students add other learning objectives such as transversal competencies? To what extent did they consider incidental learning?
Interdisciplinary. Did the students focus on one subject matter or did they use the opportunity to integrate several disciplines?
It is to be noted that all criteria were considered simultaneously in order to assess the global constructivist flavour of each scenario.

3.3.2 Forums

For the forums we proceeded differently. First, we focused on two aspects : the positive/negative attitude toward the ICTs. Secondly, we looked at the perception of the teacher's role. In addition, we attempted to assess the student's capacity to reflect critically, that is we observed whether the students were able to develop and support their thoughts rather than merely contributing an unsubstantiated opinion (Quellmaz, 1987; Ennis, 1987) [4] [5].

4 Preliminary results

4.1 Forums

Attitude towards ICTs

After conducting the preliminary analysis of the telediscussions for the course ETA1700, we noticed that the students positions about the integration ICTs in the classroom are not radical as one might expect. The majority seems relatively sensitive and cautious about technologies. In fact, several interventions were concerned about the fact that the computer will never replace the teacher and that the human factor is essential for the development of the pupils. In other words, aspects such as empathy, communication, emotional support are still essential for the learners development.

Perceptions of the role of the teacher

After listing all relevant interventions, we noted three recurrent themes that could constitute categories. Some interventions directly mentioned the role of the teacher, whereas others were more or less related to the topic, but still touched on the perceptions of the teacher's role. The third group of interventions were concerned about more specific tasks of the teacher. We chose to use these categories to present the results about the perceptions.

Although not all interventions under the theme « Perception of the role as teacher » referred directly to the subject, it is interesting to discover that the perception of the role is indeed changing. The students did mention that the ICTs will help shift from a traditional role of « content deliverer » to one that assumes more guidance, more facilitation. Terms such as « facilitator », « animator », « councillor », « advisor » were used relatively frequently. However, we discovered that the students limited their intervention at the opinion level. They only named or listed the role without providing an explanation or a definition of what they meant by « facilitator » for example. Furthermore, they did not establish a priori what they view as a « traditional role ». Very few went as far as mentioning « content deliverer » or « lecturer ». In other words, students talk about the changing role without defining their assumptions. No one proceeded to compare and contrast the two positions or provide an illustration to support their thought. Indeed, the participants merely identified keywords and did not attempt to engage in a more critical discussion.

Some interventions were also addressing the issue of the changing role, but indirectly. Some students talked about the fact, for example, that the ICTs will provide the opportunity for the pupils to be more active in their learning process. Here, the guiding role of the teacher is implied in the discussion. Participants mention the possibility that ICTs will encourage the active construction process and consequently, will contribute to a more significant learning experience. In fact, in those indirect interventions, the learners are considered to be at the centre of their learning, actively engaged in the construction of their own knowledge and experience.

In sum, those students seem to think that ICTs can be used to favour collaboration between the learners as long as the learners' needs are respected. It seemed that participants perceive the ICTs as an integrated tool to teaching that favours self-learning.

The same group of students also discussed a specific aspect of teaching that will be affected by the technology : the impact of a broader access to information. Some students recognise the fact that a wider access to information will bring new tasks for their learners. One student mentioned that their pupils will have to « clarify their own research goals, define their information seeking strategy, make choices in the information, and sort the information ». This type of anticipation regarding « transversal » competencies was certainly an interesting discovery.

However, the same students who demonstrated their critical thinking abilities, still perceived themselves as the authority figure for their students. In fact, they mentioned that it will be their responsibility to assess the quality of information gathered on the Web as well as to judge the relevance of the source. Instead of making the link between the role of guide or facilitator as it would be expected in a constructivist fashion, it seems that the higher cognitive skills required, such as analysis and evaluation, will remain in the mind of future teachers, as their own territory.

4.1 Integrative scenarios

Two interesting trends have been identified in this analysis. First, the students who are more able to support their opinions by providing examples, using the literature, explaining their thoughts, seem to be more capable of producing a scenario that uses a genuine constructivist approach. In fact, if all the constructivist criteria are applied whenever it is reasonable to do so, the tone used to describe the learning activity is more opened, more respectful of both the freedom of the teacher and the learners. Here, we noticed that teams who produced a constructivist integrative scenario, were constituted of at least two members who demonstrated critical thinking abilities.

In the second trend, it seems that the students who claim that the role of the teacher is changing but who do not support their opinion, do not apply their values and perceptions in their integrative scenarios. In the telediscussions, they claim to be constructivist, but they fail to transfer their thoughts in practice. As we anticipated, the majority of the scenarios produced were meant to be constructivist. Some teams for example, will have their students work in teams but in a fragmented fashion (individual students will provide parts that will make a whole); the content will be determined and not opened for change; the learner will be rather guided in the learning process.

Two sources or information reveal the lesser constructivist approach : the instructional goal statement and the description of the lesson plan. Statements of the instructional goals in those scenarios tend to be highly fragmented, clearly measurable, well stated. Often, the students will refer to the Ministère de l' éducation du Québec programme to write the goals. There is no reformulation of the goals to suit their situation or needs. Also, there is no interpretation or critical analysis or re-evaluation of the goals. The students just take them as they come.

The design of the lesson plan is another indicator that a scenario mi ght not represent a good application of constructivist principles. Lessons plans tend to be very organised and directed as well. The outcomes, ensuing the instructional goals, are well planned. In fact, the pre-service teachers, remain perfectly in control of the predetermined outcomes. Despite their good intentions, the students remain in control of the learning process. The steps are not only too well defined, that are also not flexible. The outcomes of the intervention using ICTs are still pre-determined and nothing else, that is no incidental learning is considered.

5 Conclusions

In this exploratory research we highlighted two trends. Students who demonstrate critical thinking abilities in telediscussions are more likely to apply successfully their values and beliefs in their productions of integrative scenarios. Secondly, students who do not support their opinion in the telediscussions will be less able to apply the constructivist principles to their productions. They will remain in control of their pupils' learning. The next logical step will be to determine how we could support the development of critical thinking skills in the telediscussions, in order to encourage a better transfer of the socio-constructivist principles to the development of integrative scenarios.

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For example:

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Domain Specific Information Clearinghouses – A Resource Sharing Framework for Learners

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The World Wide Web has presented researchers and learners all over the world with unprecedented opportunities to find and distribute information. An increasing number of valuable resources are made available online. This provides an excellent knowledge base for learners. However it is often very difficult to find these useful resources. This paper describes the framework of a domain specific information clearinghouse and how these clearinghouses can collaborate with one another to enable cross-domain learning. The resources in a domain-specific clearinghouse are submitted by trusted domain experts to ensure its quality. Learners with multiple domain interests can also effectively retrieve the information they need using the cross-domain collaboration framework presented. This is achieved with a union agent that manages the collaboration and sharing of resources between different domains. We also present a toolkit that facilitates the rapid deployment of such clearinghouses by domain experts.

Keywords: **Collaborative Learning, Educational Agent, Knowledge Construction and Navigation, Web-Based Learning, Domain Specific Information Clearinghouse**

1 Introduction

The tremendous success of the Internet and the World Wide Web has resulted in a global information revolution. With more and more information easily available online, people are now increasingly reliant on the Web for their information needs. They are constantly faced with the problem of finding relevant information that will suit their learning needs. Most commonly used tools for finding information, in particular search engines and Web directories, often return huge amounts of information which are neither useful nor relevant to the learners' needs. A more effective way of assisting these learners in finding information is lacking.

A possible solution would be the use of a domain-specific information clearinghouse managed by human domain experts. In a nutshell, a *Domain Specfic Information Clearinghouse*, or *DSIC*, is a Web-based clearinghouse and resource repository for information resources available on the Web. Learners would be able to find relevant and higher quality information from these resources. However, most information and research nowadays do not dwell on a single domain. Cross-domain learning requirements need to be met. This can be achieved through collaboration between multiple DSICs. With this cross-domain collaboration, we are able to discover and learn more about how each domain is related to one another.

In the following sections we will discuss the various approaches that are currently adopted by learners and the concept of the Domain Specific Information Clearinghouse. Section 4 describes the framework of a Domain Specific Information Clearinghouse network to facilitate cross-domain learning. In Section 5, we describe a toolkit currently under development for the quick deployment of a domain-specific information clearinghouse. Finally, we would conclude with Section 6.

2 Current Approaches for Finding Information Online

The primary means by which learners find information on the Web are tools like search engines, Web directories and metasearch engines [1] [5].

Search engines operate by plowing through the Internet and indexing web pages. Typically, only keywords are indexed. Some examples of search engines are AltaVista[1] and Hotbot[2]. Using this method, a lot of information can be retrieved. However, there is a trade off between quantity and quality. In this huge list of results, though it may contain many relevant items, most of the search results are usually irrelevant. Learners will lose a lot of time following useless links.

Web directories like Yahoo![3] and Excite[4] are maintained manually by a dedicated group of catalogers. These directories contain user-submitted resources that are indexed categorically. These indices are usually human-created or computer-generated. They would usually include some description that helps the user in determining the usefulness of the resource. As the resources contained by Web directories are user-submitted, there is the problem of scalability: it is impossible to scale personnel to match the rate at which the Web is growing. Web directories are outdated rapidly due to the ever changing and ever growing Internet. Important resources for the different categories and topics are often missing.

Metasearch engines are web tools that poll multiple sources like search engines and Web directories. The compiled resources are then processed and returned as results to the user. Metacrawler[5] and SavvySearch[6] are examples of metasearch engines. However, as pointed out in [4], although metasearch engines can significantly increase coverage, they are still limited by the engines they use with respect to the number and quality of results.

After looking at the above approaches, the problem of finding relevant and useful resources is not solved. Although these approaches may be adequate for a casual Web user, they do not serve learners who require specific information from certain domains well. We shall discuss our proposed solution in the next section.

3 Domain Specific Information Clearinghouse

Figure 1 below depicts the DSIC model.

[1] http://www.altavista.com
[2] http://www.hotbot.com
[3] http://www.yahoo.com
[4] http://www.excite.com
[5] http://www.metacrawler.com
[6] http://www.savvysearch.com

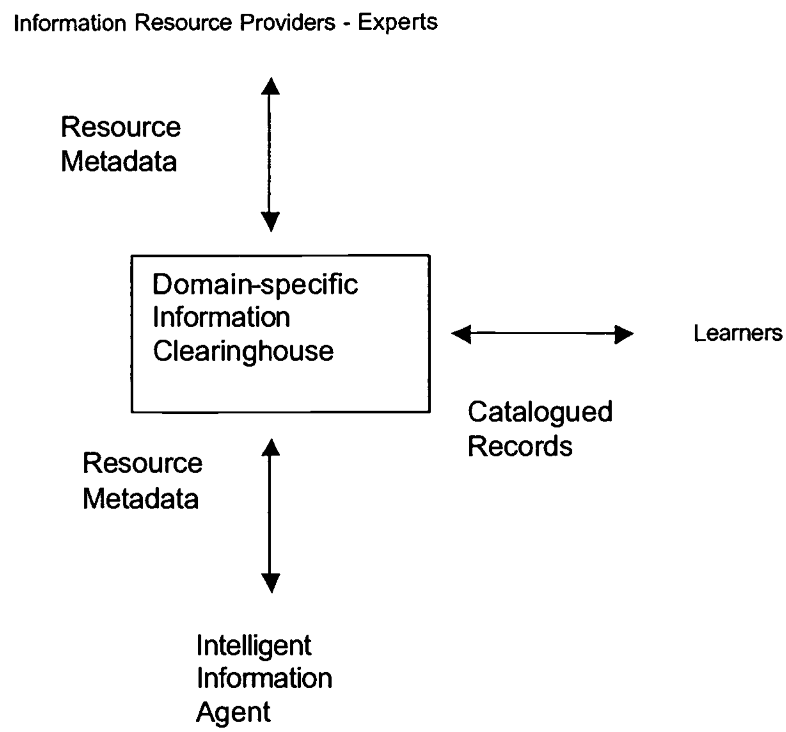

Figure 1: Domain-Specific Information Clearinghouse Model

As mentioned earlier, a Domain Specific Information Clearinghouse is a web-based clearinghouse and resource repository for domain-specific resources available on the web. One or more domain experts maintain the resources found in the clearinghouse. From now on, we will refer to *experts* as people who supply information to the clearinghouse and *learners* as people who access the clearinghouse for information.

The clearinghouse contains a classification of topics found in the domain and an intelligent information agent. With a good classification, the clearinghouse would be better organized and would increase learners' ease in finding the information they want. An intelligent information agent should be made available to facilitate the knowledge sharing and exchange both within and outside the clearinghouse.

An expert registers with the clearinghouse as a trusted information provider. He will then be able to submit resources that are in turn classified and cataloged. Using information found in these submitted resources, the intelligent information agent could scour the Web for more resources that can be added into the clearinghouse. The quality of these resources is much higher as they are being submitted by domain experts. What is useful and relevant to these experts are also usually useful to the learners as well. With all these information clearly classified, learners can then search or browse through the resource collection effectively in the domain specific clearinghouse.

4 Cross-Domain Learning

The DSIC caters to the needs of experts and learners in a single domain. However, learners often have not just one but multiple domains of interest. It would be useful for a learner with multiple domains of interest to be able to find the information he needs across all the different domains. Moreover, there are often no clear boundaries between domains, as the figure below shows. Resources from different but related domains may overlap.

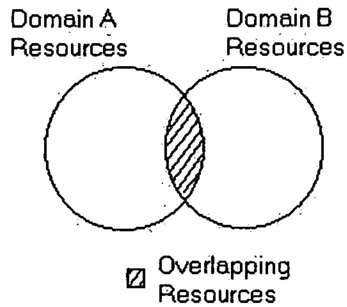

Figure 2: Overlapping Domain Resources

This potentially allows for different DSICs to collaborate and share resources with each other. To provide such a resource sharing framework, two issues needs to be addressed: distributed service and metadata exchange.

4.1 Distributed Service

The proposed framework for collaboration between multiple DSICs is essentially a distributed service. Domain experts maintaining each individual clearinghouse would register it with the *information union agent*, which is a central service that keeps track of all the existing clearinghouses that has been set up. This is illustrated in Figure 3 as follows:

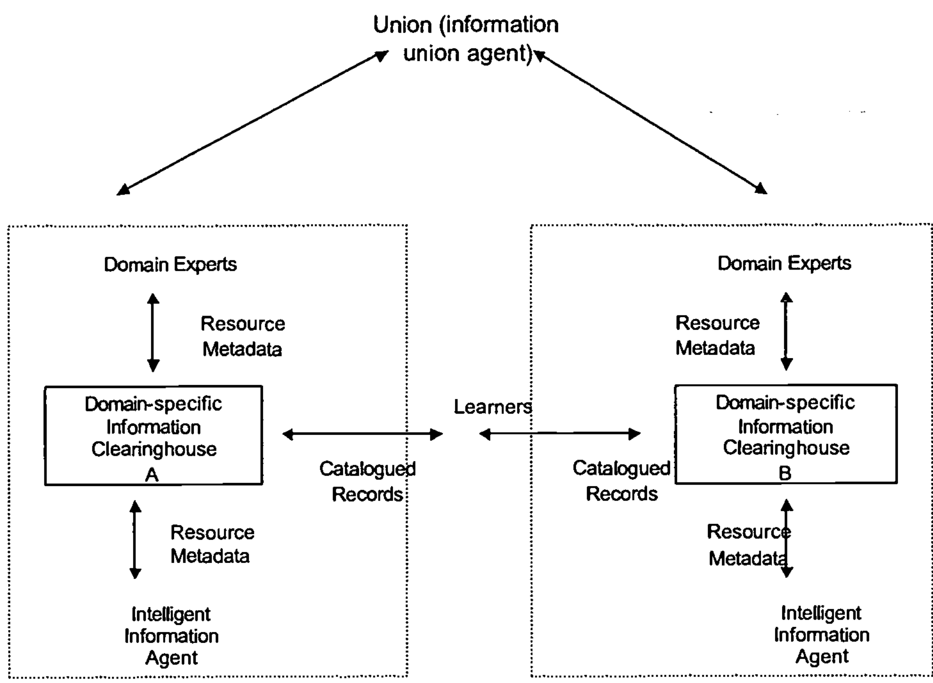

Figure 3: Multiple Domain Resource Sharing

Upon registration with the information union agent, each clearinghouse would declare the metadata attributes that are used to describe resources in that particular clearinghouse. Relationships with other domain clearinghouses are also declared. This information is then broadcasted to all the clearinghouses in the union to facilitate metadata exchange, which will be discussed in section 4.2

Besides maintaining the relationship links between the different domains, the information union agent would also apply data mining techniques to learn and discover relationships between resources in the different domains. For example, when the number of similar resources that are found in two different categories of different domains exceed a threshold value, the union agent would automatically update the union with this relationship if it has not already done so. Through this process, the union agent can learn and discover new information and relationships between different clearinghouses in the union and update the respective clearinghouses with the new information. This allows the clearinghouses to provide learners with higher quality information.

4.2 Metadata Exchange

A DSIC union needs to provide a mechanism to facilitate the exchange of machine-understandable information among different DSICs. Being domain specific, each DSIC has its own set of metadata attributes and values. A mechanism needs to be provided for a DSIC to automatically interpret metadata that comes from another DSIC of a different domain and transform it to a human-readable form. This problem is non-trivial because classification schemes and metadata formats can vary widely between different DSICs.

The *Resource Description Framework* [7], or *RDF*, is an evolving specification developed by the World Wide Web Consortium. RDF's nucleus is an archetype for depicting named properties and their values. The properties are representations of resource attributes as well as the relationships between resources. This data model provides a syntax-independent means of representing RDF expressions.

We have developed a mechanism adapted from the RDF standard that would suit the needs of the DSIC union. We called this mechanism the *Metadata Schema*.

A metadata schema is simply a set of attribute names that is used to describe all the resources cataloged in a particular DSIC uniformly. Each DSIC is associated with exactly one metadata schema at any one time.

A metadata schema is unambiguously represented by an ordered n-tuple of the form

$$< N_1, N_2, N_3, \ldots, N_n >$$

In the above notation, each N_i, $i \in \{ 1, 2, 3, \ldots, n \}$ can be any sequence of alphanumeric characters, including spaces, that starts with a letter. Usually, these would correspond to attribute names such as "Author", "Company", "Description" and "E-mail Address".

The Metadata Schema, together with the information union agent, are the main mechanisms for interoperability between different DSICs. The following scenario illustrates how the Metadata Schema is being used.

A learner using a particular DSIC X to search for information can indicate that he wants to cross-search another DSIC Y. Through the union agent described in Section 4.1, DSIC X would already know the Metadata Schema of DSIC Y and would request DSIC Y for metadata records that correspond to the user's search request. DSIC Y would then respond with a set of results of the form

$$R = \{ R_1, R_2, R_3, \ldots, R_m \}$$

where each R_i, $i \in \{ 1, 2, 3, \ldots, m \}$ is an ordered n-tuple of the form

$$<V_1, V_2, V_3, \ldots, V_n>$$

Each element in the set R is then mapped to the known Metadata Schema of DSIC Y, after which the results are formatted and displayed by DSIC X.

The above scenario can be extended to more than 2 DSICs by simply requesting metadata tuples from each DSIC in turn. In this way, the DSIC union can be regarded as a single, distributed service with multiple access points, providing high quality cross-domain information to learners seeking such information.

5 An Example

An example of a domain specific information clearinghouse is the Simulation/Gaming eXchange [6]. This is a clearinghouse for resources in the simulation and gaming domain. Most of the resources in the clearinghouse are submitted by domain experts and are of high quality. Some entries are submitted by the *SGX Information Agent*, a software agent which uses techniques found in [2] and [3] to scour the Web and retrieve resource related to those submitted by the domain experts. A typical entry in [6] is show in Figure 4.

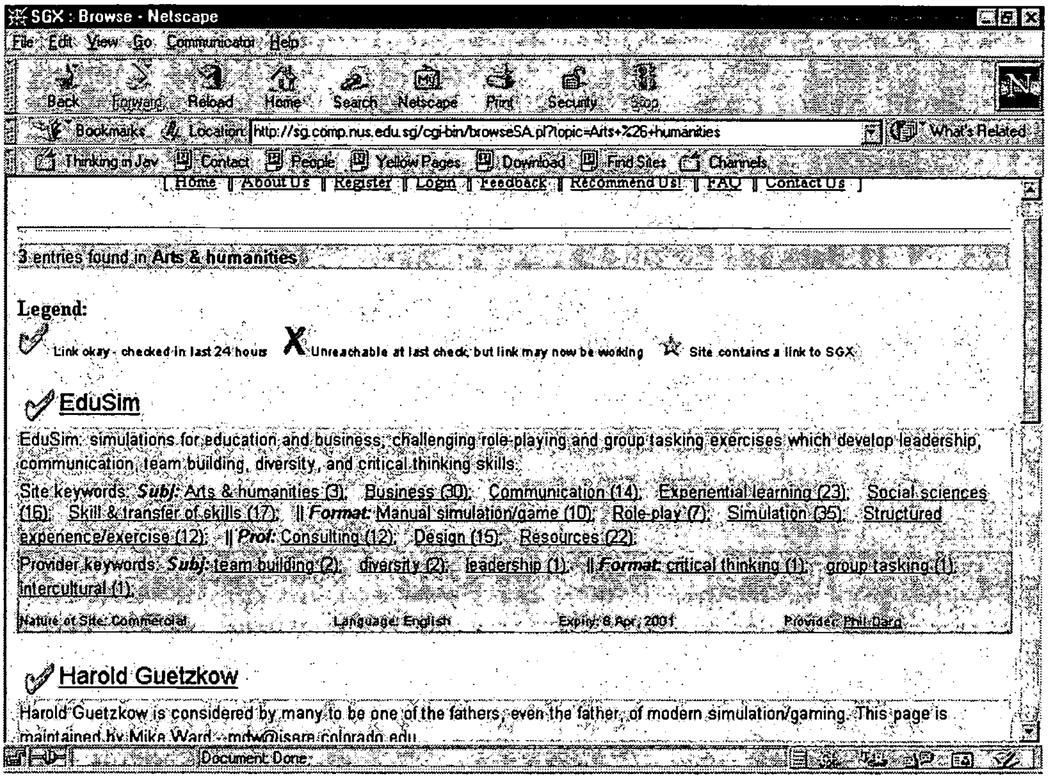

Figure 4: The Simulation/Gaming eXchange

Assuming that there is another information clearinghouse in the domain of CAI. This information clearinghouse also has its list of classifications and resources that have been submitted by experts. Upon registration into the union, the CAI clearinghouse will identify its relationship and links with the other clearinghouses that are already in the union. In this case, the CAI clearinghouse has to determine its relationship with the simulation/gaming domain. Some of the overlapping regions between CAI and simulation/gaming include edutainment, the use of simulations and virtual reality in learning. These resources can be applied to both the simulation/gaming domain and CAI domain when simulation/gaming is used as a tool in teaching using computers

Both CAI and simulation/gaming experts have submitted resources to their respective domain-specific information clearinghouses. Some of these resources are similar and will overlap each other. Using the overlapping regions as a starting point, the information agent in each clearinghouse will collaborate by sharing the resources they have. When a learner searches for virtual reality related resources in the CAI domain clearinghouse, he will be prompted that more resources are available in the simulation/gaming domain. He will also be linked and directed to these resources found in the simulation/gaming information domain. In this way, more resources can be retrieved without compromising on the quality of the results. This is very useful for learners with multiple domain interests. Furthermore, learners are also able to see how other domains relate to his domain interest. This sharing is done with the help of the union agent.

6 DSIC Toolkit

Although different domain specific information clearinghouses catalog resources in different domains, they have the same main functionality as follows:

- **Registration** – Users can register as information resource providers via online forms
- **Catalog** – Registered domain experts can login to the system and catalog resources. In addition, an automated information agent is used to gather resources from the Web automatically. Authors are identified by the agent and invited to refine the catalog of their own resources.
- **Browse** – Web users can browse through the resources cataloged in the clearinghouse using the classification scheme employed
- **Feedback** – A feedback mechanism must be provided for users to give feedback to the DSIC administrator
- **Administration** – An authorized administrator is allowed to make administrative changes to the system as an administrator

These similarities in different clearinghouses provide the foundation for the development of a generic, flexible toolkit for the rapid deployment of a domain-specific information clearinghouse. Domain experts with little or no Web development expertise but wish to deploy and maintain an information clearinghouse can make use of this toolkit to rapidly set up one.

The DSIC toolkit is designed as an integrated package with the following components:

- Web server
- Classification Scheme Editor
- HTML Template Editor
- Administration Module
- User Module
- Information Agent Module

A set of default templates are provided together with the toolkit so that a domain expert who wishes to set up a clearinghouse can selectively use the components of the toolkit and set it up in a short time span instead of having to start from scratch.

7 Conclusions

In this paper we have proposed a framework that allows learners to collaborate and share resources. With the use of domain specific information clearinghouses, learners are able to find useful, valuable and related resources. The clearinghouse union is a mechanism that allows different domains to come together and share their resources. This is especially useful for researchers and learners who have multiple domain interests. They are able to find resources across the different domains without compromising on the quality of the results.

Knowledge discovery and sharing is also made possible with the help of the union agent that overlooks all the domain clearinghouses in the union. The union agent not only helps learners retrieve related resources in other domains but also searches through the huge databank of resources to find hidden relationships about the different domains, giving us information on how different domains are linked and related to one another.

Finally, we also presented a clearinghouse toolkit currently under development for the rapid deployment of an information clearinghouse. Through the use of the toolkit, domain experts can quickly specify a classification scheme and set up a clearinghouse. The newly deployed clearinghouse is automatically registered with the union and start sharing resources with other clearinghouses already in the union.

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Everything in Moderation? Developing successful collaborative projects between European initial teacher education students

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Computer mediated collaborative projects have the potential to strengthen the European Dimension in teacher education whilst giving students an appropriate context to develop their computing and collaborative skills. This paper evaluates the success of such a project through the completion of a three-year action research enquiry involving student teachers from four European countries. The results of three cycles of development are presented. The project was evaluated using student questionnaire data, participation in tutor meetings, and analysis of students' web page development and bulletin board contributions. Results suggest that successful collaborative project work depends on ease of access to reliable computer networks, giving equal weighting to resource production and levels of international communication, and effective moderation of the project by all tutors involved. The paper concludes by detailing future developments in European cooperation involving the partner institutions. These developments involve using the Ecoschool communication networks to discuss pedagogic and multi-media design issues involved in a cross-curricular CD-ROM which has been developed by the same group of partner institutions.

Keywords: **computer mediated communication, European co-operation, moderation.**

1 Introduction

This paper reviews a three-year cycle of telematics curriculum development and action-research in initial teacher education. The project has been made possible by funding via the SOCRATES European Module ECOSCHOOL (1997-2000). The project has two aims; to develop learning by using the World Wide Web (WWW) and email across Europe, and to learn about the social and economic aspects of the participant's home city. The outcomes of the project include the creation of a collaborative open learning course that teacher education students can follow as part of their training.

The Ecoschool developments originated from European collaboration on the EUROLAND project (1996-99). It brings together partners from Austria, England, Finland and the Netherlands in building the European Dimension into the curriculum of schools and teacher education courses (Hudson et al, 1997 and Hudson et al, 1999). Teacher education institutions and departments lead both projects in close collaboration with partner schools and teachers in each country. The resources that have been produced by both the Ecoschool and Euroland projects have been used as the basis for the development of pedagogic approaches with teachers on intensive in-service training courses, which have been supported under the Comenius 3.2 Action of SOCRATES.

The paper reports on four aspects of the Ecoschool project; the three year cycle of curriculum development, the tutor and student evaluation of the project, lessons learned regarding telematics pedagogy, and future developments that link the outcomes of the Euroland and Ecoschool projects.

1.1 Participants in the project

The participants are primary teacher education students from Linz and Sheffield together with students on an international teacher education course at Oulu. A more recent partner to this development is the University of Darlana in Sweden. This has led to the participation of a group of social studies student teachers from Falun in Sweden. English was used as the medium for communication and a total of eighty five students took part over the three years.

1.2 Collaboration and communication

A key aim of the project has been to promote the European Dimension and the use of Information and Communications Technology (ICT) in teacher education across Europe. The development of the European Dimension provides ample justification for collaborative communication but such projects can also reflect sound pedagogic principles. The pedagogical approach is based on a socio-cultural communicative perspective, which owes much to the works of Vygotsky (1987). Collaborative learning is at the heart of the Ecoschool project and has been used during the three cycles of student work. Many authors, including Hudson (1998) and English and Yazdani (1999) see such an approach as essential in developing students' learning skills when using ICT or learning without the aid of new technology.

2 Use of new technologies

The resources and tools being used are university email communications and the resources provided by the ProTo environment at the University of Oulu – *Project Learning Tools on the Web*. This is an open learning environment that has been developed at the University of Oulu. Students can access the ProTo system via the World Wide Web. They have a password that allows them to create simple web pages and enter messages on a bulletin board. Students also created web pages using Netscape Composer and posted them on their home pages. In cycle three they used an electronic bulletin board as well as using ProTo and email.

Use of such technology is now a key focus in the education of teachers across Europe. Student teachers in England and Wales follow the National Curriculum for Initial Teacher Training (DfEE 1998). This curriculum requires students to show evidence of using and creating multi-media presentations, and of using web technologies to communicate with colleagues. In addition, recently published guidance detailing an ICT primary school curriculum (QCA, 1998), suggests that children aged ten should be able to design and evaluate simple multi-media presentations, and children aged eight should be able to take part in an email exchange. Clearly student teachers need the confidence and skills to develop these abilities in their pupils. The Ecoschool gives students this experience through their participation in a computer mediated collaborative project and by their evaluation of its potential use in their future educational roles.

2.1 Pedagogic approaches

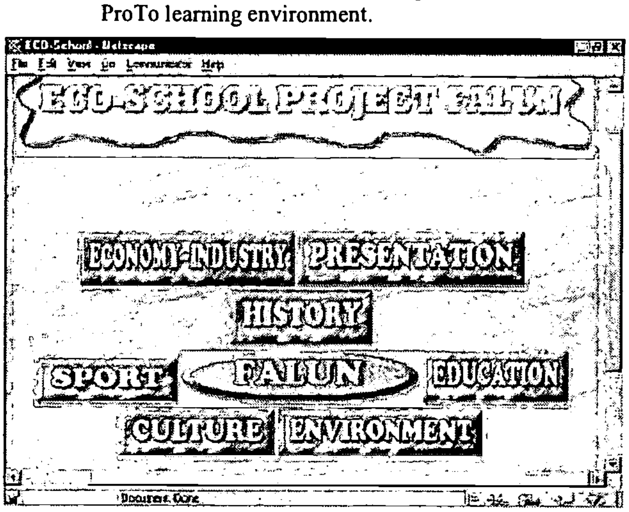
As previously stated the Ecoschool project uses a pedagogic approach that seeks to promote learning through 'electronic talk' in collaborative groups. These groups use a plan, do and review strategy as proposed by Kolb (1984) in his model of experiential education and by Schon (1987) describing the planning cycle used by reflective teachers and learners. The groups planned the construction of webpages, constructed and evaluated their own pages and those of other groups, then finally evaluated the whole project. Tutors developed their own pedagogy of distance learning during the project. The success of the tutors' approaches are analysed using guidance developed by McGee and Boyd (1995) to facilitate dialogue during computer mediated communication.

3 The three cycles of curriculum development

3.1 Cycle One

Focus : comparing students' home cities
Outcomes: web pages explaining local city

Figure 1: Work from the Swedish students posted to the ProTo learning environment.



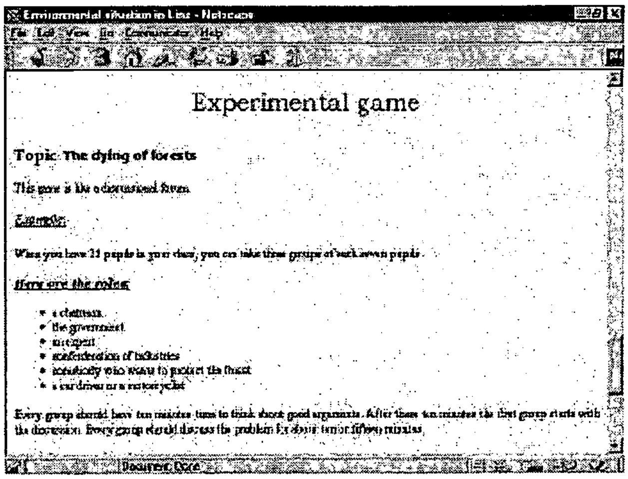
Students in each country worked in collaborative groups to produce a short illustrated report on one of the following aspects of their home city. This involved a general description of the city, an explanation of the environmental situation and the employment structure of the city, and an analysis of the regional or national education system.

Subsequently they presented these reports as web pages by writing them in to the ProTo learning environment. Figure 1 shows a page produced by the Swedish students. They also emailed their work to other students in the partner countries who were presenting the same topic. Once all web pages were complete, they read their partner's pages, asked questions and made comments about them on the bulletin board. Each group evaluated their work using the same criteria designed by the tutors in each country. The tutors then read each group's pages, assessed the pages and provided feedback to the each group. The students' work was assessed against the criteria and graded A to C. The tutors posted written feedback on the bulletin board.

3.2 Cycle Two

Focus : Comparing lesson planning
Outcomes: web pages giving examples of lesson plans

Figure 2: Teaching and learning about the environment in Lin

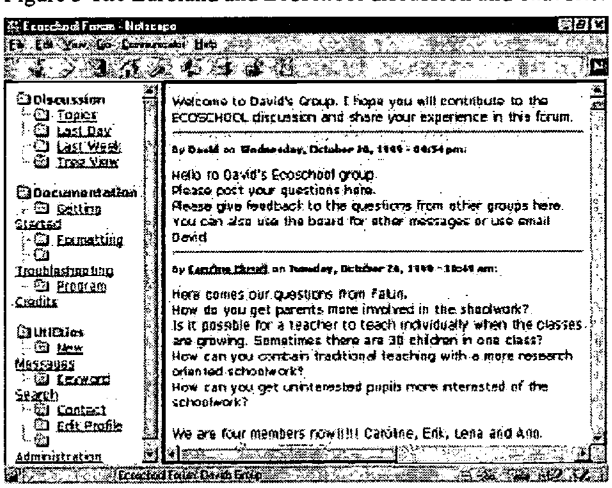


The aim of this round of co-operation was for students to share lesson plans and teaching ideas. Each group of students planned lessons with the aim of children learning more about their local town or city. Again, students presented these as web pages on the ProTo system or, in the case of the Swedish students, on their university home pages. Each group of students again evaluated the pages of their partner groups, responded to each other's questions, and received feedback from the tutors in each country. Students' work was again assessed.

3.3 Cycle Three

Focus: suggesting and solving educational problems
Outcomes: range of solutions to five educational problems

Figure 3 The Euroland and Ecoschool discussion and chat site.



The Ecoschool project ran during autumn 1999 with several new developments. The students were in internationally composed groups rather than from one single country and the focus of the project was to choose an educational problem and present a solution to this by co-operating using ICT. The students could use email, create their own web pages, use ProTo2 (a more sophisticated version), or use the Ecoschool bulletin board (see Figure 3). The majority of students chose to use the bulletin board to present their problem and solutions although some students did use the ProTo2 learning environment. Again tutors gave feedback to the students and responded to their questions although the work was not graded.

4 Methods of curriculum development and evaluation

Ecoschool developments have followed an action research model, as the aim of the project was to develop a successful curriculum for initial teacher education over the three years of the project. The Ecoschool curriculum was developed in face-to-face planning meetings and followed up by email communication between partners in Austria, Finland, Sweden and England. The results of student and tutor evaluation were fed into the curriculum planning at the end of each cycle. The following methods have been employed in gathering evaluation data:

Student evaluation questionnaire. All students completed a questionnaire by email or on paper. Many groups posted the results of their evaluation on the ProTo system or on the Ecoschool bulletin board. The questionnaire requested information on student expectations of the project, levels of interaction, the role of the tutor, use of new technology and ideas for the future.

Tutor evaluation. A tutor from each country completed a written evaluation of their experience at the end of each cycle and presented the document for discussion at the annual Ecoschool development meetings.

Web page analysis. The students created web pages of differing levels of complexity during cycles one and two. The web pages construction process is evaluated against the six components of infomedia literacy as proposed by Lee (1999, pp.147-149). These components are:
1. An understanding of the nature and functions of infomedia and their impact on individuals and society.
2. The development of critical thinking ability.
3. The skill of efficient searching and critical selection of information.
4. Knowledge of multi-media production using appropriate technology.
5. Aesthetic appreciation of hypertext, graphic design and visual images.
6. Social participation in influencing the development of infomedia technology.

ProTo communication log analysis. The record of tutor and student communication during cycles one and two was analysed using Boyd and McGee's (1995) guidance on facilitating dialogues using computer-mediated communication. They suggest that facilitators provide both technical and content-specific support; are responsible for regularly communicating with the group; communicate in ways that require a response; and model standards of high quality interaction

Ecoschool bulletin board observation. The Ecoschool bulletin board was set up in September 1999 and provided the student groups with a shared electronic space for presenting and discussing their ideas. Each group had a separate area for their own use. The frequency and quality of communication was analysed as well as the level of interaction between group members.

5 Evaluation Results

Student evaluation questionnaire data was collected from 12 of the 16 student groups over the three years. The key points arising were:
- In cycles one and two students who were apprehensive about using the technology felt that had been successful and the majority of students found that resource production was enjoyable and had developed their ICT skills.
- Communication between groups was successful in cycles one and two but sporadic in cycle three. This was attributed to pressure of work from other areas of their degree (Oulu), lack of clarity in terms of the aims of the project and technological problems in Linz and Sheffield.
- In cycle three, two of the five groups were critical of the lack of commitment of their partners.
- Students in Sheffield requested formal computer sessions where they could meet and use university facilities for the project. All students felt that their tutors had supported them in cycles one and two, but three groups wanted clearer guidance in cycle three.
- By cycle three the students from Falun and Oulu requested the use of chat and video conferencing technology in any future work. Individual students in Linz and Sheffield experienced technical difficulties during November 1999 due to network problems at their institutions.

Minutes of three *Tutor evaluation* meetings and five written reports state that:
- The role of the tutor was clear in cycles one and two but not in cycle three
- Cycle three was seen as a radical departure from previous work and was viewed as 'experimental'
- Students in Linz, Oulu and Sheffield were hampered by block teaching practices taking place during key times in the project.
- Tutors were pleased with the progress made by their students in cycles one and two and had discussed how work in cycle three could be improved.

Web page analysis using Lee's concept of infomedia literacy reveals:
- Only two groups took a critical approach to the sources they used when constructing pages about their

home city in cycle one.
- Three groups overtly discussed the problems of representing people and places on their web pages in cycle two.
- Four groups of students in cycle one saw the pages as similar to written text so did not exploit the advantages of hypertext fully.
- All students changed from passive users of web pages to active publishers of their own content.
- The students from Falun produced a website in cycle two that clearly demonstrated a collaborative approach and a high level of aesthetic appreciation in regard to page design.
- Students from Oulu and Falun were in general more adept at making critical comments about their own and other's work than the Linz and Sheffield students.

ProTo communication log and *Ecoschool bulletin board observation* using McGee and Young's guidance shows:
- In cycles one and two tutors adequately fulfilled the roles of moderator, mediator and facilitator.
- Tutors communicated with the participants by asking one or more questions, giving examples from their own experience to add to discussions and modelling high quality interaction.
- The cycle three work led to the production of questions and solutions but little discussion. In general tutors did not moderate the discussion effectively as they were unsure of their roles.
- The decision to limit the role of the tutor in cycle three had a negative effect on the level of interaction and quality of discussion. Student evaluations reveal uncertainty about technical issues as well as pleas for stronger leadership and rigid deadlines.

6 Discussion

The cycles of curriculum development and evaluation have identified many important features in the development of collaborative ICT projects. Establishing an international electronic community requires access to reliable technology for the students and also skill and commitment on the part of the tutors. Asynchronous communication is seen as one of the great advantages of electronic communication and university tutors may take their own ease of access for granted. In a study of barriers to student computer usage McMahon et al (1999) found that students identify real problems in accessing computers to complete course tasks. A Sheffield student reflects their conclusions when evaluating her experience in cycle three:

> *If we had been given time in our lectures to get together and a set routine with correspondence time every week then we would have got more out of it. As a group of people we are all in different (teaching) groups, so getting together is difficult and finding a PC when we have free time is also difficult.*

This highlights the question of computer access as well as the importance of study and group work skills in such a project. Very clear project goals and explicit expectations on student participation are also needed. Is it the students ' responsibility to meet and organise communication sessions during their own time, or will better levels of communication occur by booking computer access during student practical classes? If this is done are the benefits of asynchronous communication being demonstrated? An unexpected outcome of this project has been to highlight the importance of developing students' teamworking skills.

Once access is assured, the roles of the tutor as moderator, mediator and facilitator are crucial. A key finding from the evaluation is that communication was much more successful when the tutors had a strong moderating role in cycles one and two. When planning for cycle three, tutors limited the moderation role and gave the student groups much more independence. The majority of the students interpreted this as poor planning and one group described it as 'lack of leadership'. This highlights the complexity of the moderator's role and a recommendation from this project would be that the tutors spend time in the final evaluation meeting exploring their experiences in this role.

Developing a successful collaborative curriculum is dependent on creating a fine balance between resource production and communication. In cycle one the web pages produced were basic, but quality of interaction between students was high. In cycle two the web-based products were much more sophisticated but students paid less attention to communication, perhaps because more academic credit was gained for page development rather than communicating with fellow students. Student's work in the final cycle showed some evidence of sound international cooperation, but less in-depth critical analysis. Experiences gained during the three cycles have led to the development of a formal curriculum unit (see http://www.shu.ac.uk/schools/ed/teaching/dho/). Students will gain high grades only by giving equal weighting to communication, resource production and critical evaluation in their group work.

Finally, teacher education students need to transfer their learning to a classroom situation. One student has already set up a similar project whilst on teaching practice. In this example infant school children communicated via email with children in Bermuda and compared their localities, hobbies and homes as part of English and geography learning. Tutors need to set up opportunities for students to use their newfound confidence and skill in the classroom. Nook Lane Primary School in Sheffield is now linked with partner schools in Linz and Oulu as a result of the project, and students can now contribute to the development of this partnership.

6.1 Future developments

As a result of ongoing evaluation the following developments have been planned for 2000-2001. A chat facility had been added to the Euroland/Ecoschool discussion area in addition to the bulletin boards. Building on the success of a trial video-conferencing session held in November 1999, students will be able to use this form of communication from September 2000 in all countries. Students and teachers can also now access the communication tools via the Hallam Geography Education web site as well as from the Euroland web pages. Finally, with the imminent completion of the Euroland CD-ROM, the two projects will be brought together. Students and teachers will be able to use the CD-ROM as a focus for collaboration and discussion in the areas of infomedia literacy and multi-media development, the pedagogy of computer-mediated collaboration and the comparison of European social and environmental learning.

7 Conclusion

The Euroland and Ecoschool projects represent successful examples of how an international perspective can be developed in the university and school curricula. Sustained and effective communication is the key to such initiatives, alongside ease of access to computing facilities and a focus on the crucial role of the tutor as moderator. Both projects have provided tutors, students and pupils with membership of an expanding European network, which is a solid platform for the development of further collaborative work.

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http://wwwedu.oulu.fi/homepage/ejeronen/eco/index.htm
All cycle one and cycle two work can be viewed at this location.

Explorers or Persisters? Evaluating Children Interacting, Collaborating and Learning with Computers

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In this paper we discuss our observations of a group of 10 and 11 year old children using an Interactive Learning Environment called the Ecolab. The design of this software was informed by our interpretation of Vygotsky s Zone of Proximal Development in which *Interaction* and *Collaboration* are definitive characteristics. The relationship between the differences in interaction/collaboration style and the learning gains made by the children are discussed. The results show that children can be grouped into profiles according to the differences and similarities in their use of the system and that common interaction features are influenced by the design of the software being used. We suggest that children are poor at managing their own learning experience with technology even when the software offers both opportunities to complete challenging activities and support to ensure success. The children in this study needed explicit direction towards activities which were beyond their ability. However, caution with regard to this provision of *direction* is important to ensure that the child is also offered opportunities for creativity: a suggestion from the system about what and how to proceed is often sufficient.

Keywords: **Interaction, Collaboration, ZPD, ILE.**

1 Introduction

Computers are now an accepted part of classroom life for most young learners whether they are used for communication, visualization, simulation experience or simply for fun. But how do children actually interact with computers? Does the nature of their interactions vary from child to child in a way that could inform the design of the software which engenders these interactions? This paper explores children s use of an Interactive Learning Environment (ILE) called the Ecolab which was designed to help children learn about ecology. The system attempts to fulfill the role of a more able learning partner for the child and invites collaborative interaction. The collaboration is thus between the system and the child and not between children. Here we describe the nature of the interactions that a class of children had with this system. The nature of these interactions is considered in the light of pre- and post-test learning gains to explore the relationship between learning and interaction style. The Ecolab software has been designed using a framework derived from our interpretations of the Zone of Proximal Development (ZPD) [10, 11]. The ZPD describes the most fertile interactions which occur between the more and less able members of an educational culture and focuses attention on how the more able can help learners to learn. The ZPD offers a theory of instruction which emphasizes the inseparability of the teaching and learning processes and thus recognizes the inherent interactivity of children s learning with computer software. It also stresses the need for learners to have the help of a collaborative learning partner in the form of a peer, a teacher or in the case of the Ecolab, a computer. Within a Vygotskian, socio-cultural model of education human activity is mediated by tools and sign systems that have arisen through social interaction. Developmental explanations are used to address the complex internalisation process by which the interpsychological relations between partners in social interaction becomes intrapsychological within the individual learner. Interaction and Collaboration are therefore definitive characteristics of the ZPD which form the linchpin of the socio-cultural framework and thus form the focus of our investigations of children using the software.

In this paper we provide a brief description of the Ecolab software before discussing an evaluation study of its use. We report the results with particular emphasis upon the nature of the Interaction and Collaboration profiles we were able to construct from our records of system use. We provide examples of individual learner s use of the system and discuss the relationship between the nature of the interactions and the learning gains recorded after system use.

2 Ecolab Software

Ecology is a subject that involves the study of relationships between organisms within our environment. These relationships can be extremely complex; they can also be introduced in a simplified manner through concepts such as food chains and food webs. These form the foundations of more complex ecosystems and are part of the curriculum for primary school children in the United Kingdom. The Ecolab software provides 10 and 11 year old children with the facilities to build, activate and observe the ecological relationships which exist between members of a simple food web in a woodland ecosystem. It provides a simulated ecology laboratory environment into which the child places the animals and plants of her choice. This environment can be viewed by the child from several different perspectives or *views*, including:

World - a picture of a woodland environment and the organisms the child has chosen to place within it.
Web - a traditional text book style diagram of the organisms in a food chain and food web.
Energy - a graphical representation of the energy levels of the organisms currently alive in the Ecolab.
History - a linear narrative of what has happened in the Ecolab world to date, which animal has eaten which other animal for example.

As we have already stated the nature of the relationships that can exist between organisms in the real world can be very complex. We wished to allow each of the children using our system to learn about relationships at a level of complexity that was appropriate to them. We therefore built the learning environment in a manner that would allow children to learn about relationships ranging from the simplest, between just two single organisms, to the much more complex network of relationships that could exist in a very simple ecosystem involving populations of organisms. The complexity of the relationships represented within the Ecolab can be varied at any stage during the child's interaction with it. It is also possible to alter the abstractness of the terminology used to describe the organisms in the Ecolab so that a snail, for example, can be described by the words "herbivore", "primary consumer", or "consumer" as well as the word "snail".

In addition to this simulated laboratory environment, the system acts as a collaborative learning partner for each learner which can provide assistance of the following sorts:

Extension of the learner s knowledge through increasing the complexity of the relationships she is asked to study and/or the abstractness of the terminology used to describe what is happening in the Ecolab.

Collaborative Support which can take the shape of *Activity Differentiation:* in the form of alterations to the difficulty of the activities the learner is asked to complete, or context sensitive *Help* of variable levels of quality and quantity.

At the start of this paper we discussed our use of the Zone of Proximal Development to underpin our system design and the importance of *Interaction* and *Collaboration*. In order to explore the nature of the interactions children had with our software, the collaboration that might occur between system and learner, and the relationship between interaction, collaboration and the changes in learning outcome recorded after system use, we varied the manner in which collaboration from the system was offered to the learner. The Ecolab consists of three system variations: VIS (Vygotskian Inspired System), WIS (Woodsian Inspired System) and NIS (Non-theoretically Inspired System). These three system manipulations implement different design elements in order to adjust the assistance they provide (see [4] and [5] for more detail). The way in which each of the system variations adopts a different approach is summarised in Table 1. In particular, VIS makes more decisions than WIS which makes more decisions than NIS. In other words NIS gives the learner most freedom of choice to the learner and VIS the least.

3 Interactions with the Ecolab

An exploratory evaluation of the Ecolab software was conducted with a class of children aged 10 and 11 years. We wanted to investigate the extent to which the system would be able to adjust to learners of differing abilities, and also the ways in which the interactions and collaborations between user and system varied with users of different abilities. The children's school assessments were therefore used to allocate each child to one of three ability grouping: High, Average and Low. Prior to using the software each child completed a written and a verbal pre-test, the latter of which was in the form of a structured interview recorded on audio tape. Each child used the Ecolab software as an individual for a total of 60 minutes over two sessions. In addition, a 20 minute initial session with a smaller 'demo' versionensured that all children were comfortable with the mouse skills required and the interface. After the system intervention subjects were given a written and verbal test, identical to the pre-test, and a short additional extension interview. A delayed post-test was conducted 10 weeks after the end of the original post-test. Of the 30 children who started the study only 26 completed all sessions between, and including, pre and post-test. The four who did not complete these sessions had either left the school or been absent during the evaluation period. Only 24 completed all sessions including the delayed post-test. Once again the reason for non-completion was absence from school.

Table 1 Collaborative Support within Ecolab

Collaborative Support within Ecolab			
	VIS	**WIS**	**NIS**
Levels of Help Available (different levels provide differing qualities of help - 5 represents the greatest and 1 the least)	5	5	2
Decision about Level of Help made by	system	system and child	child
Levels of *Activity Differentiation* Available	3	3	3
Decision about type of Activity and Differentiation level made by	system	child - system makes suggestions	child
Extent of Learner Model maintained by the system and used to make decisions about the support to be offered to the learner.	Bayesian Belief Network (BBN) of values representing the system's beliefs about child's ZPD formed from its knowledge about the amount of collaborative support used to date.	Record of help used to enable contingent calculation of next help level. Record of curriculum nodes visited maintained to permit suggestions.	Record of Curriculum nodes visited maintained to help child keep track.
Abstractness of Terminology selected by	system	child	child
Area of the Curriculum and complexity of the next activity selected by	system	child - system makes suggestions	child
Ecolab View selected by	mostly child	child	child

The results of the pre- and post-test were used to assess the efficacy of the three variations of the Ecolab software. This work is reported elsewhere [4, 5] and is not the main focus of the current paper. It is the character of the interactions between each child and the system that we will focus upon here. We wanted to investigate what sorts of interactions had resulted in the greater learning gains and which systems had supported and encouraged various types of interaction and collaboration in order to inform the design of our next system. For each child a summary record of their interactions was produced from the detailed logs maintained during their two sessions of system use and this was used to build up a picture of the types of interactions each child experienced with the system (for full information see [4]).

Cognitive or learning styles have been a subject of active interest in recent years [1, 3, 6, 8], for a brief review see [9]. The influence which a learner's style can have upon the way they interact with technology has also been recognised [7]. Within this literature there are examples of classification systems which differentiate learners according to their learning preferences; for example, as serialists or holists [6]. The analysis of the annotated interaction summaries of children's experiences with the Ecolab software takes a fresh perspective on classification using only the styles of interaction or *Profiles* which can be found in the records of each child's system use and emphasizing our interest in the nature of *Interaction* and *Collaboration*. Characteristics were identified and children categorised through:

- **Interaction Profiles** according to the character of their interactions with the Ecolab.
- **Collaboration Profiles** according to the nature of the collaborative support provided by the system for the child.

4 Results

One aspect of the evaluation looked at whether the different variations of the Ecolab had been more or less effective in increasing the child's learning gain in terms of her understanding of the feeding relationships which exist in a food web as reflected in the pre- and post-test data. This indicated that the system variation (VIS, WIS or NIS) which the child used was relevant to her subsequent learning gain and a detailed discussion of these results can be found in [5]. Here we wish to concentrate upon the analysis of the records of interaction which was used to try and pinpoint the elements of VIS and WIS which led to their superior performance with particular ability groups.

4.1 Interaction profiles.

There were two characteristics which could clearly be seen as either present, or largely absent within the children s interactions. These were referred to as:

- **Busyness** and
- **Exploration**

Busyness was considered to be a characteristic of interactions in which the children completed an average or above average number of actions of any type, such as adding an organism to their Ecolab world or making one organism eat another. The interaction summaries of these children contained an above average number of events. The opposite of Busyness is referred to as **Quietness.**

Exploration was considered to be a characteristic of an interaction if the child had been involved in some sort of action which allowed her to experience more than one level of complexity or more than one level of terminology abstraction, beyond her initial starting levels. The opposite of Exploration is referred to as **Consolidation.**

Some children also switched frequently from one type of interaction to another. For example, they might switch from attempting to make one animal eat another, to looking at their organisms in a different view (i.e. perspective), to accessing a new activity entirely. Their interactions contained no or few series of repeated actions of the same type. They were particularly prone to frequent changes of view. These users have been characterised as **hoppers.** Other learners exhibited a more persistent approach, with sets of actions of a similar type grouped together. These users have been referred to as **persisters.**

These characteristics allow the children to be categorised , in principle, into 1 of 8 (2x2x2) possible Interaction Profiles.

The three parameters of categorisation: Busy/Quiet, Exploration/Consolidation and Hopper/Persister bear some similarity to features found in other categorisation systems. Pask's [6] differentiation of tendencies in learners towards being either "top-down" holists or being "bottom-up" serialists shares some common ground with the Hopper/Persister characteristic, for example. The differentiation of exploration from continuing activity at a level of consolidation is likewise similar to the challenge/safety division of [2]. However, the motivation for the analysis reported in this paper was not the presentation of a generally applicable categorisation system. The aim was twofold:

- To investigate the relationship between interaction style and learning gain.
- To examine how each of the system variations (VIS, WIS and NIS) of the Ecolab supported and encouraged particular learning styles.

Children fell into 6 of the 8 possible Interaction Profile groups. The distribution within these groups is illustrated in Table 2.

Table 2 Interaction Profile Membership

Profile Description	% of children in Profile group
Busy - Exploring - Persister (BEP)	28%
Busy - Exploring - Hopper (BEH)	12%
Busy - Consolidating - Persister (BCP)	8%
Busy - Consolidating - Hopper (BCH)	12%
Quiet - Consolidating - Persister (QCP)	20%
Quiet - Exploring - Persister (QEP)	20%

4.1.1 Examples of User Interaction Profiles

S10 (Gene) was a typical example of the *Busy - Exploring - Persister* style of interacter. Her first action was to switch from world view to energy view and then back to world view. She then added 15 organisms to the Ecolab and visited energy view again. Upon switching back to world view she made one of her organisms eat another, switching to energy view to see the effect. This pattern of making organisms act, either eating or moving and looking at the effect in an increasing number of different views continued. Introductory, investigative and rule-definition activity types were completed for the first two nodes in the curriculum before her first session drew to a close. She chose not to save her current Ecolab world which meant that at the start of her next session her first actions were the addition of organisms. Once again she added all 15 and then moved into the next phase of food web complexity and used more abstract terminology to view her organisms. Whilst the nature of the actions she completed was now more advanced and several instances of help were used, her pattern of activity remained one of initiating an action or actions appropriate to the evident goal. Actions were often completed in pairs and were followed by viewing the result from different perspectives (most commonly, energy, web and world). She did not experiment with writing a program or attempt to escape from completing the activities offered to her.

This profile group contains only high and average ability children from the VIS and WIS system user groups. In terms of performance at post-test there was a tremendous spread: A *Busy - Exploring - Persister* style learner attained the lowest learning gain, another, the second highest learning gain. The high ability children within the group all achieved an above average learning gain, but within the average ability children there was a wider spread of learning gain scores. Membership of this group was limited to VIS and WIS users, of whom the VIS users all achieved above average post-test learning gains, including the highest learning gain within this user group.

4.2 Collaboration profiles.

Two characteristics were found to be the most useful for differentiating collaborative style within the interactions: Amount of support and Depth of support used. These collaboration characteristics were used to group the children into one of four Collaboration Profile groups.

Amount of support: the average amount of activity differentiation (i.e. the degree to which the activity is presented in a simpler form) and the average number of help instances for the experimental group was calculated. An above average amount of either activity differentiation or instances of help was the criteria necessary for a child to be considered as using 'Lots' of collaborative support.

Depth of support: this characteristic was based upon the level of help and level of differentiation used. Once again the average levels used within the experimental group were calculated. Help or differentiation above the average level resulted in a child being considered as using 'Deep' or higher level support.

Interactions could be grouped into all 4 of the possible Collaboration Profiles. The first group was the largest and was further divided in accordance with the type of support which was most prevalent. The distribution of children into these groups is illustrated in Table 3.

Table 3 Distribution of children within Collaboration Profile groups

Profile Description	% of children in Profile	Profile sub-group Description	% of children in Profile sub-group
Lots and Deep (LD)	53%	Differentiation and Help	19%
		Differentiation	19%
		Help	15%
Lots and Shallow (LND)	12%		
Little and Deep (NLD)	16%		
Little and Shallow (NLND)	19%		

4.2.1 Examples of User Collaboration Profiles

S1 (Jason's) use of the available support was typical of the *Lots and Deep* profile group and of a user of above average amounts of both help and activity differentiation. He used level 4 help early in his first session of system use to achieve success in making organisms eat each other. His initial activities were completed with maximum differentiation of level 3. This was gradually reduced and then increased again. During his first session of system use he completed a range of activities for three nodes in the first phase of the curriculum. All instances of successful help were at level 4 or level 5. Fewer activities were completed during his second session. However, these activities were at a lower level of differentiation and there were fewer instances of help.

This Collaboration Profile group was the largest and was subdivided to account for the type of support used. Only VIS and WIS system users shared the profile. Jason was a member of the subgroup which used above average amounts and levels of both activity differentiation and help. This subgroup again consisted only of high and average ability children whose mean learning gain is above the average for the whole class (16% as compared to the class average of 11.5%). The subgroup of children who used greater levels of differentiation than help contained children from all ability groups. This second subgroup also produced above average learning gains at post-test (18% as compared to the class average of 11.5%). The last subgroup of children, who used greater amounts of help than differentiation, were all average ability children. Their average learning gain was well below the class average (3.9% as compared to the class average of 11.5%).

System variation had a greater impact upon the nature of the Interaction and Collaboration profiles than ability. A Pearson Chi-squared statistical test was also used to assess the relationship between the Ability groups, System Variation Groups, Interaction Profile Groups and the Collaboration Profile Groups. There was a significant association between System variation membership and Collaboration Profile membership ($X^2 = 28.52$, $df = 6$, $p < .0001$), and also between System variation membership and Interaction Profile membership ($X^2 = 25.79$, $df = 10$, $p < .01$).

So far little has been said about the NIS user group, they have not belonged to either of the Profiles used in the examples. In fact, all the NIS users belonged to a Consolidating Interaction profile; there were no explorers in this system user group. In addition, and as has previously been mentioned, no NIS users were in the Lots and Deep Collaboration profile group.

S9's (Tim's) Interaction profile which was that of a Quiet, Consolidating Persister, was typical of a NIS system user. His initial session consisted of adding a single snail and then making 11 view changes to look at this organism from all perspectives. This initial stage was followed by a series of organism additions (commonly in blocks of 4); single actions, such as move or eat commands, in blocks of 1 to 5; and view changes which were almost always in pairs. In session 2 he adopted the commonly seen approach of adding a considerable number of organisms to start (in this case 12) and then once again completing single actions and view changes.

Likewise S26 (Karlie) s Collaboration profile reflecting low use of all types of help (Little and Shallow: NLND) was typical. She placed herself at the far extreme of food web complexity and started dealing with populations of organisms straight away. She only completed one type of action during both sessions of computer use: she built food webs using the *build web* command. Initially she made errors and used only occasional low level feedback, persisting until successful. The children in this profile group were all of high or average ability, but their average learning gains were well below average (5.2% as compared to the class average of 11.5%)

A further difference found within the NIS user group relates to the relationship between ability and learning gain. In the VIS and WIS user groups it was the higher ability children who achieved the greatest learning gains. By contrast, amongst the NIS users none of the high ability children made an above average learning gain, in fact the only learners who made above average learning gains were the low ability children. Whilst the numbers are small and the study exploratory this result is interesting and is certainly informing our current research. We had expected that of all three systems, the one which left most control within the hands of the learner would be most effective with the more able learners. Our results indicate that the opposite was in fact the case in our study.

5 Conclusions

This is an initial exploratory study with small numbers of children. However, there are several observations which are informative in building up a picture of the sorts of interactions which children experienced with the version of the system they used. VIS was the system which explicitly selected the next curriculum area for the child to complete and controlled the complexity and abstractness of the learning environment. Not surprisingly, all VIS users were members of profile groups with the 'Exploring' characteristic present. The split between 'Busy' and 'Quiet' was almost even. Only two of the VIS users scored a below average learning gain at post-test and both were in the same 'Quiet, Exploring, Persister' profile group. The majority of WIS users were also 'Exploring' profile group members and only one did not belong to a 'Busy' profile group. However, whilst all the WIS above average learning gain achievers were members of 'Exploring' profile groups, the below average achievers were all members of different profile groups, with no common features between all of them. The WIS system variation did not set the curriculum area for the users, but did make suggestions which resulted in it being easier for a WIS user to avoid being an 'Explorer' than a VIS user. The NIS users were the children with the greatest freedom and the least finely tuned help system. It is perhaps not surprising therefore that none of them belonged to a profile group with the 'Exploring' characteristic. They were evenly split between being 'Busy' and 'Quiet' and the majority were 'Persisters'. Only two NIS users achieved above average learning gains and unlike the WIS and VIS users, both were in profile groups which shared the 'Comfortable' characteristic, they were also both in the low ability group.

These results suggest that simply providing children with the means for extension through becoming involved in challenging activities is not enough to ensure that these challenging activities are undertaken. The child needs also to be explicitly directed towards activities which are beyond her ability. However, caution with regard to this provision of *direction* is important to ensure that the child is also offered opportunities for creativity. The success of WIS indicates that a suggestion about what and how to proceed is often sufficient. The consistency within the high and average ability groups across the different systems for above average learning gain achievement to be linked to the 'Exploring' profile characteristic is not reflected in the low ability group. The definition of the 'Exploring' characteristic may of course be too crude to encompass the possibility that the low ability children were 'Exploring' within interactions in a single phase of the Ecolab.

The manner in which each variation of the system collaborates with the child is a design feature of that variation and as such a big influence upon the resultant user Collaboration Profile. It was no surprise, therefore, that there was a significant association between system variation and collaborative support profile membership. However, it is possible, in principle, for a user of any of the variations to interact in line with any of the Collaboration Profiles described. In reality Collaboration Profile 'Lots and Deep' was exclusive to VIS and WIS users, whereas Collaboration Profiles 'Lots and Shallow' and 'Little and Deep' were exclusive to WIS and NIS users. The only system which allocated both help and differentiation to users was VIS, so the fact that VIS users all used a high quantity and quality of help is unsurprising. WIS users often used a high level of assistance too, but in smaller quantities, they all belong to profiles where the support used was of a high level. In contrast, all NIS users are in profile groups in which the level of support is low. The choice of help available to NIS users was admittedly more limited being of only two levels, however none of the users ever chose to use the higher level of help offered.

The absence of some forms of assistance from the interaction summaries of the less successful users offers support for the suggestion that it is the combination of being challenged, or extended, plus the provision of ample quantities and qualities of support which is important for learning. The lower ability children present a somewhat different picture as there is no apparent consistency between the use of collaborative support and learning gain. The only tentative conclusions are that this group responded to interactions in which the extent of the challenge was limited and that the nature of the assistance the system could offer was not effective for them. Those who were successful took up less different types of assistance and tackled less of the curriculum than their successful more able peers. There is also evidence that these children were not good at managing their own learning. The NIS Interaction and Collaboration profiles in particular would suggest that children who are given control for their own learning experience are not good at setting themselves challenging tasks or indeed seeking collaborative support. Our current work with children is investigating this issue in more depth.

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Group Composition Methods for Cooperative Learning in Web-based Instructional systems

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The objective of this research is to find effective group composition methods to increase the interaction among students in asynchronous distance education using the theories of cooperative learning, group dynamics and social cognitive theory as foundations. The outcome can be a reference for the design of network cooperative learning activity and web-based instructional system in the future. This study is conducted in NSYSU Cyber University (http://cu.nsysu.edu.tw) using surveys and observations to investigate the influence of cognitive style on cooperative learning when different types of tasks are assigned. This research concludes that the choices of discussion tools in the chat room are different under intellective and decision-making tasks. Moreover, regardless of the task types, the heterogeneous groups outperform the homogeneous group during the cooperative learning process. Finally, the cognitive style is significantly related to group satisfaction in a cooperative learning environment

Keywords: **cooperative learning, web-based instructional system, cognitive style, group efficacy, group goal commitment**

1 Introduction

Group cooperative learning is defined as forming a group of two to six people with different abilities, genders or racial backgrounds. These differences may lead to effective interaction. If during the pursuit of personal goals, the group member can also consider other members and the group learning objectives, the learning efficacy can be improved [6]. Many of the previous researches use "gender" as group decomposition variable in investigating the effectiveness of cooperative learning under different task types. They find that the male groups usually outperform the female groups when computer is used in solving the tasks. However, "gender" should not be the only variable affecting the group performance. Thus, it is essential to conduct a research based on individual characteristics. Moreover, many scholars also point out that task types are one of the important variables in cooperative learning. When facing with different task types, the participants' discussion process evolved, skills required, communication tools used, and the communication methods adopted will all be varied.

From the social cognition point of view, group cognitive behavior, which is often ignored in-group performance experiment, is an important factor affecting group performance. In addition, group members' participation is another significant issue. The higher the participation rate, the more focused the members are in completing the tasks assigned. The group satisfaction will also increase [2]. Thus, this research chooses cognitive behaviors such as group participation rate, group efficacy and group goal commitment as important variables in cooperative learning. The objective is to find their impacts on group performance in different group types with different task types. Nunamaker et al. [5] point out that group; task, environment and technology are the four variables affecting the decision-making process in electronic meeting. In turns, they will affect the outcomes of the discussion. They are part of the input-process-output structure. This structure can be applied to this research on investigating the group cooperative learning in a web-based instructional system.

2 Literature Review

we consider those factors as follows• •

- Cognitive style - Theory of field-independence

  When individual is having perception judgment, he/she is field-dependent if he/she tends to make decisions based on the surrounding. Otherwise, he/she is field-independent, i.e. the judgment is resulted from some inner reference.
- Task types

  The task types in this paper are the intellectual and decision-making task types under the "choose" category. According to McGrath [4] and Johnson [3], Intellective tasks are tasks with a "correct" solution. The solution may be obtained from calculating, choosing or creating. Decision-Making tasks are tasks with the most appropriate solution instead of the best solution.
- Group efficacy

  Bandura [1] thinks that group efficacy directly influences the extent to which group members can mobilize and coordinate their skills, the amount of effort they will put into the task ,and their persistence when group efforts fail to produce results. In addition, individual efficacy theory is widely applied to management, computer skill training and education. It is found that the individual with high efficacy level performs better.
- Group goal commitment

  Goal commitment plays an important role in goal setting. When group members identify with the goal of the mission, the main purpose is then to achieve the appointed or self-set goals and improve the group performance. Thus, there is a positive relationship between group goal commitment and group performance.

3 Research Methodology

The research structure is modified from the Electronic Meeting System (EMS) proposed by Nunamaker et al.[5]. Task types and cognitive types are the independent variables. This research focuses on finding their effects on cooperative learning process and performance in a web-based instructional system.

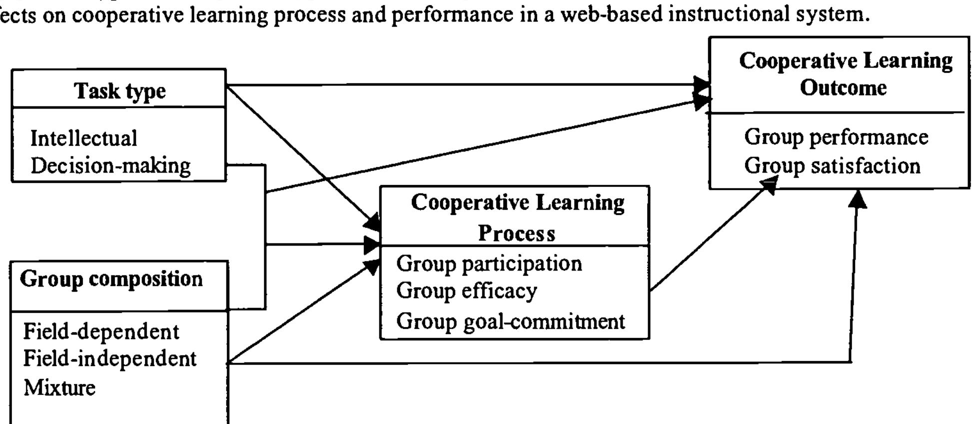

Figure 1. Electronic Meeting System (EMS) Structure

- **Samples**

  The samples are taken from master students of asynchronous Computer Networks and Internet course in NSYSU Cyber University. Most of the students are part-timed. The total number of students is 191. After rejecting students who did not complete the experiment, the valid sample size is 80 with an average age between 31 to 35. There are 59 males and 21 females. According to Group Embedded Figures Test, individual cognitive types are classified into two categories: field-dependent and field-independent. As a result, 35 people belong to field-independent category and the other 45 belong to field-dependent.
- **Group composition methods**

  Based on field-dependency, three types of groups are formed. They are groups with all field-independent individuals, all field-dependent ones and a mixture of the two. The average number in each group is about four or five. Since the field-independent samples are ten less than the field-dependent ones, there is a group with three field-independent and one field-dependent student.

For observation convenience, this group is classified as the 'all field-independent' class. Overall, there are six field-independent groups, seven field-dependent groups and seven mixtures, which add up to a total of 20 groups in this experiment.

- **Research procedure and its implement**

  At beginning of the semester, students are asked to complete a "Hidden Figural test" so that their cognitive types are known for later group composition. The experiment would start after groups are formed. There are three parts to the experiments where a task is assigned to each part. The sequence of the type of assigned tasks is intellective, decision-making and intellective tasks. All group members are new to each other. Thus, there is no previous interaction between them. The intellective task - 1 is therefore used as a warm-up exercise. Data from the other two tasks will be collected and analyzed. The samples are not informed of the difference between groups. The duration for each task would be one week. In addition, the cooperative learning process is sub-divided into two phases. After the tasks are given, the group members would have discussions on job assignment. This is called the "prepare phase". Each group member has to complete the group efficacy and group goal commitment surveys. After the groups complete the tasks and are aware of the group performance, the so-called "task complete phase" begins. Within this phase, each group member has to fill the surveys regarding the group satisfaction. Among the variables measured, group performance is graded after three experts have evaluated the task reports of each group.

- **Research Tools• •**

  Each group uses the discussion tools offered by NSYSU Cyber University for communication during the experiment. The tools available include group discussion board, chat room and mailing group. Group participation is measured based on the records of the use of the proceeding discussion tools. Regarding the group discussion board, the number of posting is recorded, whereas in the group chat room, the numbers of times individuals express themselves are recorded. In the mailing group, number of message sent is recorded.

- **Task Performance**

  Three experts review the outcomes of each group and they give each group an overall grade. Thus, the outcomes have a certain level of credibility.

4 Results and Analysis

This research uses t-test with independent variable - task type, to see if there is any difference between the average of group cooperative learning and its outcomes. The results show that the p-value for the group chat room category is less than 0.05. Thus, there is a significant difference. Since decision-making tasks encompass more areas than intellective tasks, more time and efforts are spent on them. Therefore, it is expected to find more frequent communication when this type of tasks is assigned. Many of the past researches find that groups communicate face-to-face outperform groups communicate via computers. This is not only because body languages can be used when members can see each other but also there can be instantaneous discussion on issues. Among the discussion tools, only group chat room is synchronous and allows instantaneous interaction. Group discussion board and group mailing list do not provide the same advantages.

When assigned with intellective tasks, there is a significant difference between the heterogeneous group (i.e. the mixtures) and the homogeneous groups in "group discussion board", "group chat room", group efficacy group satisfaction and group performance under the group cooperative learning category. This finding is consistent with the past researches because heterogeneous groups contain people with different characteristics and thinking pattern so that they can supplement and stimulate each other.

Our outcome shows there is a significant difference between heterogeneous group and the homogeneous groups in "group discussion board", "group chat room", and group efficacy when assigned with decision-making tasks. In the past, many researchers find that homogeneous group will perform better in communicative tasks but this is inconsistent with the finding of this paper. However, the paper is consistent with Johnson [3] who thinks that heterogeneous group outperform the homogeneous groups in creativity and decision-making tasks. In addition, it is found that there is a significant difference in goal commitment between field-dependence group and mixture during the cooperative learning process but not in Cooperative Learning outcome. According to the writer's experience in tutoring the class, it is concluded that the outcome may be affected by the performance of the previous intellective tasks. Part of the field-independent groups holds different opinions regarding the answers to the first and the third questions. This, in turn, affects the group members' answer to goal commitment survey in the decision-making tasks. This is related to the characteristics of field-independent members who often have more autonomy over outside messages. They process and decode messages according to their own cognitive reorganization style. They will not accept answers that are doubtful and uncertain to them.

The interaction of different task types and cognitive style have no significant impact on there is no significant difference on cooperative learning.

It is respectively concluded that to intellectual and decision-making tasks group cooperative process and its outcome have the following in common:

- 1• There is a positive relationship between the number of posting during the group participation and group satisfaction level of group cooperation outcome.
- 2• There is a positive relationship between the group efficacy during the group cooperation process and group satisfaction level of group cooperation outcome.
- 3• There is a positive relationship between the group goal commitment during the group cooperation process and group satisfaction level of group cooperation outcome.

However, there is no significant positive relationship between group cooperation process variables and group performance when assigned with intellective tasks. This research concludes that since the intellective tasks have the one 'correct' solution, once the group members have deviation about the task, the group performance will be affected regardless of group efficacy or goal commitment.

5 Conclusion

From the survey, 86% of the participants agree that cooperative learning do increase the interaction among students. Moreover, 92% of the students are satisfied with the group discussion environment in the NSYSU Cyber University. This indicates that cooperative learning indeed reduces learning isolation and also heightens the students' learning motivation and willingness. Besides, it is concluded that heterogeneous groups outperform homogeneous groups in both group cooperative learning process and its outcomes within a web-based instructional system. However, field-dependent groups perform worse than the other two groups in both intellective and decision-making tasks. Since the field-dependent members are easily influenced by their surroundings and require the guidance of either teachers or well-performed students, they should not be grouped together when conducting cooperative learning in web-based learning environments. In addition, from the viewpoint of group dynamics and social cognition, group efficacy and goal commitment will affect the performance of the group cooperation. This research finds that there is a significant relationship between these variables. Under different task types, the group satisfaction is also significantly different. Thus, group efficacy and goal commitment can also be used as measurement in quantifying the outcome of group cooperation.

Acknowledgement

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Initial Evidence for Representational Guidance of Learning Discourse

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Little work to date has addressed the effects that problem/solution representations have on collaborative learning processes. This paper outlines empirical and theoretical reasons why the expressive constraints imposed by a representation and the information that a representation makes salient may have important effects on students' discourse during collaborative learning. It then reports initial results from a pilot study. Students worked together in pairs on hypertext-based "science challenge" problems. Pairs used either free text, matrix or graph representations of evidence, with two groups assigned to each kind of representation for a total of six groups. Analysis of discourse transcripts suggests that these representations have quite different effects on the extent to which students discuss evidential relations.

Keywords: **Collaborative Learning Discourse, Representational Tools**

1 Introduction

Decades of research into cognitive and social aspects of learning have developed a clear picture of the importance of learners' active involvement in the expression, examination, and manipulation of their own knowledge, as well as the equal importance of guidance provided by social processes and mentorship. Recently these findings have been reflected in software technology for learning: systems are now providing learners with the means to construct and manipulate their own solutions while they are being guided by the software and interacting with other learners. My work is within this spirit, providing representational tools in support of collaborative learning. *Representational tools* may range from basic office tools such as spreadsheets and outliners to "knowledge mapping" software. Such tools help learners see patterns, express abstractions in concrete form, and discover new relationships [4, 8]. These tools can function as *cognitive* tools that lead learners into certain knowledge-building interactions [3, 7].

For a number of years, my colleagues and I have been building, testing, and refining a diagrammatic environment ("Belvedere") intended to support secondary school children's learning of critical inquiry skills in the context of science. The diagrams were first designed to capture scientific argumentation, and later simplified to focus on evidential relations between data and hypotheses. This change was driven in part by a refocus on *collaborative* learning, which led to a major change in how we viewed the role of the interface representations. Rather than viewing the representations as medium of communication or a formal record of the argumentation process, we came to view them as resources (stimuli and guides) for conversation [12, 17]. Meanwhile, various projects with similar goals (i.e., critical inquiry in a collaborative learning context) were using radically different representational systems, such as hypertext/hypermedia [6, 9, 13, 22]; node-link graphs representing rhetorical, logical, or evidential relationships between assertions [11, 14, 19, 20] containment [1], and evidence or criteria matrices [10].

Both empirical and theoretical inquiry suggests that the expressive constraints imposed by a representation and the information (or lack thereof) that it makes salient may have important effects on students' discourse during collaborative learning. Specifically, as learner-constructed external representations become part of the collaborators' shared context, the distinctions and relationships made salient by these representations may influence their interactions in ways that influence learning outcomes. However, to date little systematic research has undertaken to explore possible effects of this variable on collaborative learning, except for [5].

This paper motivates and describes our research and reports initial results from such a study.

2 Representational Guidance

The major hypothesis resulting of this work is that variation in features of representational tools used by learners working in small groups can have a significant effect on the learners' knowledge-building discourse and on learning outcomes. The claim is not merely that learners will talk about features of the software tool being used. Rather, with proper design of representational tools, this effect will be observable in terms of learners' talk about and use of *subject matter concepts and skills*. We have begun investigations to determine what features have what kind of effect. This section develops an initial theory of how representations guide learning interactions, and applies this analysis to make specific predictions concerning the effects of selected features of representational tools. The discussion begins with some definitions.

Representational *tools* are software interfaces in which users construct, examine, and manipulate external representations of their knowledge. Our work is concerned with symbolic as opposed to analogical representations. A notation/artifact distinction [16] is critical to the theory, as depicted in Figure 1. A representational tool is a software implementation of a representational *notation* that provides a set of primitive elements out of which representations can be constructed. (For example, in Figure 1, the representational notation is the collection of primitives for making hypothesis and data statements and "+" and "-" links, along with rules for their use.) The software developer chooses the representational notation and instantiates it as a representational tool, while the user of the tool constructs particular representational *artifacts* in the tool. (For example, in Figure 1 the representational artifact is the particular diagram of evidence for competing explanations of mass extinctions.)

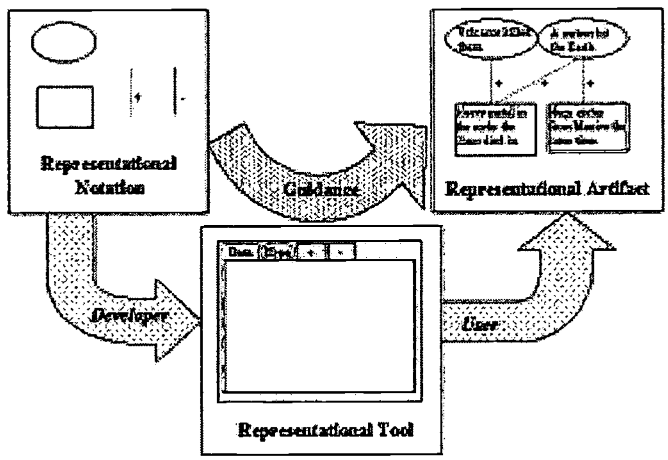


Figure 1 Representational Guidance

Learning interactions include interactions between learners and the representations, between learners and other learners, and between learners and mentors such as teachers or pedagogical software agents. Our work focuses on interactions between learners and other learners, specifically verbal and gestural interactions termed collaborative learning discourse.

Each given representational notation manifests a particular representational guidance, expressing certain aspects of one's knowledge better than others do. The concept of representational guidance is borrowed from artificial intelligence, where it is called *representational bias* [21]. The phrase *guidance* is adopted here to avoid the negative connotation of *bias*. The phrase knowledge unit will be used to refer generically to components of knowledge one might wish to represent, such as hypotheses, statements of fact, concepts, relationships, rules, etc. Representational guidance manifests in two major ways:

- *Constraints*: limits on expressiveness, i.e., which knowledge units can be expressed [15].
- *Salience:* how the representation facilitates processing of certain knowledge units, possibly at the expense of others [8].

As depicted in Figure 1, representational guidance originates in the notation, but affects the user through both the tool and artifacts constructed in the tool.

The core idea of the theory may now be stated as follows: Representational tools mediate collaborative learning interactions by providing learners with the means to articulate emerging knowledge in a persistent medium, inspectable by all participants, where the knowledge then becomes part of the shared context. Representational guidance constrains which knowledge can be expressed in the shared context, and makes some of that knowledge more salient and hence a likely topic of discussion. The discussion now turns to three predictions based on differences between representational notations.

2.1 Representational notations bias learners towards particular ontologies

The first hypothesis claims that important guidance for learning interactions comes from ways in which a representational notation *limits* what can be represented [15, 21]. A representational notation provides a set of primitive elements out of which representational artifacts are constructed. These primitive elements constitute an ontology of categories and structures for organizing the task domain. Learners will see their task in part as one of making acceptable representational artifacts out of these primitives. Thus, they will search for possible new instances of the primitive elements, and hence (according to this hypothesis) will be guided to think about the task domain in terms of the underlying ontology.

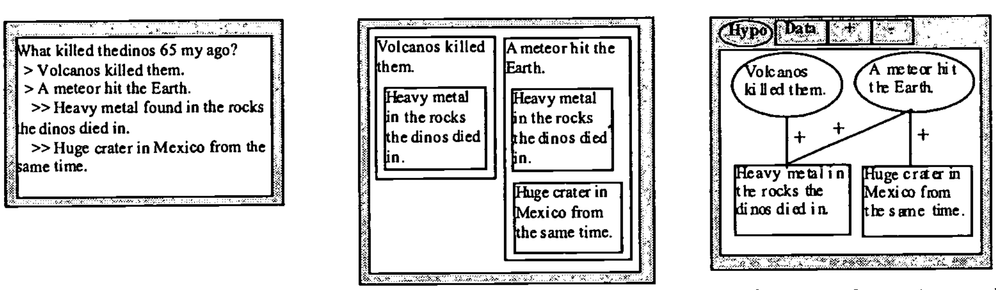
For example, consider the following interaction in which students were working with a version of Belvedere that required all statements to be categorized as either *data* or *claim*. Belvedere is an "evidence mapping" tool developed under the direction of Alan Lesgold and myself while I was at the University of Pittsburgh [18, 19, 20]. The example is from videotape of students in a 10th grade science class.

S1: So data, right? This would be data.
S2: I think so.
S1: Or a claim. I don't know if it would be claim or data.
S2: Claim. They have no real hard evidence. Go ahead, claim. I mean who cares? Who cares what they say? Claim.

The choice forced by the tool led to a peer-coaching interaction on a distinction that was critically important for how they subsequently handled the statement. The last comment of S2 shows that the relevant epistemological concepts were being discussed, not merely which toolbar icon to press or which representational shape to use.

2.2 Salient knowledge units are elaborated

This hypothesis states that learners will be more likely to attend to, and hence elaborate on, the knowledge units that are perceptually salient in their shared representational workspace than those that are either not salient or for which a representational proxy has not been created. The visual presence of the knowledge unit in the shared representational context serves as a reminder of its existence and any work that may need to be done with it. Also, it is easier to refer to a knowledge unit that has a visual manifestation, so learners will find it easier to express their subsequent thoughts about this unit than about those that require complex verbal descriptions [2]. These claims apply to any visually shared representations. However, to the extent that two representational notations differ in kinds of knowledge units they make salient, these functions of *reminding* and *ease of reference* will encourage elaboration on different kinds of knowledge units.



***(a) Threaded Discussion:** limited representation of relation.* ***(b) Containment:** Implicit representation of relations.* ***(c) Graph:** Relationship as object of perception.*

Figure 2. Example of Elaboration Hypothesis

For example, consider the three representations of a relationship between four statements shown in Figure 2. The relationship is one of evidential support. The middle notation uses an implicit device, containment, to represent evidential support, while the right-hand notation uses an explicit device, an arc. It becomes easier to perceive and refer to the *relationship* as an object in its own right as one moves from left to right in the figure. Hence the present hypothesis claims that relationships will receive more elaboration in the rightmost representational notation.

The opposite prediction is also plausible. Learners may see their task as one of putting knowledge units "in

Is a Learning Theory Harmonious with Others?

To form Effective Collaborative Learning Groups with Ontological Engineering

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Our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. In this paper, we describe the outline of a system of concepts concerning learning goals expected to attain by learners through collaborative learning process with justification by the learning theories. We propose possibility that theory-based learning groups can be combined into one in order to help a learner attain his/her learning goals and showed an example of effective learning group formation which is formed by combining multiple theory-based learning groups. With the ontology, it will be possible to compare and synthesize the learning theories to design the collaborative learning settings.

Keywords: **Ontology, Collaborative Learning, Distributed Learning Environments**

1 Introduction

Our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. To fulfill these objectives, we have to consider the following:

1. How to detect the appropriate situation to start a collaborative learning session and to set up the learning goal,
2. How to form an effective group which ensures educational benefits to the members of the group, and
3. How to facilitate desired interaction among learners in the learning group.

We have discussed item 1 in our previous papers[10, 11], and this paper focuses on item 2. When we have clarified item 2 and extracted the desired interaction in the group, we would consider item 3.

There are many theories to support the advantage of collaborative learning. For instance, Observational learning[2], Constructivism[19], Self-regulated learning[9], Situated learning[15,16], Cognitive apprenticeship[5], Distributed cognition[21], Cognitive flexibility theory[22, 23], Sociocultural Theory[25, 26], Zone of proximal development[25, 26], and so on. If we select a theory from these and form a learning group based on the theory, we can expect effective collaborative learning with the strong support of the theory. However, it is difficult to understand all theories because these theories are derived from a wide research area including pedagogy, sociology and psychology. Moreover, we can expect different educational benefits based on these learning theories, and observe various kinds of interaction between learners through collaborative learning process. Due to the diversity, it is difficult to list the learning theories effective to gain a specific educational benefit for a learner, and to compare the theories to form a suitable collaborative learning group for the learner.

Therefore, we have been constructing a system of concepts to represent collaborative learning sessions supported by these learning theories[12, 14, 24]. We call the system of concepts "Collaborative Learning Ontology". Although advantages of collaborative learning over individual learning are well known, the collaborative learning is not always effective for a learner. Educational benefit that a learner gets through the collaborative learning process depends mainly on interaction among learners. The interaction is partly influenced by relations among members of learning group, which suggests that how to form an effective group for the collaborative learning is critical to ensure educational benefit to the members. In this paper, we focus on "Learning Goal Ontology" which is a part of the Collaborative Learning Ontology.

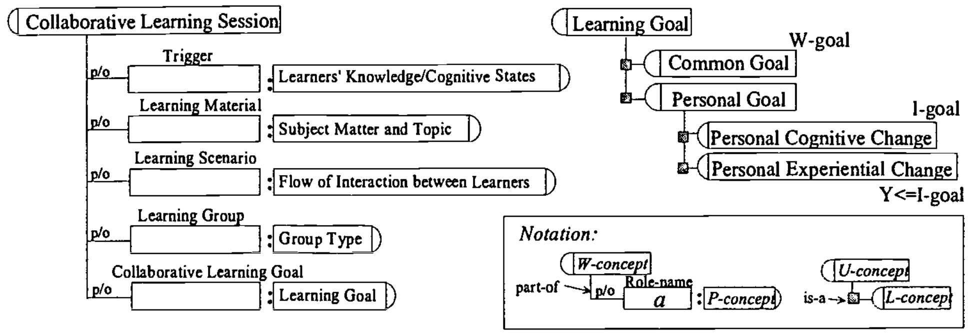

Fig. 1. Collaborative Learning Ontology

The concept "Learning Goal" is one of the most important concepts for forming a learning group because each learner joins in a collaborative learning session to attain some learning goals.

To help a learner obtain a specific educational benefit we can find several learning theories useful for the purpose and form different learning groups according to the theories. If the groups are merged into one, we may form a better learning group which is guaranteed its effectiveness by multiple learning theories. So, we also discuss the combination of learning groups supported by different learning theories.

This paper is organized as follows: we first show briefly the structure of our "Collaborative Learning Ontology" and "Learning Goal Ontology". Then we summarize advantages and remaining tasks: how can we narrow down candidates of learning groups into one? Finally we propose a new learning group formation formed by combining multiple learning theories.

2 Learning Goal Ontology for Collaborative Learning

Through a survey of studies on collaborative learning, we picked up concepts to represent a collaborative learning session. As a result, we set up five primitive concepts to characterize the session: Trigger, Learning Material, Learning Scenario, Learning Group, and Learning Goal. Fig. 1 shows the conceptual structure of Collaborative Learning Ontology.[1] Here, we concentrate on the concept"Learning Goal" which is one of the most important concepts for forming a learning group, because each learner joins in a collaborative learning session to attain some learning goals. The "Learning Goal" can be specified as two kinds of goals: "common goal" as a whole group and "personal goal" for each learner. The concept "personal goal" can be specified as two kinds: the goal represented as a change of a learner's knowledge/ cognitive states, and the goal attained by interaction with other learners.

We classify the goal of the first person (*I*), that of the first person to interact with the second person (*You*), and that of the whole group as I-goal, Y⇐I-goal, and W-goal, respectively. I-goal, which is described as G:I, represents what a learner is expected to acquire. Y⇐I-goal, which is described as G:Y⇐I, represents what a learner is expected to acquire through the interaction. W-goal expresses the situation being set up to attain Y⇐I-goals and we describe the goal as G:W. W-goal is a common goal characterizing the whole group.

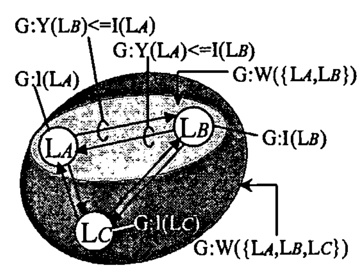

Fig. 2. Learning Goal Ontology

Fig. 2 represents learning goals in a group where three learners: L_A, $L_B$and $L_C$are participating. Learner $L_A$has an I-goal which is attained through this collaborative learning session and this goal is described in Fig. 2 as G:I(L_A). Both $L_B$and $L_C$have I-goals, and they are represented as G:I(L_B) and G:I(L_C) respectively. G:Y(L_B)⇐I(L_A) is a Y⇐I-goal between $L_A$and $L_B$observed from L_A's viewpoint. In other words, it means the reason why $L_A$interacts with L_B. Concerning this interaction between $L_A$and L_B, there is also a Y⇐I-goal observed from L_B's viewpoint. That is, it is the reason why $L_B$interacts with L_A. This Y⇐I-goal is represented as G:Y(L_A)⇐I(L_B). Both G:I(L_A) and G:Y(L_B)⇐I(L_A) are personal goals of

[1] Notation: the schemata define the W-concept and the U-concept. The W-concept has entity a, which is an instance of the concept P-concept, as a part. The entity a plays a specific role (Role-name) in the W-concept. The concept P-concept has a semicircle on the right sides. It means the concept is defined in other schema. The L-concept is a specification of the U-concept, and the U-concept is a generalization of the L-concept.

Table 1. W-goals

		W-goal	Definition	Src.
Singleton W-goal	M-P x S-S	Setting up the situation for Peer Tutoring PT	Setting up the situation where a learner teaches something to another learner.	[6, 7]
		Setting up the situation for Anchored Instruction AI	Setting up the situation where a learner diagnoses another learner's problem and then solve it (Problem-based Learning)	[4]
	S-P x M-S	Setting up the situation for learning by Cognitive Apprenticeship CA	Setting up the situation to learn knowledge or skill as an apprentice	[5]
		Setting up the situation for sharing (Meta-) Cognitive function between learners SC	Setting up the situation to share cognitive or meta-cognitive function between learners based on Sociocultural Theory	[25, 26]
		Setting up the situation for sharing Multiple Perspectives CF	Setting up the situation to evoke a learner's reflective thinking based on Cognitive Flexibility theory.	[22, 23]
	M-P x N-S	Setting up the situation based on Distributed Cognition DC	Setting up the situation where full participants, whom knowledge bases are different each other, discuss problems	[21]
		Setting up the situation based on Cognitive Constructivism CC	Setting up the situation where full participants discuss problems	[19]
CW-goal		Setting up the community for Legitimate Peripheral Participation LPP	Setting up the the community of practice for peripheral participant	[15, 16]
		Setting up the situation for Observational Learning OL	Setting up the situation to share other learners' learning processes	[2]

Note: ** means an abbreviation for the W-goal.
e.g., The W-goal "Setting up the situation for Peer Tutoring" is abbreviated as "PT".

L_A. G:W($\{L_A, L_B\}$) is a W-goal of the learning group ($\{L_A, L_B\}$). G:W($\{L_A, L_B, L_C\}$) is a W-goal of the learning group ($\{L_A, L_B, L_C\}$).

We have identified goals for collaborative learning for each of the three categories, and constructed I-goal Ontology, Y⇐I-goal Ontology, and W-goal Ontology with justification based on learning theories.[2] We can expect learners to acquire not only new knowledge concerning problems they solve, but also cognitive skills, meta-cognitive skills, and skills for self-expression through the collaborative learning session (I-goals). Each I-goal has several phases of development. It is difficult to understand from a theory what educational benefit is expected to a learner, because of lack of unified systematic terminology to represent a variety of phases. So, we adopt the terminologies used in two established findings: Rumelhart & Noman's work[15] on knowledge acquisition and Anderson's one[1] for skill development. The process to acquire a specific knowledge includes three qualitatively different kinds of learning[15]: Accretion, Tuning, and Restructuring. Concerning development of skills, there are also three phases of learning: Cognitive stage, Associative stage, and Autonomous stage[1, 8].

The learner is expected to achieve these I-goals through interaction with other learners. For example, to achieve the I-goal "Acquisition of Content-Specific Knowledge (Accretion)", some learners could take the Y⇐I-goal "Learning by being Taught[5]", while some learners could take another Y⇐I-goal "Learning by Observation[2]".

Table 1 shows the W-goals. The W-goals are classified into four kinds (*i.e.*,Three kinds of singleton W-goals and one Composite W-goal) according to their structures. To form a learning group means to pick up learners who join in the group as members and to assign a specific role in the group to each member. The formation should have rationale supported by learning theories. The structure of learning goals expresses the rationality. A W-goal, which is a learning goal as a whole group, provides the rationale for the interaction among the members. It means that a W-goal specifies a rational arrangement of Y⇐I-goals. Fig. 3 shows a typical representation for the structure of a W-goal. It would be more easily to understand a learning theory by preparing the structure to represent the theory and filling in each component of the structure with suitable concepts according to the theory.

A learning theory generally argues the process that learners, who play a specific role, can obtain educational benefits through interaction with other learners who play other roles. The theories have common characteristics to argue effectiveness of a learning process focusing on a specific role of learners. So, we represent the focus in the theories as Primary Focus and Secondary Focus.

Primary Focus (P): a learner's role that is mainly focused in the learning theory. The learner who plays this role (P-member) is expected to gain the main educational benefit.

[2] The details of the ontologies are described in our previous paper[14]. Here, we show the outline of the ontologies.

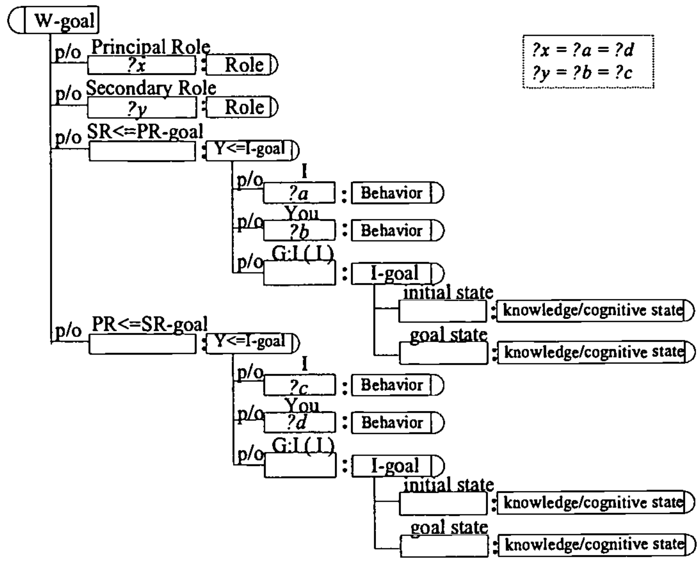

Fig. 3. Conceptual Structure of a W-goal

Secondary Focus (S): a learner's role that is weakly focused in the learning theory. The learner who plays this role (S-member) is needed as a companion to enable a P-member to attain his/her learning goals.

We classify the W-goals into the following four kinds depending on the number of the components P and S.

Singleton W-goal: Each Singleton W-goal can exist independently.

- **Multiple-P x Single-S:** The W-goal of M-P x S-S type can have multiple P-members and single S-member.
- **Single-P x Multiple-S:** The W-goal of S-P x M-S type can have single P-member and multiple S-members.
- **Multiple-P x No-S:** The W-goal of M-P x N-S type has only one role for its members. In this group, each learner plays a role of companion for the other learner, while he/she gains main educational benefit.

Composite W-goal: The CW-goal includes another group as its component S.

For example, in the situation of Peer Tutoring, there are two roles: *Peer Tutor* and *Peer Tutee*. Main educational benefit is tuning of content-specific knowledge by externalizing a learner's knowledge[6, 7]. So, P is identified as *Peer Tutor* and S is identified as *Peer Tutee*. From the viewpoint of assigned task, the role of main problem-solver is *Peer Tutee* who wants to get a new knowledge to perform assigned tasks, while the role of helper is *Peer Tutor*. The number of members who play *Peer Tutee* (S) should be single, the number of members who play *Peer Tutor* (P) can be multiple, and the W-goal **PT** is identified as a M-P x S-S type.

A group attaining a W-goal(W_i) can have another group, which has another W-goal(W_j), as the component S of the W-goal(W_i). We call the W-goal(W_i) "**CW-goal**" which means a composite W-goal. Fig. 4 shows the conceptual structure of the CW-goal Observational Learning[2]. The learning group has *Observers* as its component P.

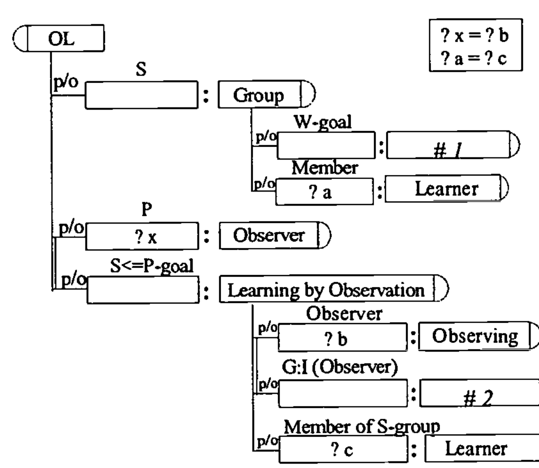

Fig. 4. An Example of CW-goal: OL

The *Observers* require a group (*i.e.*,its component S) as an object to observe meaningful interaction. In the figure, the W-goal, which is set in #1, depends on what I-goal is set in #2. For example, if accretion of content-specific knowledge is set in #2 as *Observer*'s I-goal, the W-goal **PT** is recommended as S's W-goal (#1).

A W-goal has two kinds of goals of interaction as follows:

S⇐P-goal: a Y⇐I-goal which means how and for what purpose the P-member interacts with the S-member.

P⇐S-goal: a Y⇐I-goal which means how and for what purpose the S-member interacts with the P-member. In the collaborative learning session, all members of learning group are expected to get some educational benefits. So, the S-member also has an I-goal, and the P⇐S-goal should be effective to attain the I-goal.

The entities of these goals refer to the concepts defined in the Y⇐I-goal Ontology. The conditions, which are proper to each W-goal, can be added to the concepts, if necessary. Each of the Y⇐I-goals referred to by S⇐P-goal and P⇐S-goal consists of three components as follows:

I: a role to attain the Y⇐I-goal. A member who plays I role (I-member) is expected to attain his/her I-goal by attaining the Y⇐I-goal.

You: a role as a partner for the I-member.

G:I: an I-goal which means what the I-member attains.

Each W-goal can be expressed by a set of Y⇐I-goals and I-goals. We can identify a group formation to start an effective collaborative learning session with these goals.

3 Advantages and Remaining Tasks of Learning Goal Ontology for Forming an Effective Learning Group

In a traditional classroom, sometimes a teacher divides students into several subgroups, and then the students start collaborative learning in the subgroup all at once. Such collaborative learning does not ensure educational benefits for every student, because it depends on a student's knowledge/ cognitive state whether collaborative learning is effective or not, and progress in learning differs from student to student.

So, we have been proposing a network-based new learning environment to support individual learning and collaborative learning dynamically. In the environment, each learner is solving problems individually with an ITS. When the ITS detects a desired situation for a learner (triggered-learner) to shift from individual learning mode to collaborative learning mode, the ITS forms an effective learning group for the learner, and then the members of the group start a collaborative learning session. In the group, not triggered-learner but every member should be ensured to attain individual learning goals through specific interaction with the other members. To encourage the interaction, every member is assigned a specific role in the group. When the members attain their learning goals, they close the session and return individual learning mode. We call the idea of dynamic group formation *"Opportunistic Group Formation (OGF)"*.

With our Learning Goal Ontology we can represent the several group formations whose effectiveness is ensured by learning theories. It means that the ontology brings the following benefit: When a personal goal for a learner (*i.e.*,I-goal or Y⇐I-goal) is decided, we can identify learning theories which propose learning groups to facilitate that the learner attain the personal goal. And then, we can form a specific group and identify roles assigned to the members of the group according to the theory.

If there are many theories to enable a learner to attain a specific personal goal, we can form many learning groups supported by the theories as candidates. Then, we have to narrow down the candidates to one. How can we select one?

Each learner plays a specific role in collaborative learning session. Every role has necessary conditions which should be satisfied by a learner who plays the role. The conditions will work as constraints to narrow down the candidates. If there are still some candidates after checking the conditions for role assignment, there are no rules for conflict resolution between all possible learning theories.

One might want to select one of the most profitable theory-based learning groups for a learner to attain a personal goal. Every theory expresses a different learning situation. The differences between theories do not mean the differences of the degree of effectiveness, but diversity of means to attain a goal. So, it is hard to compare a theory with the others on the effectiveness for helping a learner attain a personal goal.

There is another solution of the problem for narrowing down the candidates to one. Are learning theories exclusive each other? If the candidates can be integrated into one, a stronger learning group will appear: a learner is expected to attain a personal learning goal through some kinds of interaction, and each interaction is justified by a learning theory.

4 Is a Learning Theory Exclusive or Harmonious with Other Theories?

In actual learning environment, teachers often adopt the style of collaborative learning. If the group includes a member $L_A$whose knowledge base and/or experiences are relatively poor, it would be difficult for $L_A$to discuss with other members and to solve a problem collaboratively. $L_A$is expected to grow into a senior through practice in the group. This type of learning group is similar to the group based on the theory "LPP" which describes a process in which a newcomer grows into a senior[15,16]. Fig. 5 shows typical learning group formation the W-goal "LPP" where three learners: L_A, $L_B$and $L_C$are participating. As a whole group, all members solve a problem collaboratively, and $L_A$is regarded as a **Peripheral Participant** and $\{L_B$and $L_C\}$ are regarded as **Full Participants**.

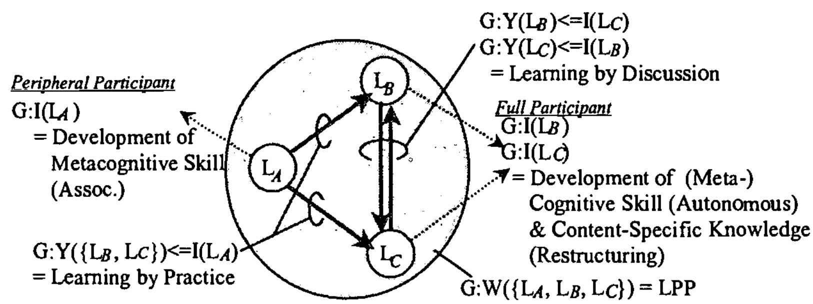

Fig. 5. An Example of Group Formation: LPP

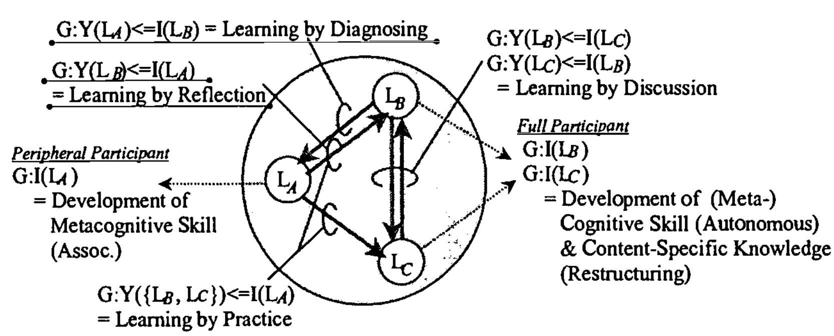

Fig. 6. An Example of Actual Learning Group

In this case, many skillful teachers will arrange for an excellent learner (*e.g.*,L_B) to help $L_A$in the group. For example, when a new student comes to our laboratory, a senior student may work as a tutor for the new student. Fig. 6 shows this type of learning group formation. We can find additional Y⇐I-goals between $L_A$and $L_B$in Fig. 6 as compared with Fig. 5. The teacher will expect different types of interaction between $L_A$and L_B, which bring additional educational benefits to them. This type of group formation can not be interpreted by a single learning theory.

In a learning group supported by "LPP", can all Peripheral Participants grow up into full participants? According to the theory "LPP", a learner (*i.e.*,Peripheral Participant) can acquire knowledge on the community and develop his/her (meta-) cognitive skills only by the learner's own practice. It is not assumed the other learners (*i.e.*,Full Participants) help the Peripheral Participant grows up. It seems that there is a gap between the Peripheral Participant and the Full Participant. Especially concerning the development of (meta-) cognitive skills, a Peripheral Participant can observe not the process in which

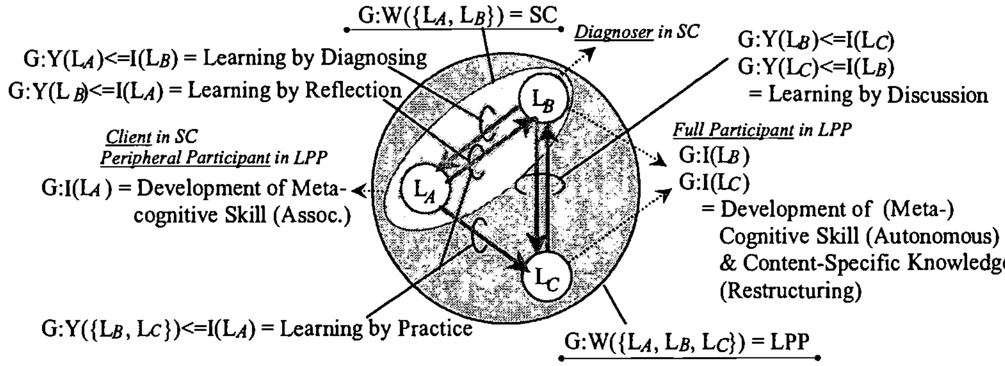

Fig. 7. An Example of Combined Learning Group: W-goal LPP & SC

a Full Participant uses the skill, but input and output for using the skill. It is difficult to learn the process by observing only input and output.

Concerning the W-goals, both W-goals "AI"[4] and "SC"[26] assume to have a "poor learner" who engages to solve a problem and a "helper" for the learner. The W-goal "AI" has a **Problem-Holder**, who has a difficulty in solving a problem, and an **Anchored Instructor**, who diagnoses the Problem-Holder's problem and gives advice to him/her. Similarly, the W-goal "SC" has a **Client**, who externalizes his/her own thinking process, and a **Diagnoser**, who diagnoses the Client's thinking process and evaluates the process. In both W-goals, a "poor learner" is expected to attain his/her I-goal, by a "helper"'s advice. Each of these W-goals can be combined with one of the other W-goals. That is, if it is difficult for a learner to attain an I-goal, we can combine the W-goal "AI" or "SC", and one of the other W-goals to help the learner attain the I-goal.

In the case of Fig. 6, we can interpret the group as a combination of two groups. One group ($Group_i$) consists of two Full Participants ($L_B$and L_C) and one Peripheral Participant (L_A). The W-goal of $Group_i$ is "LPP". Another group ($Group_j$) consists of a Client (L_A) and a Diagnoser (L_B), and the W-goal of the group is "SC". Fig. 7 shows the combination of two groups. In this learning group, $L_A$is expected to participate in the session more easily thanks to the help of L_B. For L_B, it is an opportunity for diagnosing L_A's authentic problems and helping $L_A$to participate in the collaborative learning session. Through the experience, we can expect $L_B$to develop his/her cognitive skill in two ways. For L_C, he/she will be able to get the same educational benefit with participating in the group shown in Fig. 5, because his/her activity is equal between the both groups.

For the combination of theory-based learning groups, the role of ontology is to clarify principles of combination. In combined groups, it should be guaranteed that all members can attain their own learning goals. At this stage, we store possible patterns of combining some theory-based learning groups as a pattern library. The ontology should not only represent the patterns, but also the principles which express the design rationale why the groups can be combined into one. When we can clarify the principles, an intelligent educational support system will be able to infer an effective learning group formation based on the principles opportunistically: The group formation is not picking up an appropriate one from the static pattern library. In this paper, we have described the possibility of combination the W-goal "AI" or "SC", and other W-goals. We have to consider the other types of combination.

5 Conclusions

We have discussed Learning Goal Ontology which will be able to make it easier to form an effective collaborative learning setting and to analyze the educational functions for a learning group. By considering the personal and common goals, we have identified three kinds of learning goals; I-goal, Y⇐I-goal and W-goal. In this paper, we described the outline of Learning Goal Ontology, and summarized advantages and remaining tasks for the ontology. We proposed possibility that theory-based learning groups can be combined into one in order to help a learner attain his/her learning goals and showed an example of effective learning group formation which is formed by combining multiple theory-based learning groups. With the ontology, it will be possible to compare and synthesize the learning theories to design the collaborative learning settings.

At this stage, we mainly focus on the learning goals. Future work includes to construct ontologies on remaining concepts in Collaborative Learning Ontology. Advantage of collaborative learning includes emotional factors: *e.g.*,motivation, familiarity. It is also our future work how to treat these factors.

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Learning Protocols for Knowledge Discovery: A Collaborative Data Mining Approach to Creative Science Education

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One of the creative capabilities of scientists is the ability to turn data (observations) into knowledge, that is, the capability for knowledge discovery. In this paper, we propose a collaborative data mining approach to designing learning tools in educational environments for creative science education. Specifically, students can experience knowledge discovery by engaging in collaborative data mining activities that enable students to cooperate both with the computer and the other students. Data mining process is typically made up of a set of activities such as selection and sampling, preprocessing and cleaning, transformation and reduction, forming knowledge rules, evaluation and revising knowledge rules. The learning process is modeled as a set of learning protocols that properly distribute the data-mining work among students and computers. Based on these protocols, we design and implement a set of learning tools in a web-based learning environment for global climate exploration.

Keywords: **Learning protocol, knowledge discovery, data mining, learning environment, collaborative learning, science education.**

1 Introduction

Among the creative capabilities of scientists, the most important one is the ability to turn data (observations) into knowledge, that is, the capability for knowledge discovery. In this paper, we propose a collaborative data-mining approach to creative science education in learning environments. In this data-mining supported environment, students could observe real world data in different perspectives, derive their own classification rules and test the rules collaboratively, such that they can experience knowledge discovery by engaging in collaborative data-mining activities.

In this paper, we adopt learning protocols [9] to describe the learning processes. Learning protocols are a set of constraints, rules, or processes for structuring learning processes, and are externalized as executable methods, with roles, events, and actions made explicit. Learning protocols can be used to coordinate goal-directed, effective interaction in a group of learners. In this paper, we will devise a set of learning protocols that properly distribute the data-mining work among students and computers.

Based on the collaborative data-mining protocols, we design and implement a set of learning tools in the CILSE-GCE learning environment [7, 8]. CILSE-GCE is a web-based collaborative learning environment for global climate exploration. The task domain, global climate exploration, is inherently a scientific classification problem. Students are expected to induce classification rules by making observations under a couple of climatic features. These tools are designed with the intention not only to teach students the target knowledge, but also the scientific ways of study skills. We believe the students will achieve higher learning goals through the collaborative process of creating knowledge by themselves.

2 The CILSE-GCE Learning Environment

The target domain draws sources from the instructional material in the geographic climate course of senior high schools in Taiwan. One of the domain knowledge is the classification of each climate pattern, which is recognized as a specific set of the climatic attributes. In this paper, we focus on the construction of the climatic classification knowledge. Three components of the CILSE-GCE learning environment were built. They are the Virtual Classroom, Visualized Data Viewer, and Intelligent Tutor, respectively, which are outlined below.

The Virtual Classroom serves as the origin where teachers and students coordinate and collaborate. Through the Virtual Classroom, students could access the multimedia coursebase, the climatic GIS database (via the Visualized Data Viewer) and the historical literature database. These rich data sources allow students to observe, search and collect related information in different aspects regarding to the problems at hand. The CILSE-GCE environment also provides an intelligent tutor to help students induce the classification rules. During the rule induction process, a student has to identify what the settings of the relevant attributes are by exploring resources of all kinds. When he/she determines a specific set of attribute values, the intelligent tutor would evaluate the student's answer, and give suggestions to guide the student's further exploration.

A set of rich data sources are needed to allow students to observe, search and collect related information in different aspects regarding to the problems at hand. In the Visualized Data Viewer, rich climate information could be displayed in different layers of maps covering the globe. Students could select, resize and combine different information layers for display to investigate the climate attributes in different perspectives. Hotlinks to climatic data and statistical graphs associated with the typical cities are also provided to allow students to do some measurements and inferences. Up to now, we have collected more than 1700 city records of various kind of climatic information, such as latitude, temperature, precipitation, height above sea level, etc. This database is the main data source that students can collect related data and perform data-mining process to discover the classification knowledge. Figure 1 shows a snapshot of the Visualized Data Viewer.

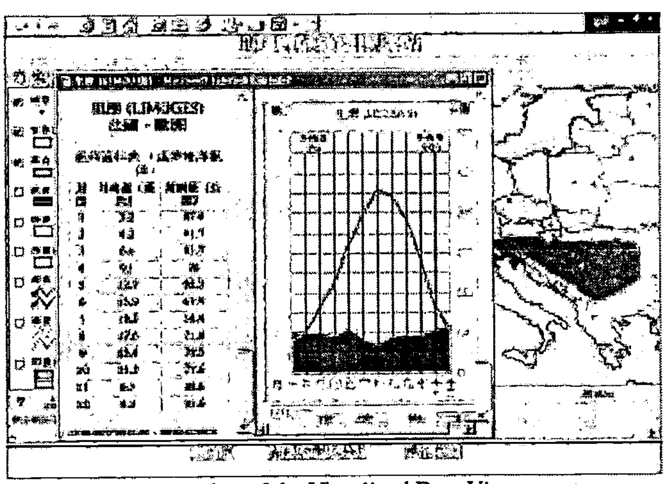


Figure1 A snapshot of the Visualized Data Viewer system.

3 Collaborative Data Mining as Knowledge Discovery

For creative science education, students are asked to acquire the learning skills of knowledge discovery, such as making observations and data collections, performing data analysis, generating hypotheses, testing hypotheses, and making conclusions. Standing from the viewpoint of knowledge discovery [2], we model the learning process as a data-mining process. Figure2 shows the set of data-mining activities, such as selection and sampling, preprocessing and cleaning, transformation and reduction, forming knowledge rules, evaluation and revising knowledge rules. Some steps of the data-mining process can be handled well with computer supports, especially those involving tedious computations and comparisons. Other steps are more suitable to be learning tasks for human students. In this section, we propose the framework of collaborative data mining within which each student member first applies the data-mining process to generate his/her private knowledge base, and then all students collaboratively integrate their private knowledge bases to a more general knowledge base, a result of social consensus process.

The first step in the data-mining process is to select a target data of interest from database, and to possibly sample the target data. The learning skills required of the students are the capability of observation and data collection. Based on the aspects they observe data, students can select all relevant attributes they think might be important to the classification problems at hand. Besides, there are so many samples in the database that students have to learn the sampling skill by selecting as typical samples as they can.

Secondly, the preprocessing and data cleaning step handles noises and unknown values, as well as accounting missing data fields. This step can be dealt with quite well with computer software. Thirdly, the data reduction and transformation step involves checking relevant features depending on the goal of the learning task and certain transformations on the data such as converting one type of data to another (e.g., discretizing continuous values), and/or defining new attributes. It is this step that testifies the hypothesis of attributes that students generated at the previous data observation step.

In the knowledge formulation step, students may apply one or more knowledge discovery techniques and tools on the transformed data set to extract valuable patterns. In this step, students can learn domain-dependent skills as well as the ability to work with computers, as is practiced by most scientists nowadays. Finally, the knowledge evaluation step involves interpreting the result with respect to the goal/task at hand. And as is often the case, students may get back to previous steps based on the evaluation results. Well-designed OLAP (OnLine Analysis Processing) tools are required for students to practice such kind of data analysis tasks. Note that the data-mining process is not a linear one. It might involve a variety of feedback loops, because any one step can result in changes in preceding or succeeding steps.

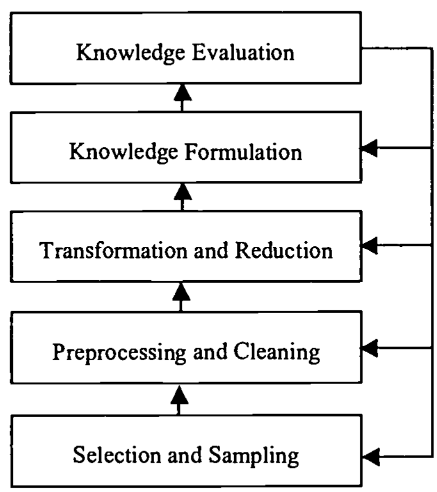


Figure2 The data-mining process.

4 Learning Protocols for Collaborative Data Mining

Learning protocols can be used to coordinate goal-directed, effective interaction in a group of learners. A learning protocol consists of a set of components. First, a protocol has a name signifying the situation type to which the protocol can be applied. Secondly, a protocol consists a set of states and transitions. In each state the users can perform actions such as communicate or manipulate artifacts. A transition to another state is triggered by an action or a specific condition. Actually, a learning protocol can be represented as an event-driven state-transition graph. Thirdly, a protocol includes different roles pertaining to the persons involved in the enactment of the protocol. Finally, a protocol may contain various types of artifacts, such as text documents, graphical objects, test forms, etc. In the following, we design a set of learning protocols for the collaborative data mining process.

4.1 The protocol to construct member knowledge

The protocol shown in Figure 3 outlines the actions of personal data-mining process and coordinates the interactions between a student and the computer. There are totally ten states in the protocol. Each state and transition is described as follows. In the Observing Data state, the student observes the data in all aspects he/she consider important to classify the climatic patterns. The main data source is the Visualized Data Viewer. The student then defines a set of attributes (in the Defining Attribute state) that will be used to classify the climatic patterns. In the Sampling state, the student starts to collect data (cities) and fill in all the details of the climatic attributes that he/she had defined. Since some of the attributes are numeric values, the student has to transform them into symbolic ones (like temperature is high or low) in the Discretizing Attributes state for more data understandability.

In the Mining Rule state, students have to extract and write down the classification rules hidden in the collected data. For this purpose, we design a set of data analysis tool that depicts the distribution graph or dependency graph of the climatic data based on the attributes specified by the students, such as the ones shown in Figure 4.

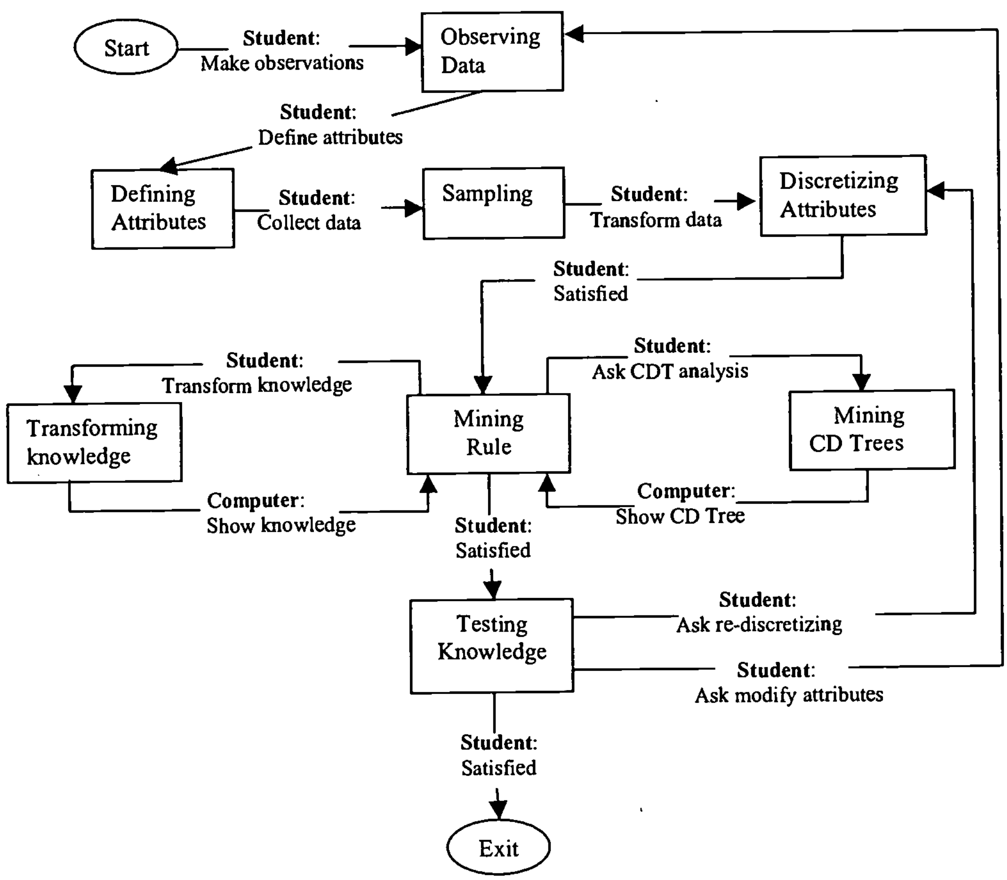
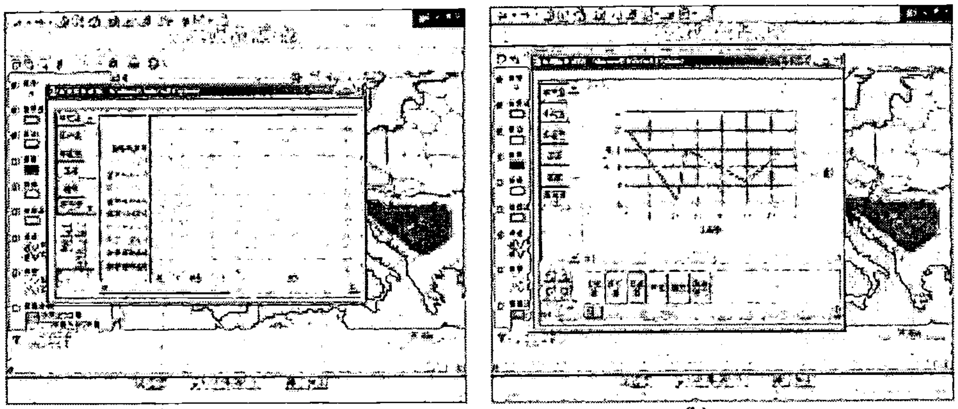


Figure3 The personal data-mining learning protocol.



(a) (b)

Figure4 (a) A data-mining support tool for comparing frequency distributions. (b) A data-mining support tool for depicting data dependency graphs.

Nevertheless, it would be still difficult for some students to discover the hidden knowledge (rules) without further computer supports. Hence, we design and implement another tool to facilitate the data-mining process in the Mining Decision Tree state. This tool uses a variation version of ID3 algorithm [4] to devise a Composite Decision Tree (CD Tree) out of the collected data. A As shown in Figure 5, students can use the CD tree to select and compose classification rules that are of more accuracy, stability and understandability. While rules provide a good local view of each knowledge unit, CD Trees provide another view that facilitates the comparison of different rule structures. . In the Transforming Knowledge state, the student can exchange the knowledge format from CD Trees to Rules, and vice versa. At last, the student can test his/her classification knowledge against the city cases in the Testing Knowledge state, and decide whether to further revise the knowledge.

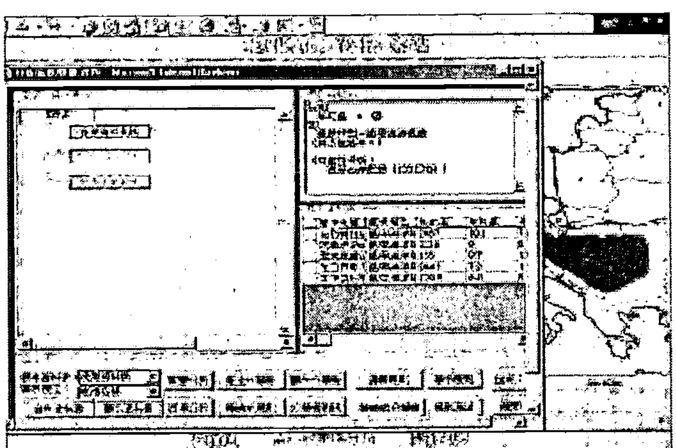


Figure5 A data-mining support tool to help students extract hidden knowledge (classification rules) from data.

4.2 The protocol to integrate group knowledge

After each student member establishes his/her own knowledge, the student group starts to perform the knowledge integration task collaboratively. The students achieve the knowledge integration goal by solving the classification problem collaboratively, trying to reach a consensus, which is the group knowledge. The corresponding learning protocol is shown in Figure 6. In the Presenting Cases state, a Coordinator (a software agent) selects a city case from the database for the student group to identify its climatic pattern. In the Classifying Case state, each student member applies his/her knowledge to solve the problem, and shows the applied rule and related information (such as the symbolic terms for each numeric attribute) in a shared working space. With the information shown in the shared working space, each student member starts revising his/her own knowledge by references to the correct answers and the colleagues' knowledge. Detail of the Revising Knowledge state is described in next protocol. Each time the member knowledge is revised, a new applied rule is sent once again to the shared working space. This process will loop until a temporary consensus is reached. At last, the Coordinator store the final rule set into the integrated knowledge base (i.e., the group knowledge). We adopt the Blackboard Architecture [3] to implement this learning protocol.

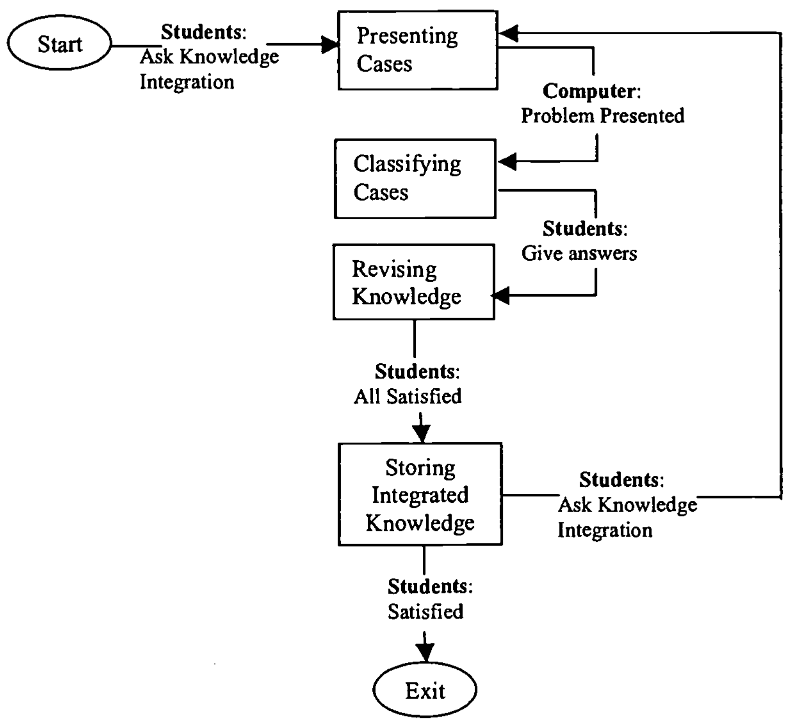


Figure6 The collaborative knowledge integration learning protocol.

4.3 The protocol to revise member knowledge

When students ask to revise his/her private knowledge, the knowledge revising learning protocol, as shown in Figure 7, is entered. In this protocol, two kinds of knowledge operations, the knowledge generalization and knowledge specialization operations, are supported. Each student member can revise his/her private knowledge by applying the two knowledge operations and/or exchange knowledge through the Group Chatting state that involves chatting-support tools. Each kind of knowledge operation can be applied to the various artifacts such as rule structures, numeric attribute intervals, and attributes. Specifically, in Knowledge Generalization state, students can delete conditions from rules, reduce numeric attribute intervals or delete some attributes from the attribute set, while in Knowledge Specialization state, the students can add conditions into rules, extend some numeric attribute intervals or add new attributes into the attribute set. To facilitate both kinds of knowledge revision, an automated rule testing and warning subsystem is implemented to list the rules that are potential for further generalization or specialization based on the test result against any data set.

5 Conclusions

In this paper, we have proposed and implemented a collaborative data-mining support tools for knowledge discovery in creative science education. These functional extensions are being integrated to our previous Web-based learning environment, CILSE-GCE. This collaborative process fosters all the constructive design principles mentioned in [1, 5], such as observation, interpretation construction, contextualization, cognitive apprenticeship, collaboration, multiple interpretations, ownership of knowledge, self-awareness of construction process. In this collaborative learning model, students would experience the process of looking for patterns collaboratively. Besides, we find that learning protocols are very effective ways to the description and implementation of learning processes. Finally, it is indicated that during free exploration of a problem space, greater learning occurred if students adopted more systematic strategies for rule induction [6]. Further evaluation tests will be conducted to provide beneficial evidences of such kinds of discovery learning.

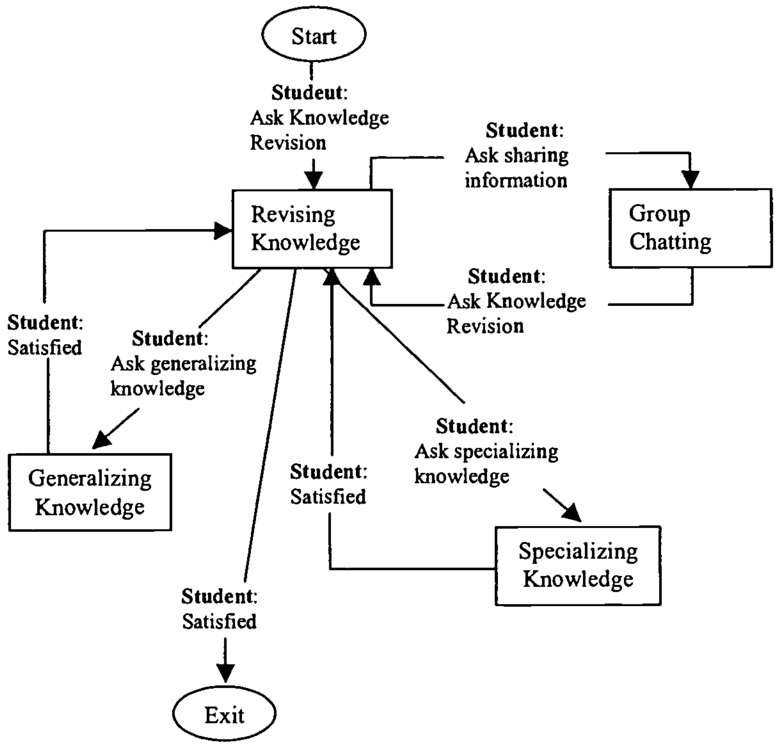


Figure7 The knowledge revising protocol.

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On Supporting Semantic Indexing in a Mediabase System which Facilitates Collaborative Learning

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Our mediabase system "ShareMedia" can facilitates collaborative learning, especially, inductive knowledge acquisition. In ShareMedia, learners in a community add, collaboratively, structured query to the electric data, which is to be registered in the mediabase. Structured queries consist of query units. Pieces of electric data express concrete knowledge or cases. Then they can navigate and retrieve pieces of electric data express by use of the queries. In other words, they can compare and examine the pieces of electric data and know their relationships. Consequently, they can acquire knowledge inductively. However, it is difficult for them to select suitable query units for a structured query. In this study, then we applied Latent Semantic Indexing to the supporting method. In our method, pieces of electric data and query units are represented as a vector space. The vectors are decomposed by Singular Value Decomposition, and then new vectors will be created. The piece of electric data that a learner wants to index is also processed with the same method. Then, the new electric data vector is compared with the new query unit vectors, and suitable query units will be selected. As a result of evaluation, our supporting method was proved to perform well.

Keywords: **indexing, navigation, collaboration, hypermedia, mediabase**

1 Introduction

In the field of education, teachers and researchers are, recently, more concerned about collaboration. Because of it, Many Computer systems are developed to support collaborative learning. For example, CSILE[1,2] facilitates knowledge building in a community, Collaboratory NoteBook[3] supports scientific inquiry activities in high school.

The mediabase system "ShareMedia[4,5]", which we are developing now, is such a system that supports learner's activities of description and accumulation, sharing, searching, selection of knowledge. In detail, it can not only promote the process of learner's browsing accumulated cases or knowledge and discovering their relationships, but also train their skills to share and use such cases and information in a community. Though we now assume that learners in high school geography class use ShareMedia, of course ShareMedia can be used in another domain.

ShareMedia needs not to link between nodes explicitly, and requires only indexing retrieval indices to media representations (see chapter 2). Then, ShareMedia enables learners to retrieve flexibly based on the semantics or concept of data by use of retrieval indices. Through the functions mentioned above, ShareMedia facilitates collaborative learning in a junior high school geography class to acquire generalized knowledge from individual cases and knowledge inductively and to index semantic indices to them in order to enable such activities.
ShareMedia supports learning activities as follows:

1) In a small community (e.g. a classroom or a group), learners collect electric media as individual knowledge or concrete cases and add indices express their concept to them. Then, learners store their shared mediabase with the electric media.

2) The learners browse the shared knowledge and compare pieces of the knowledge, which are extracted with indices, many times. As a result of this activity, the learners can abstract the pieces of the concrete knowledge and understand the relationships between them.

3) The learners discover inductively generalities or rules, which exist in the relationships, and deal with them as hypothesis.

4) The learners apply deductively the hypothesis to pieces of individual knowledge and can acquire then as generalized knowledge if their propriety is confirmed.

2 Mediabase system "ShareMedia"

The current version of ShareMedia (Fig.1) was developed on UNIX environment (Solaris CDE ver.1.3) with JAVA Development Kit ver.1.1.7 and K-Prolog Compiler ver.4.0. ShareMedia consists of several components. Above all, media representations, semantic frames, semantic indices and retrieval requests are important. Their details are as follows:

2.1 Media representation

Media representations (Fig.1.a) are electric data of pieces of individual knowledge or concrete cases. They are represent as texts, images, pictures, movies, sounds and so on. In this paper, however, only text form is dealt with because of presumption of semantic frames with natural language processing. Learners index a semantic index mentioned below to the block of a media representation and store the shared mediabase of ShareMedia with the media representation. After storing, learners can chose media representations from the list of them. With semantic indices, however, learners can navigate them more flexibly.

2.2 Semantic frame

Semantic frames (Fig.1.b) are used as query units and are primitive units of concept or semantics of media representations. They have slots that express subject, object, means, moment and so on. For example, "utilize" frame has "who", "what" and "to what" slots and "be factor" frame has "what" and "of what" slots. Learners should decide their form by mutual agreement in order to use them effectively in learning activities and store shared mediabase with them consistently.

2.3 Semantic Index

Semantic indices (Fig.1.c) are structured queries to express concept or semantics of media representations. Learners select semantic frames that are suitable to a media representation, which the learners will store mediabase with. Then, the learners combine them and link their relative slots. Like this, semantic indices are created by combining semantic frames and are indexed to media representations. They are used when learners retrieve or navigate media representations.

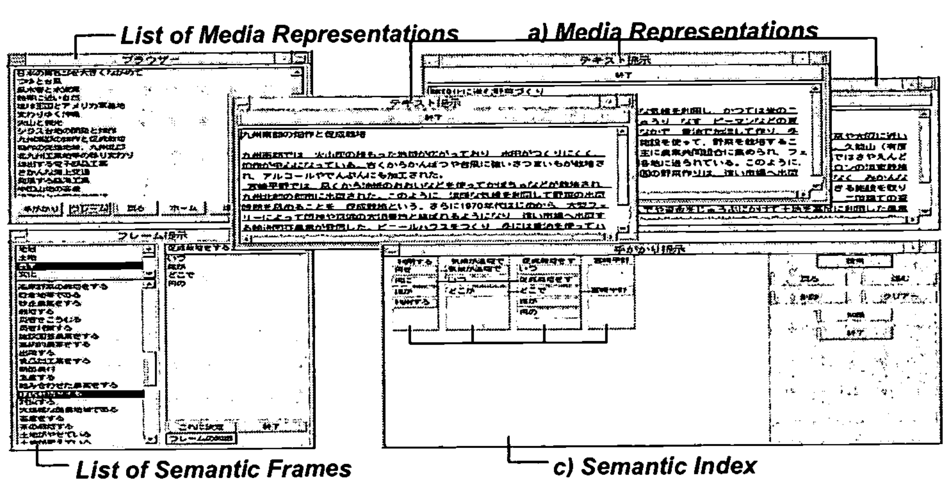

Fig.1. Interface of ShareMedia

2.4 Retrieval request

Retrieval request is used when learners retrieve or navigate media representations that are stored in shared mediabase. A learner creates it in the same way as semantic indices. Then, the learner submit it to ShareMedia, he will be presented media representations, which were indexed semantic indices that match the retrieval request. Owing to semantic indices and retrieval requests, learners can retrieve and navigate semantically.

These components mentioned above can facilitate learner's activities to navigate pieces of knowledge semantically, to understand their relationships inductively and to discover generalities, which exist in them, deductively. However, it is difficult for learners to select suitable semantic frames for a semantic index or a retrieval request.

3 Supporting learner's selection of semantic frames

In this study, we applied LSI[6] (Latent Semantic Indexing) to the supporting method for selecting semantic frames. Because LSI is one of statistical method, similarity of documents can be presumed without any dictionaries. In LSI, documents are dealt with a term by document matrix. Then, rows of it can be considered to be term vectors and columns to be document vectors. In addition, these vectors are decomposed by SVD (Singular Value Decomposition), as a result, terms and documents are abstracted.

In our method, media representations and semantic frames are represented as a vector space model. In training, the vectors are decomposed by SVD, and then new vectors will be created. In presumption, The media representation that a learner wants to index is also processed with the same method. Then, the new media representation vector is compared with the new semantic frame, and suitable semantic frames will be selected. Their details are as follows:

3.1 Training

Training needs a data set, which is a collection of combinations of paragraph and semantic frames. Here, paragraph is a part of media representation and contains one or more blocks, which are indexed parts of the media representation. And semantic frames are contained in the semantic indices, which were indexed to the blocks. First, Paragraphs are done morphological analysis with Chasen, which is one of Japanese morphological analysis tool. As a result, word lists of each paragraph are created.

Next, they are filtered in order to extract only the words, which have noun, verbal, and adjective morph. After filtering, they are sorted by frequent descending ordcr. Based on them, a sorted list of all words is generated. On the other hand, based on the relation between the word lists and the semantic frames, sorted word lists of each paragraph collection, which relate each semantic frame, are created.

Then, word by semantic frame matrix is computed from these two type lists. This matrix can be divided to word vectors and semantic frame vectors. SVD decomposes them and creates new word vectors, new semantic frame vectors and the diagonal matrix of singular values. These vectors and matrix are used in presumption.

In addition, latent relationships will be available in presumption, because this decomposition abstracts the words and the semantic frames

3.2 Presumption

To presume the semantic frames that are suitable to a whole media representation or a block of it, the vector of these text strings is processed with new word vectors and diagonal matrix, which are created in training. As a result, new text vector is created. It is compared with each new semantic frame vector by computing cosine between them. The more cosine value is large, the more the semantic frame that corresponds to the new semantic frame vector is suitable to the text string. Then, a list of semantic frames, which are arranged by descending order of cosine values, is made. This list will support learners to select semantic frames, which is suitable to a media representation.

4 Experiment

4.1 Training data set

We prepared 304 media representations, 318 semantic frames and 318 blocks, which were indexed semantic indices by manual. A block, we call in here, is a part of a paragraph where semantic indices are indexed. A media representation contains one or more paragraphs. A block might extend through several paragraphs. Though media indices are indexed to blocks, we use paragraphs to training because of giving redundancy to the presumption. Media representations and semantic frames used in here were extracted from the Japanese geography area of Japanese junior high school geography textbooks. By making use of this data set, new word vectors, new semantic frame vectors and diagonal matrix were computed.

4.2 Evaluation

We use 93 blocks, which are used in training and chosen at random, in order to evaluate the presumption of our method. Each media indices, which were indexed to the blocks, have 3.63 semantic frames on the average. The method presumed suitability of each one of 318 semantic frames to each one of 93 blocks by computing cosine values

4.3 Result

We confirmed their propriety about top of 5, 10 and 15 semantic frames, which were arranged by descending order of presumed suitability to each one of 93 blocks (see, Table 1). In Table 1, "Suitable to Blocks" indicates the average number of frames which experimenter judged suitable to each block. In the same way, "Suitable to Paragraphs" indicates the average number of frames to each paragraph. "Indexed by Manual" indicates the average number of frames, which are indexed to each block by manual beforehand.

Table 1. Average numbers of semantic frames which experimenter judged suitable.

	Suitable to Blocks		**Suitable to Paragraphs**		**Indexed by manual**	
Top	average	precision	average	precision	average	recall
5	2.10	42.0%	2.78	55.6%	1.81	49.9%
10	3.13	31.3%	4.39	43.9%	2.44	67.2%
15	3.72	24.8%	5.32	35.5%	2.77	76.3%

4.4 Discussion

A glance at Table 1 will reveal that presumption of our method is good. For example, seeing top 10 row, the precision within the range of blocks is 31.3%, the precision within the range of paragraphs is 43.9% and recall is 67.2%. Take it into consideration, our method can extract many of semantic frames which should be indexed. In short, learners can easily extract many of necessary semantic frames by selecting from them, which our method presented.

To illustrate the performance more precise, however, we need to make another experiment, because this experiment used same data in both training and evaluation.

5 Conclusion

In this paper, we described the process that ShareMedia supports learning activities, abstract of main components of ShareMedia, our supporting method for learner's selection of semantic frames and it's performance. As a result of the experiment, our method proved to perform well. To judge the performance of our method more strictly, however, we need another experiment with data sets that differ in training and evaluation. And we will improve our supporting method based on the result of it.

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Peer Help for Problem-Based Learning

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This paper describes the I-Help peer help network, where helpers and helpees are paired according to the contents of their user models. Although originally designed for large groups, in this paper we suggest ways in which I-Help may be used in a small group, problem-based learning curriculum. The use of I-Help will be very different in this context: it is not expected to be necessary for all students. However, some learners may experience difficulties with some aspects of problem-based learning, such as: scheduling of meetings; involvement in discussions; understanding roles; acquiring skills for problem-based learning; different interaction preferences; differences in cognitive styles. We describe how I-Help may be used to alleviate some of these difficulties, in particular: by putting groups into contact with other groups; or putting individuals into contact with someone outside their group who can advise, or who is facing similar problems, and would like to explore the issues jointly. At the same time, group cohesion is not disrupted.

Keywords: **peer help, problem-based learning, student modelling.**

1 Introduction

Problem-based learning (PBL) is used in many academic subjects (e.g. architecture, business, education, engineering, law, medicine). The first implementations were in medical education, and PBL is still used in many medical sciences courses today. We therefore focus on medical education in this paper, though many of the arguments are applicable to a range of subjects.

Medicine is a difficult subject to teach and learn: the knowledge to be acquired and integrated is broad and very complex. This knowledge is useful only if it can be applied to problems presented by real patients. Such problems are ill-structured, specified with partial information, and often complicated by diverse interacting factors. While acquiring basic domain knowledge is a fundamental activity in medical education, integrative problem-solving is also a fundamental goal.

PBL attempts to focus learning around authentic patient problems or cases, which bring together many interacting issues of a multidisciplinary nature. A core aspect of PBL is that problems should be only partially specified. PBL involves the student in a practical activity, carried out in small groups (usually 4-8, facilitated by a tutor) in which students identify and research their own learning issues [17]. Typically a group will meet to discuss a case, identify learning issues, and then research these individually using a variety of resources (e.g. print-based, web-based and people). They then meet again to report and discuss the case further.

Investigations into the benefits of PBL have produced mixed results, possibly in part because traditional assessment mechanisms are less appropriate measures of the goals of PBL [13,30]. It is stressed that there is, as yet, no evidence that a PBL curriculum is more successful than a traditional approach [27]. Nevertheless, PBL has been embraced by some as the preferred approach to medical education, advantages cited including: the self-directed nature of PBL [27]; a greater tendency towards a deep approach to learning [21]; and positive student attitudes [6]. Others suggest that acquisition of basic domain knowledge may not be well supported in PBL. Learners may later recall less factual knowledge, since they are spending time learning other skills in addition to content [30], and they may lack depth of knowledge [18]. Explanations generated by PBL students can be less coherent, and more frequently incorrect [23]. Learners may also become bored with the PBL process [29]. It has also been recognised that PBL may simply not suit all students' ways of learning [10]. While the peer help system described in this paper can assist in a number of areas, it is this latter aspect that we focus on here.

This paper is neither a critique nor an endorsement of PBL. However, we emphasise that in PBL (as in traditional education), there is a need for tools to support peer interaction for situations where learners need assistance. In this paper we describe how the I-Help (Intelligent Help) system can be used to support students who have difficulties with the PBL approach by putting groups into contact with other groups, or an individual into contact with another learner who may advise or collaborate.

Section 2 of this paper introduces existing examples of computer support for PBL, and describes other systems which mediate peer help. The advantages of I-Help in large groups are described in Section 3. Section 4 discusses how the large group implementation of I-Help may be adapted to support PBL students when they are experiencing problems with the PBL approach. Conclusions are presented in Section 5.

2 Computer support for problem-based learning and peer help

Computer support for group interaction in PBL has been implemented for the asynchronous distance education context; the synchronous distributed learning context; and the co-present small group situation. Kamin et al. [15] describe a combined Web/CD-ROM program containing a video patient case, for use by a group of third year medical students and tutor. It is designed to facilitate asynchronous PBL during a clinical course component, requiring independent and collaborative involvement. Cameron et al. [5] discuss a distributed problem-based learning project using conferencing software together with a web page, to support synchronous sessions aimed at enabling 'authentic PBL' to occur amongst distributed first/second year medical students and a tutor. Koschmann et al. [16] introduce a method of conducting PBL meetings between students and tutor in a face-to-face context, using connected individual laptops and a large shared display. This approach is close to that found in PBL meetings not supported by computers, but offers some advantages: parallel polling (to ascertain each group member's views before they hear the ideas of others); and a record of contributions.

Computer support for PBL may, or may not include actual cases within the program: students may be collaborating about computer-presented cases, or interacting through the computer environment about externally introduced cases. External cases may be provided by the tutor off-line, or may be drawn from a database of patient cases (e.g. PATSy [19]). Systems to support PBL may help to structure and focus PBL discussions. However, even where such systems are available to a student, we believe that additional support is needed by some learners, to help them cope with the PBL situation if they feel uncomfortable with some aspects of it.

While it is acknowledged that many learners benefit from collaborative work, it is also the case that collaboration will not suit all learners; or a particular instantiation of a computational or non-computational collaborative learning environment may not suit a learner who could potentially gain much from collaborative interaction. Thus more flexible means of facilitating peer interaction would be useful. This kind of support will differ from that provided by systems such as the above: students who find the PBL approach difficult may find it useful to be put into contact with a peer who can share experiences about specific aspects of PBL.

An increasing number of peer help systems are attempting to organise learner interactions according to the student models of the individuals concerned – i.e. they have a matchmaking component; or by learner selection of available helpers. The matchmakers in such systems can take account of a variety of factors, but they most often look at students' relative proficiencies in the target domain. A few examples are given below.

An example of a peer help environment is that of Yu et al. [31], where more advanced learners act as mentors. Mentors are selected according to their knowledge, with reference to the following criteria: students who have successfully completed the course; students with high grades in other courses; students who have finished assignments; students who have successfully completed the computer-based tasks about which others need help; teachers and teaching assistants. The assumption is that the group of mentors and the student group do not overlap (though Yu et al. suggest extending the system to allow student-student help). Students select mentors based on availability (mentors may be involved in up to three help sessions); and the current problem (mentors may only help on one problem area at a time).

The above example has the advantage that learners choose to receive help when they need it, and are not forced into a collaborative context if they prefer not to participate. Further, they are guaranteed a knowledgeable helper. Nevertheless, there are drawbacks to this approach outside the setting for which it was designed. The set-up is very rigid: currently only externally acceptable (i.e. tutor-selected) individuals may be mentors. This does ensure that helpers are knowledgeable, but it does not require that they are good helpers. It also does not take account of the fact that students may benefit educationally from giving help, as well as receiving it.

Hoppe [14] proposes integrating knowledge from individual student models to support group learning – i.e. to parameterize group learning. One of the benefits is that peer helpers may be selected for help sessions: a knowledgeable helper can be partnered with a less knowledgeable student. In Hoppe's work this occurs as follows: a learner issues a help request; a menu of potential suitable helpers is offered; the learner selects their choice of helper; the selected helper receives the help request; the helper accepts or rejects the request. This approach is claimed to avoid personal conflicts, as helpers are neither assigned, nor must they interact directly with the helpee if they wish to refuse. It also allows all participants the opportunity to be helpers, as long as they know about the topic. It does not guarantee, however, that selected helpers will be proficient at helping.

Ogata et al. [22] extend this notion of peer help networks, taking into account pre-existing social networks amongst individuals, claiming that these are at least as consequential in a help context, as more official organisational structures. Ogata et al.'s approach allows users to register their proficiencies and social networks, and it also automatically traces user relationships by logging email exchanges. This provides additional information on personal networks, and also on abilities of the user: if an individual answers a question posed by a peer, the helper is assumed to be knowledgeable. These relationships are taken into account when matching potential helpers with those requesting help.

The above approaches allow peer interactions to be initiated by a learner, as required. Helpers are contacted, and may choose to take up or reject interactions. The first example [31] does not require extensive student models, but is quite restricted. The second example [14] expects student models to be in place, though overlay models are sufficient to indicate knowledge levels of individuals. The final example [22] does not require detailed models of knowledge, since it relies on social closeness and self-evaluations together with assumptions about competence based on question keywords in a help request, that has been responded to by the individual being modelled. However, what is not present in these approaches is an ability to match students according to their preferences of interaction method, or individual cognitive style, or to take into account a helper's ability to *help*. Such issues may be just as important for peer interaction to be successful.

The following section describes I-Help: an environment based on multiple user models, to match students who have help requests with potential peer helpers. I-Help aims to accommodate a broader range of characteristics that might be important when pairing learners. Suggestions of how I-Help might be usefully applied in PBL are then given in Section 4. This includes the more common face-to-face PBL context, and use alongside software to support group interaction in PBL, such as described at the beginning of this section.

3 I-Help

I-Help is the integration of several information/help sources brought together through the metaphor of a help-desk [12], designed originally for large student groups. The two principal components are an asynchronous public discussion forum [3], and a one-on-one private discussion facility which may be used synchronously or asynchronously. In the case of the private discussions, multiple distributed user models are used [20] to match students who can help each other in their learning. Each user has a personal agent which uses its owner's student model as a source of information for negotiating help sessions with other users, through their respective personal agents [28]. (Some examples of agent personas are shown in Figure 1.) The following illustrates the sequence of events for a help request. (For an example see [11]).

1. A student contacts their agent to issue a request for peer help;
2. The student's agent negotiates with the agents of other learners, to find appropriate helpers;
3. The top five user-matches are emailed that there is a help request waiting for them in I-Help;
4. To ensure maximum immediacy of response, while not duplicating effort, the first helper to accept the request starts a one-on-one discussion. Requests to other potential helpers are thereby cancelled;
5. Upon completion of discussion, each learner receives an evaluation form through which they evaluate their partner, for student modelling purposes.

The I-Help student model is composed, as stated above, in part from peer evaluations given at the end of a help session by both helper and helpee, about the knowledge of the other participant. The student model also comprises self-evaluations of knowledge level in each of the domain areas. In addition, helpees rate the utility of the help received. Social issues are also considered: learners can add users to their 'friends' list–i.e. people with whom they will preferentially interact, be they 'real friends' or people they do not know, but who have been helpful to them in the past. Students may also add individuals to their 'banned' list–people with whom they wish to have no further dealings. Much information for the student model is easily captured, since it is user-given. It is continually updated as peers evaluate help sessions once they are completed.

Also modelled are individuals' cognitive styles. The identification of cognitive style is based on Riding and Cheema's classification [26], which comprises two dimensions: wholist-analytic and verbal-imagery. The wholist-analytic dimension refers to the extent to which an individual usually *processes* information in *wholes* or separate *parts*; the verbal-imagery style relates to the degree to which an individual tends to *represent* information during thinking in a *verbal* or *image* form. In I-Help this information is provided through a front-end questionnaire. The questionnaire is very short, designed for students who may not themselves be interested in the outcome. The aim is to encourage learners to provide at least some information. While recognising that this is not ideal, partial cognitive style information is considered preferable to no information at all.

Five question types were identified, requiring different cognitive style combinations of helper and helpee:

1. *How does this fit with other things?*
   The first choice of helper for this type of question is a wholist, regardless of the cognitive style of the helpee, because wholists will tend to be better equipped to provide a broader overview.
2. *What are the details of...?*
   For this question type an analytic helper is preferred, regardless of whether this matches with the cognitive style of the helpee, because analytics tend to grasp the details of a topic more readily than wholists.
3. *Can you recommend any good materials for...?*
   The aim is to match individuals on the verbal-imagery dimension, since a verbal learner will more likely recommend materials helpful to another verbaliser, and an imager will do likewise for another imager.
4. *Miscellaneous question*
   This category covers any questions not included in the above. The default is to match all learners on the wholist-analytic dimension. If possible, learners are also matched on the verbal-imagery dimension.
5. *Questions requiring simple answers*
   No cognitive style matching is undertaken for straightforward questions requiring a simple answer, as cognitive styles are likely to have little impact here.

When submitting a help request, the learner indicates the question type from the above selection.

In addition to self and peer user-given information, learner models are updated automatically based on observations of eagerness (browsing and active posting behaviour in the public discussion forums, and amount of help given in private discussions). Furthermore, personal agents note which cognitive style matches seem most successful for different question types, and update the user model accordingly. (This also helps to overcome potential inaccuracies in the initial self-report.) Figure 1 illustrates the sources of information for the student model (open arrowheads), and the differences between private and public discussions. In the private discussions a learner interacts directly with a single peer in each dialogue, to give and receive help. Public discussions take place in forums – there is no direct interaction between two people (solid arrowheads).

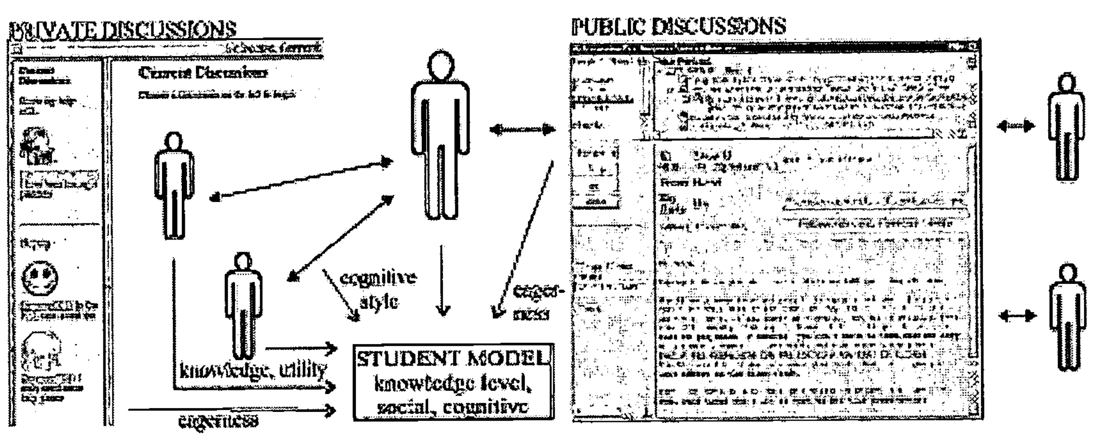

Figure 1: I-Help public and private discussions

In seeking partners, a personal agent tries to balance all relevant information (knowledge level of helpers; helpfulness of helpers; eagerness to help; preferential friends; exclusion of banned people; appropriateness of cognitive style). By default these issues are given equal weighting, but the learner may re-rank each component, as is important for them. For example, some learners may have more flexible cognitive styles. For such students, style may be a relatively unimportant factor. Other students will have more difficulty adapting to someone else's way of learning, and will assign greater importance to cognitive styles – perhaps even preferring this kind of match above the requirement that a helper should be very knowledgeable.

A variation on the peer help scenario involves permitting students to choose the kind of interaction they want, based on the S/UM system [4]. In addition to peer help, students may seek: peer feedback about work drafted or completed; collaborative learning; cooperative learning (i.e. X learns A & Y learns B, followed by tutoring or reporting). In addition to peer help, this allows students who wish to learn collaboratively or cooperatively the opportunity to find the most suitable partner. When a user sends an interaction request, they specify the kind of interaction they are seeking. Their agent negotiates a match with someone who also wishes to interact in that manner, and who has appropriate characteristics (e.g. a helper should have greater proficiency in the topic than the helpee; a collaborative partner should have a similar, non-expert, knowledge level).

In summary, the utility of I-Help increases with the number of users, as good matches become more feasible. Much of the user modelling is performed quickly and naturally by users (self- and peer-evaluations), and these models by themselves are sufficient even early during interactions, before additional system modelling has occurred. Student models contain content, cognitive and social information, which can be ranked in order of importance by learners. Further, I-Help can easily be applied across a broad set of courses: all that is required is a course description (in the form of course component labels) to be provided by the course tutor. Knowledge levels represented in user models, to contribute to matchmaking, are then related to these labels. Apart from reducing the load on tutors, from students requesting information, there are three major educational benefits:

- Students receive help when they have difficulties;
- Students learn through encountering the possibly conflicting viewpoints of others;
- Students will necessarily reflect on an issue when giving help on it.

Thus it is not only those receiving help, who benefit.

4 I-Help in problem-based learning

Due to the nature of PBL, students undertake a lot more research than traditionally educated learners, relying less on teacher-recommended texts. Many students use electronic resources more heavily than other resources [8], and they also use general library resources more extensively than their traditional counterparts [2]. I-Help provides additional human resources, forming a natural extension of this situation, and is likely to be useful to many students in PBL during the research phase. However, in this paper we focus on supporting those students who are uncomfortable with some aspects of the PBL approach itself.

Since PBL is focussed around small pre-established peer groups it is less obvious how I-Help might be applied, as opposed to in larger, traditional classes for which it was originally designed. Nevertheless, as illustrated in the following description, there are a number of situations in which I-Help could be useful in PBL.

There are a variety of potential difficulties to take into account in a PBL course. For example:

- It can be difficult for some students to find time to meet outside scheduled class hours;
- For a group to function effectively, individual team members should all be involved in group discussions;
- Students may not fully understand their role in the group;
- Students may lack the skills to make group interactions work;
- Students have different interaction preferences;
- Students have different cognitive styles.

Considering the first two of these issues, the public discussion forum of I-Help is a useful tool to keep all students in contact with their own group's discussions, but also allowing interaction between particular group members, should help or clarification be needed by some participants, on some group issue. At the same time, all students remain up-to-date with all interactions, at a time that suits them, thus freeing up part of meeting times for questions and group issues less easily handled through computer interaction.

Perhaps more unusual in the PBL context: there may be occasions when students could usefully interact *across* groups. As suggested above, it is not the aim to exclude any group members from any interaction important for group progress, but there may be situations where individuals from different groups could help each other, on issues perceived as not directly relevant to either group as a whole. For example, in some PBL contexts the various roles are divided amongst group members, often rotating. In such situations it might be helpful if individuals from different groups who are performing the same role (e.g. scribe; group leader; information analyst), could interact – especially if it is early in the rotation, and there is less group experience on which to draw. It will also be helpful for students finding their role difficult, who are part of a group whose members do not appreciate the learner's problems. Their personal agent could locate a helper who has successfully fulfilled the responsibilities of the role in the past, or find another student with similar problems, with whom they can jointly explore aspects of the role. Where the whole group acknowledges a lack of understanding of any role, one of the group members may seek outside assistance on behalf of everyone.

I-Help's user models must therefore be extended to include information about student roles. I-Help must know the current role of individuals, in order to put students in touch with others facing the same tasks; and it should also remember the roles that individuals have previously held, and whether they were competent, and whether they are willing to offer help to novices in these roles. I-Help may then be used to pair individuals in interactions relating to role responsibilities, keeping such interactions amongst those for whom the discussion is currently relevant and/or helpful. As more students come to perform each role, previous help session archives may be accessed as help resources. In this manner, it is hoped that more students may develop an understanding of how to meet their various responsibilities, resulting in improved group functioning.

It has been commonly noted that many students entering the medical sciences do not possess the skills necessary for effective group interaction in PBL – e.g. discussion, decision making, conflict management, leadership, group feedback processes [24]. Although I-Help does not teach these skills, its ability to match students with others who are in a similar position, or who are able to help, provides a form of support not usually available. If a single individual has problems, the other group members may be able to compensate while also supporting the learner's development of the skill concerned. However, where group members recognise a general deficiency, they may use I-Help to put them in contact with a group that functions effectively with regard to the particular skill. They may be invited to observe, as the efficient group models the behaviour during their next meeting, or one of the effective group members may describe how their group tackles these issues. This will be especially useful where there are no resources (e.g. time, staff) for skills training.

Again the I-Help student model must be extended, to accommodate information about group interaction skills. This will involve all groups in a group evaluation process in order that they may provide skills information for the user model, which in itself will be a useful reflective activity. The main difference in the structuring of the model in this case is that skills information will relate to *group* functioning, and not to specific group members. Thus I-Help must also know which students belong to which groups. Skills information need then only be given by one learner.

A potential difficulty encountered by a student who might otherwise do well in PBL is that other group members may have different interaction preferences: some students gain much from brainstorming or spontaneous discussion, while others prefer to reflect and organise their thoughts before communicating. The combination of face-to-face meetings and the public discussion forums helps to cater for all students, while the possibility also exists to arrange collaboration, cooperation and feedback through the private discussions.

Students also have different cognitive styles. Some individuals understand verbal descriptions well, while others need pictures, diagrams, or demonstrations. Some learners deal well with abstract concepts and detail, while others tend towards a more general overview. Although a mixture of cognitive styles might sometimes be complementary in a group setting, and have a positive effect on group performance, some cognitive style combinations may lead to difficulties for some individuals. For example, if most members of a group are analytic, a wholist learner may have difficulty gaining the overview perspective they require to integrate information. Such an individual might find the situation very difficult as a learning experience. It is also possible that the other group members will not understand their difficulty. This is a problematic situation since all group members should be involved in group communications for a group to feel comfortable and function well. Full participation is essential in some groups to avoid resentment by other group members if they feel that one person is not contributing. I-Help private discussions should not, then, be used as an alternative to group interaction, as the group may suffer as a result. However, for students who have problems adapting to the way the other group members work, I-Help may provide a much-needed 'lifeline' by matching them with a student with a similar cognitive style, to support their PBL activities in a 'more comfortable' fashion. Thus they will continue to interact with their group to the best of their ability given the difficulties they experience, but they may also work with another learner outside the group context if they feel this to be useful. This need not detract from the group experience as a whole, since the learner may report back any findings. Taking the above example, such an individual's contribution may now be greater, since they will be able to provide the overview that the analytics lack. Therefore their group contribution may be stronger than any earlier contributions where they had not had this additional learning opportunity, and were interacting only within the confines of the particular group's interaction dynamics.

This section has suggested a number of ways in which I-Help might be useful in PBL. It is not suggested that all PBL students should use it (though the public forum is likely to be generally useful), but that I-Help could arrange peer support in cases where an individual is having difficulties with some aspect of the PBL approach.

Although it does not address the problem of group learning for an individual who prefers to learn alone, or in a different kind of group situation, it does at least provide them with some support that they would otherwise not have.

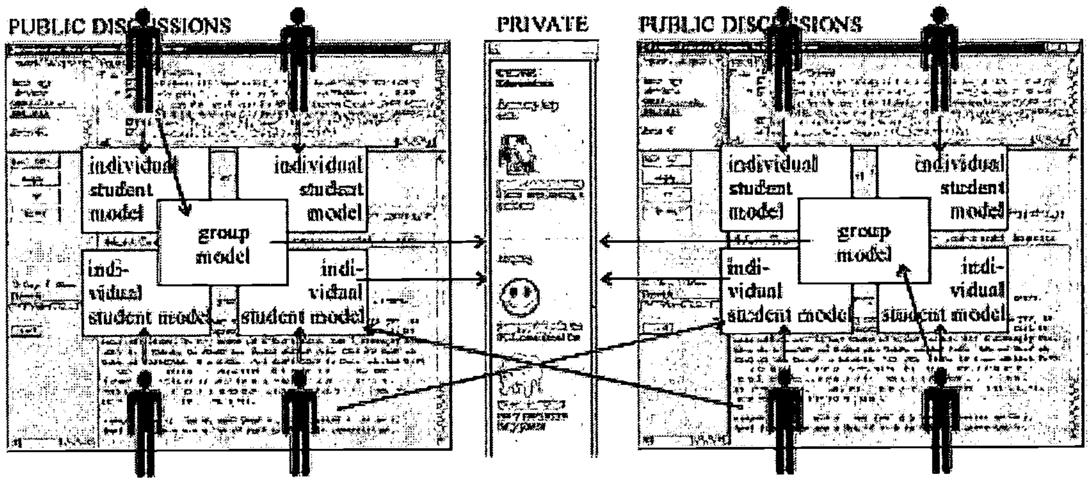

Figure 2: I-Help in problem-based learning

To introduce I-Help to the PBL setting, some additions to the user models are necessary. However, these are very easy to implement, having simplicity in common with the present representations. Currently I-Help user models contain: a quantitative measure of knowledge levels in the various domain areas; a quantitative indication of helpfulness; a quantitative measure of eagerness; a list of friends; a list of banned people; identification of cognitive style; a list of preferred interaction types. The additional information proposed above comprises: a list of roles successfully performed previously (to be added by the individual); the current role of the student (also added by the individual); a list of group membership (provided by one group member); a list of group skills (based on group evaluation, the result of which is entered by one group member). Thus minimal extensions could provide essential support to learners having difficulties in PBL. Provision of this information by students should also encourage them to think about factors that help to make group interaction successful.

Figure 2 illustrates how I-Help can support learners in a PBL setting. Students and peers provide student model information as occurs in large group uses. I-Help also performs some user modelling as described previously. The main difference with I-Help in PBL is that interactions for each group are focussed primarily around public discussions, with each person communicating with other members of their own group. There is less use of the private discussions. Where private discussions do occur, matching takes place according to the student models of individuals in the manner described in section 3. In addition to individual models, in PBL group models are required in order that groups may also be brought together where difficulties are recognised by the group as a whole. Information for the group model is obtained from one of the group members.

5 Conclusions

I-Help was initially designed to promote peer help amongst a group of learners in a large class situation. Some minor extensions to the system were suggested, to enable it to be effective also for students in PBL. Despite many successes claimed for this kind of collaborative interaction, not all students will function at their best with this type of curriculum. In this paper we focussed on PBL in medical education, but the arguments should be equally applicable to other academic disciplines and small group contexts, as long as the overall student numbers are large enough to enable sufficient choices of appropriate partners for cross-group interaction.

In addition to large and small group formal educational settings, I-Help might also be used beyond the classroom to support medical practitioners. For example, while some contexts have adequate funds to implement elaborate means of telemedicine (e.g. the U.S. Army [1]), remote areas which might benefit from access to various forms of telemedicine often find that the low population density does not provide sufficient demand to justify the expenditure required [25]. In rural locations a system like I-Help would provide a low cost means of obtaining expert help at least for some cases. Furthermore, practitioners requesting assistance do not themselves need to know who is the best person to contact. Similarly, I-Help might be useful in putting into contact physicians who would like to hear experiences of other practitioners. For example, where ethical considerations are important to a case, such as conflicts between medical advice and parental beliefs [7]. I-Help might also be used alongside diagnostic decision support systems in cases where physicians remain unsure about hypotheses, since the advice offered by such systems may sometimes be misleading [9]. Experience with I-Help at university should encourage more individuals to register once they graduate and specialise.

Acknowledgements

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Promoting Student Learning and Development in Computer-Based Cooperative Learning[1]

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The purpose of this study was to determine the impacts of different types of external contingency built within computer-based cooperative learning on student learning outcomes, and to further investigate whether various cooperative strategies produced discernible efficacy for male or female students. A 3X2 factorial design involving nine intact classes was adopted. In total 341 fifth-graders in Tainan City constituted the sample. Participants randomly assigned in dyads worked through three originally developed computer-based science programs for three consecutive weeks. Posttests and a post-session self-report questionnaire were used for data collection. Results indicated that students in cooperation with inter-group competition condition performed significantly better on posttests than students in cooperation without inter-group competition or cooperation with inter-group cooperation condition. Results also revealed that inter-group competition enhanced student attitude toward the subject matter studied better than the other two goal orientation structures. The results of this study, however, failed to show that inter-group competition within cooperation negatively influenced peer relations, and that the more pervasive the cooperation, the greater the interpersonal attraction. Lastly, females performed significantly better their males in academic achievement, and perceived their peers more positively than males. Based on the results yielded from the present study, it was suggested that embedding inter-group competition within computer-based cooperative learning situation might be an effective alternative instructional strategies to adopt so as to maximize performance and affect without sacrificing social benefits of cooperation.

Keywords: **Cooperative learning, Computer-based instruction, Competition, Learning outcomes.**

1 Introduction

The topic of how to group students to work together effectively and efficiently has been under heavy investigation in the past decades. Research findings tend to support the use of cooperative learning, as compared to competitive, or individualistic instructional methods [2, 10, 12, 15, 18, 19, 22]. Since then, several cooperative learning models have been developed and used by researchers and practitioners in an attempt to maximize student learning with the support of peers. The models vary in a number of respects. One of the dimensions in which the models vary lies in whether they embed the element of competition in their cooperative learning structures.

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Competition has been suggested as one effective alternative to increase the motivational appeal of initially uninteresting, or overly simple educational activities, and as a way to foster learner involvement and excitement in the activity [17, 25, 26]. Adding an element of competition between individuals or groups is widely believed to be a motivational-enrichment strategy in play, work, and education [3, 4, 17]. Commonly held opinions aside, several researchers have examined the effects of cooperation with versus without inter-group competition on educational outcomes. Some have found that positive effects for achievement, motivation and/or interpersonal relationships when competition was not implemented within cooperative learning environments [5, 6, 8, 11, 16, 24, 27], whereas others have reported the opposite or that cooperation with and without inter-group competition was equally effective [6, 16, 20, 25, 28]. As the evidence is limited and mixed, at best, and the majority of existing research on this area were done in traditional classrooms with Non-Asian Students; thus, one main focus of the present study was to test whether embedding an external contingency of the element of inter-group competition into computer-based cooperative learning would promote student learning and development.

In addition, based on their 1986 findings on interpersonal relationships, Johnson, Johnson, Warring, and Maruyama leaned toward the position that the more pervasive the cooperation, the greater the interpersonal attraction. Therefore, the author was interesting in finding out "would increasing widespread peer interaction and tutoring among all learning groups via establishing an external contingency of the element of inter-group cooperation within cooperative learning enhance student cognitive and affective outcomes as well." Hence, a second focus of the present study was to investigate the impacts of cooperation with inter-group cooperation on student learning outcomes as compared to cooperation with inter-group competition versus cooperation without inter-group competition condition.

Finally, as competitive learning has been reported to have an especially negative impact on female student achievement and attitudes toward the subject area being studied [12, 13], any interaction effects gender differences might have with different treatment conditions were also examined in the present study. In summary, the study intended to examine the effects of gender difference and different types of external contingencies introduced within computer-based cooperative learning on student academic achievement, attitudes and interpersonal relationships.

2 Method

2.1 Design and Participants

A 3x2 factorial design was used for this study, with learning strategies (cooperative with inter-group competition, cooperative without inter-group competition, cooperative with inter-group cooperation) and gender (male versus female) as the independent variables. The dependent variables were performance, attitude toward the subject studied (i.e., science), and interpersonal relationships both among and within the dyads.

Due to scheduling and other administrative problems, nine classes (N=341) randomly selected from one elementary school in Tainan were randomly assigned to different treatment conditions. All subjects were attending a weekly 40-minute computer literacy class and were being taught basic computer skills such as word processing, graphics and Internet surfing at the time of the study.
In all treatment conditions, students were randomly assigned to groups of two to work on computers. In the study, students participated in three instructional sessions in three consecutive weeks. The first session was essentially a training session on cooperative learning techniques aiming to help prepare all participants to work cooperatively with dyads on computers and be familiarized with navigating buttons and tools in the modules.

2.2 Materials

Three computer-assisted instructional modules on science topics were developed for the study. The first module dealt with "Recycling and Its Impacts on Environments." The second module dealt with "Seed Structure and Germination." The third module dealt with "Movements of the Earth and Four Seasons." All the modules were field tested prior to the actual study with a small group of fifth graders ranging from high to low computer and academic abilities. Revisions were made accordingly to ensure clarity for subjects and ease of navigation.

2.3 Experimental Treatment and Procedures

All treatment conditions incorporated essential cooperative elements, such as, positive inter-dependence, face-to-face interaction, and individual accountability [9, 21]. Positive interdependence was established by averaging dyads' scores on posttests. Face-to-face interaction was promoted by instructing dyads to discuss information and their responses to practice items. Individual accountability was established by having each member of a dyad independently complete the posttests upon completion of the second and third module. Conditions for different treatment conditions were set up as follows.

In the cooperation with inter-group competition condition (Treatment A), the component of competition was intentionally introduced, and emphasis was placed on which groups would achieve the top three highest scores on the posttests in the class. Students in different teams were instructed to work cooperatively with their dyads to ensure that everyone on the same team understood and learned the material presented by the computer, while, at the same time, competing against other teams in the class to be among the top three highest scoring teams based on the posttest score. The members of the final winning teams would all receive a "surprise prize" at the end of the session. To further emphasize the competitive nature of the learning situation, posters with words like "Be the best" were placed around the computer lab.

In the cooperation without inter-group competition condition (Treatment B), no element of competition was introduced in the learning process, and emphasis was placed on how well the learning group would achieve on the posttests using a fixed standard of performance for excellence. The student dyads were encouraged to share information and ideas with their dyads to master the assigned contents so as to reach the excellence level. Dyads' average score on the posttests being at least eighty points (i.e., answering at least sixteen out of twenty test items correctly) was the standard for excellence for this treatment condition. If the learning group would score at an average of at least eighty points based on the average of the posttests, each member of the dyad would receive a "surprise prize" after completion of the experiment. To further emphasize the cooperative nature of the learning situation, posters with words like "Work cooperatively with your teammate to reach the excellent level of performance" were placed around the computer lab.

In the cooperation with inter-group cooperation condition (Treatment C), emphasis was placed on how well the entire class would achieve. Like the cooperation without inter-group competition condition, no element of competition was introduced in the learning process, and a fixed standard of performance for excellence was introduced. However, the entire class scores, not mere the individual dyad's scores on the posttests, were used as the basis for determining whether the excellence level of performance was reached. An average score on the posttests being at least seventy points (i.e., answering at least fourteen out of twenty test items correctly) was the standard for excellence for this treatment condition. If the entire class scored at an average of at least seventy points based on the average of the posttests, the entire class would receive a "surprise prize" after completion of the experiment. To further emphasize the cooperative nature of the learning situation, posters with words like "Work cooperatively to reach the excellent level of performance" were placed around the computer lab.

An instructor's guide including complete oral script as well as an orientation training program was provided to two implementers to ensure experimental fidelity before initiating the treatments in the classroom. Moreover, a pilot study was conducted prior to this study to determine whether the experimental procedures and measurement instruments were reliable and appropriate.

2.4 Criterion Measures

Two 20-item, multiple-choice written posttests and a 38–item post-session self-report questionnaire with established reliability and validity were used to test the differential effects of the three treatment conditions on student academic achievement, attitudes and interpersonal relationships.

2.5 Data Analysis

Data were analyzed using the 3x2 analysis of variance technique (ANOVA) on each of the dependent variables. Scheffé multiple comparison tests were conducted when a univariate test indicated a significant main effect for different learning strategies. Alpha was set at .05 for all statistical tests.

3 Results

3.1 Performance

Based on the data analysis conducted on posttest scores, the study found a significant main effect for type of cooperative learning strategy, $F(2,310)=7.726$, $p<.001$, and gender, $F(1,310)=12.213$, $p\leq.001$. ANOVA did not reveal an interaction between learning strategy and gender. Scheffé multiple comparison tests revealed that subjects assigned to cooperation with inter-group competition (M=55.5446) performed significantly better on posttests than those assigned to cooperation without inter-group competition (M=47.5227) and those assigned to cooperation with inter-group cooperation (M=49.0714).

3.2 Attitude Toward Science

According to the data analysis conducted on attitudes toward science, the study found a significant main effect for types of cooperative learning strategy, $F(2,319)=12.283$, $p<.001$. ANOVA did not reveal an effect for gender or an interaction between learning strategy and gender. Scheffé multiple comparison tests revealed that subjects assigned to cooperation with inter-group competition (M=49.0392) rated more favorably toward science than those assigned to cooperation without inter-group competition (M=44.4414) and those assigned to cooperation with inter-group cooperation (M=41.2054).

3.3 Interpersonal Relationships

Data analysis done on subject perception toward their own dyad revealed a significant main effect for gender, $F(1,314)=15.576$, $p<.001$. ANOVA did not reveal an effect for type of learning strategy or an interaction between learning strategy and gender.

Finally data analysis on subject perception toward other dyads yielded a significant main effect for type of learning strategy, $F(2, 314)=4.018$, $p<.05$, and gender, $F(1, 314)=35.751$, $p<.001$. ANOVA did not reveal an interaction effect between learning strategy and gender. Scheffé multiple comparison tests revealed that subjects assigned to cooperation with inter-group competition (M=40.4700) perceived other dyads more positively than those assigned to cooperation with inter-group cooperation (M=37.5804).

4 Discussion

Results of the study indicated that students assigned to the cooperation with inter-group competition condition performed significantly better on posttests than students assigned to the cooperation without inter-group competition or cooperation with inter-group cooperation conditions. In addition, results of the current study also revealed that different types of external contingency built within cooperative learning had a significant influence on subject attitude toward science. Subjects that received cooperation with inter-group competition reported significantly more positive ratings toward the subject matter studied (i.e., science) than those in the other two treatment conditions. The beneficial effects of inter-group competition within computer-based cooperative learning on participant performance and attitudes found in the present study corroborated with other studies with different types of learning tasks and subjects ranging from college students to high school students to elementary students [6, 16, 20, 25, 28].

While learning strategy influenced significantly subject performance and attitudes in this study, it did not have a significant impact on student perception toward their own dyads. The non-significant results of this study provided empirical evidence for Bossert's 1989 argument that cooperation with inter-group competition maximizes performance without sacrificing social benefits of cooperation [1].
Furthermore, subjects in the cooperation with inter-group cooperation condition scored significantly lower on posttests, attitudes toward science and perception toward other dyads than subjects in the cooperation with inter-group competition and/or cooperation without inter-group competition conditions. The obtained result was somewhat surprising, especially in light of Johnson et al. 1986 study that indicated, "the more pervasive the cooperation, the greater the interpersonal attraction" [14]. The results of this study did not support the work of other researchers who reported that inter-group cooperation was better for performance and/or interpersonal relationship among the learning groups [7, 14, 23]. The decreased academic, attitudinal and social gains might be explained through direct observation. Observation noted that dyads interacted mostly with their partners during the instructional sessions and rarely cared for comments or

suggestions from other dyads. To attain their personal goal, dyads in the cooperation with inter-group cooperation not only needed to assist their own dyads to excel, but also was held accountable for other dyads in the class. This kind of arrangement, for most participants, was "too much of a task" that they never exposed to before, as aired informally during class sessions.

Though encouraging widespread peer interaction and tutoring among all learning groups via adding an extra element of inter-group cooperation into cooperation situation, theoretically speaking, might have a positive effect on student learning, it did not enhance participant cognitive, affective and social gains in the present study. Contrary to the researcher's expectation, inter-group cooperation negatively influenced participant performance, attitudes and perception toward other dyads. It was possible that longer experimental period might allow participants to get accustomed to this kind of arrangement so as to benefit from constructive interactions among the learning groups.

Lastly, the current study found that females outperformed males and perceived their classmates more favorably in all treatment conditions. The obtained results that the inclusion of inter-group competition within cooperation did not negatively influence females' cognitive and social gains in this study was understandable considering the fact that all treatment conditions of the study emphasized the importance of "cooperative behaviors." The potential negative effects that competition might have on females' learning and development might be somewhat mitigated by cooperative encounters cultivated continuously within the learning groups in all treatment conditions.

5 Conclusions

In the present study, competition within computer-based cooperative learning environments was found to maximize performance and affect without sacrificing social gains. Based on the results yielded from the present study, it was suggested that embedding inter-group competition within computer-based cooperative learning situation might be an effective alternative instructional strategies to adopt. There are, however, several limitations on the interpretation and generalization of the results of this study. Firstly, because it was implemented in a naturalistic classroom setting, it was not possible to randomly assign individual subjects to different treatment conditions. Though at the beginning of the first, third and fifth year of the participating school all subjects were re-assigned to different classes to make every class comparable to each other, classroom differences might have confounded the study's findings.

Secondly, the restrictions of time only allowed students in the selected school to participate in three instructional sessions for the study. The time constraints might not have allowed the full influence of cooperation with inter-group cooperation to manifest its beneficial effects on student learning and development.

In spite of this study's limitation, it provided practical information regarding the efficacy of different type of external contingencies within computer-based cooperative learning situations. Future studies employing longer periods of experiment time and random assignment of subjects into different treatment conditions may be desirable. Finally, as the present study tested mainly recall and memorization in science-related topics and employed only fifth-graders, studies involving different types of measures, content areas as well as populations may be needed to warrant wider generalization.

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Proposal of an XML-based Knowledge Sharing and Management System Supporting Research Activities

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The proposed system is primarily focused on research activities which create various kinds of knowledge through trial and error. The knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is easily utilized for research activities, because they are accumulated as visible data. However, the latter is not utilized in many cases even if they are informative and useful. Therefore, a web-based management system giving attention to un-formalized knowledge as well as formalized information would be a possible solution. This paper describes the features of the system based on the XML, and shows an example of usage through a trial system. Functions of the system include: (1) collecting un-formalized information related to formalized knowledge, (2) connecting un-formalized knowledge with formalized knowledge, and (3) creating feedback information while using the system. The system creates a repository in a lab, a collaborative space for research activities, and a set of new document and knowledge.

Keywords: **Research Activities, Knowledge Sharing and Management System, Formalized/Un-formalized Knowledge, XML**

1 Introduction

Researches on system environments that share knowledge on the Web have increased because of the needs for accumulating and utilizing knowledge [3][8]. Specially aiming learning activities, the Covis [1], for example, visualizes processes of collaboration between users, and memorizes the processes through the Covis Collaboratory Notebook. Another example is the CSILE [4][9] with networked computer environment particularly designed to support progressive discourse. In CSILE, students write text or graphic notes to convey their explanations. Similarly, the KIE [6] have collaborative environments that make network discussion possible by using the interface called Netbook. Users of the Shrlok [2] also have shared knowledge environments. They can discuss their opinions in an opened condition and make hypertext links between relevant knowledge. Thus, users of these four systems can exchange their own opinions and argue their individual ways of thinking, based on ideas and questions stored in the Database (DB) system [7]. Therefore, in these four systems, students can be subjective while having clear objectives. Teachers can also help students solve problems, and students can collectively work on problems.

The process of advanced researches, on the other hand, is not the same as that of education because researches might not always have definite objectives. In many cases, new things can be discovered from one trivial thought, and researchers enlighten and encourage each other. Individual studies can be more important in a condition where there is no instructive person who clearly knows and ultimate goals. Although research activities have a different characteristic from education activities that have clear goals, few studies aiming research activities have been discussed.

This paper proposes an XML-based knowledge sharing and management system. It focuses on an accumulative style of knowledge management for supporting research activities, rather than for learning.

The activities in a laboratory produce various kinds of knowledge by repeating trial and error. That knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is accumu lated as visible data in the form of paper material or digital data. On the other hand, the latter is only spoken and is not represented in the real material. Therefore most of that information is not recorded. However, it is important to accumulate and share the un-formalized knowledge because live suggestions or advices are often very useful to promoting research activity. Their accumulation is useful for participants to remember knowledge and also for peer that cannot attend the discussion process.

Thus, we focus on this un-formalized knowledge. By making the un-formalized knowledge active as memorandums and by connecting them with meta-data of formalized knowledge, the proposing system creates a new set of knowledge documents, Knowledge DB. Proposing system allows users to produce feedback information while using it. The system by using the XML could effectively help research activities. Finally we provide some considerations on the prototype system.

2 The outline and features of knowledge sharing and management system

Chapter 2 summarizes the features of the proposal.
The system consists of the following three steps.
(1). It attaches un-formalized knowledge with formalized knowledge, for example paper and reports, as memorandums.
(2). It connects the above information with meta-data of formalized knowledge.
(3). It utilizes connected knowledge and feedback the information.

If more than two documents share the same information, they are connected through a memorandums. That is to say, the memorandum connects clearly the original documents existing independently in DB. Such connections are useful for the documents retrieval and research analysis. Further, continuous cycles of connection, searches and analyses can be occurred, which assemble a lot of knowledge and information.

At this time, the trial of this system is focuses on Research DB. However, it is reasonable that fundamental policy is not changed even if the DB is changed, because XML is used for exchanging between applications and our system process only the meta-data.

Three advantages of the system are:
- It provides auxiliary information for user's document retrieval by attaching a memorandum to original documents.
- The original documents are related with each other by the connection with the memorandums, and it creates a new document set.
- It supports continuous research activities for users to analyze sets of information and knowledge.

3 Adoption of XML technology

Chapter 3 discusses advantages of the XML, which is one important characteristic in the system.

We adopted the XML, a standard language for information exchange, for two reasons. The first was the need to do knowledge management on the Web because the sharing space accumulated knowledge can be accessed anytime and anywhere. The second was the need to consider the connection with another advanced DB, such as CG and 3D data. Thus, the system would be more flexible because of the XML.

Effectively, the XML is used in two aspects. One is as a way for exchange between DB and systems. The other is for the preservation of information, including the XLink function [10]. Considering that memo randum and data items can change in near future, XML has several advantages: It can set flexible data lists, and express arbitrary number of elements in a tree structure [5].

4 The system configuration

Chapter 4 shows the configuration of the system.

The system consists of three main parts: (1) Sets of Knowledge-Memos, (2) Knowledge processing system, and (3) Interface for knowledge sharing on the Web. (Fig.1). The role of the part (1) is collection and accumulation of knowledge. Part (2) connects two kinds of knowledge. Part (3) relates to the interface for users. The followings sections present their details, respectively.

4.1 Set of Knowledge-Memos: Collection, accumulation of the memorandums

The system needs to collect un-formalized knowledge, such as advices or suggestions from teachers and researchers, even though they are not in any form. Thus, the style of memo randums to formalized knowledge, like papers, are adapted. This chapter presents the concept of "Knowledge-Memo".

4.1.1 The proposition of the Knowledge-Memo concept

The system adopts concept of memorandum called "Knowledge-Memo", in order to collect un-formalized information. We classify Knowledge-Memos into two types to be attached to the original documents in accordance with their natures. In this way, layers of un-formalized knowledge can be created.

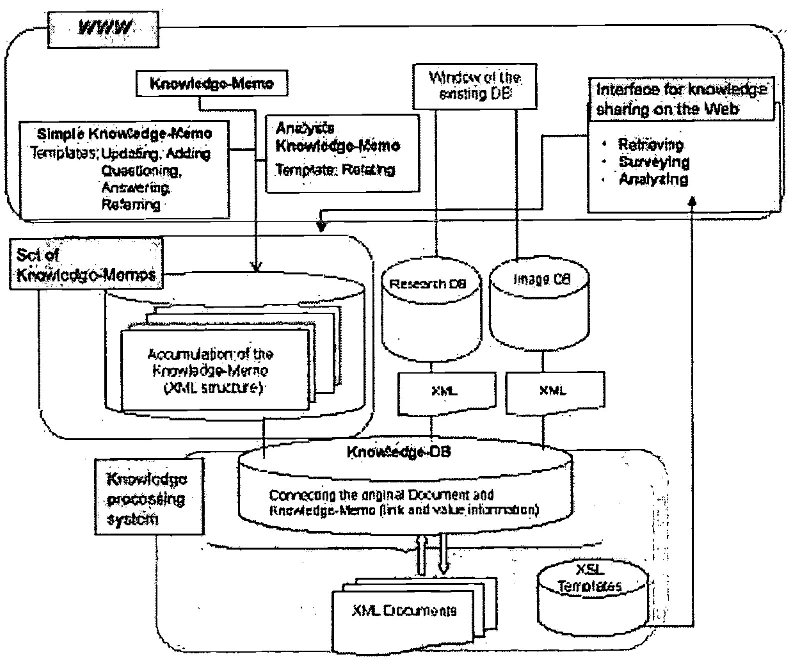

Fig.1. System overview

Simple Knowledge-Memo: specific information which users want to attach. For example, "This paper is an updated version of named B paper." This type of memo randum can be registered at the same time original paper is entered in the DB.

Analysis Knowledge-Memo: constructed and connected information that is based on researchers' analyses. This type of memo randum can be a Simple Knowledge-Memo because it can be re -analyzed. Users would register Analysis Knowledge-Memo as research results of documents and memorandums.

According to making of the Knowledge-Memo, new sets of documents are created. One objective of proposed system is to change from fragmentary and separated information to collected new knowledge, due to the analyses of researchers in a common created space.

4.1.2 · Collection and accumulation of Knowledge-Memo

The following templates make inputting memo randums simple.
Information inputted in prepared templates is stored on the Web as Knowledge-Memos through XML structure. Types of the Simple Knowledge-Memo are updating, adding, questioning, answering and referring. Analysis Knowledge-Memo includes relating memo randums.

Usage of these templates is as follows.
Updating templates: describing information and explaining reasons for renewal, which create relationships between before and after renewal.
Adding templates: adding information, such as advices and references to original documents.
Questioning templates: asking questions to documents. When inputting Questioning templates, e-mails would be simultaneously sent to a person who created the original documents.
Answering templates: answering to questions. Automatically sent to the person who wrote questions.
Referring templates: referring to external documents and create new relationships with sites on the Web.
Relating template: describing relationships between documents which are based on analysis of documents and Knowledge-Memos. More than two documents and memos can have relationships.

Several tags of the XML are also used:• • <key> for keywords, • <hi> for highlights, •
 for starting new lines. In an experimental usage of the system, users were free to use these tags without any restriction and enforcement. If tags were used, words would be shown in only emphasized style on the screen. (Fig.2). However, the system would better more reflect users' intentions if the use of new tags were available and inventive Extensible Stylesheet Language (XSL) was developed.
As previous discussion shows, the system has an advantage of creating sets of documents, which reflects users' intentions.

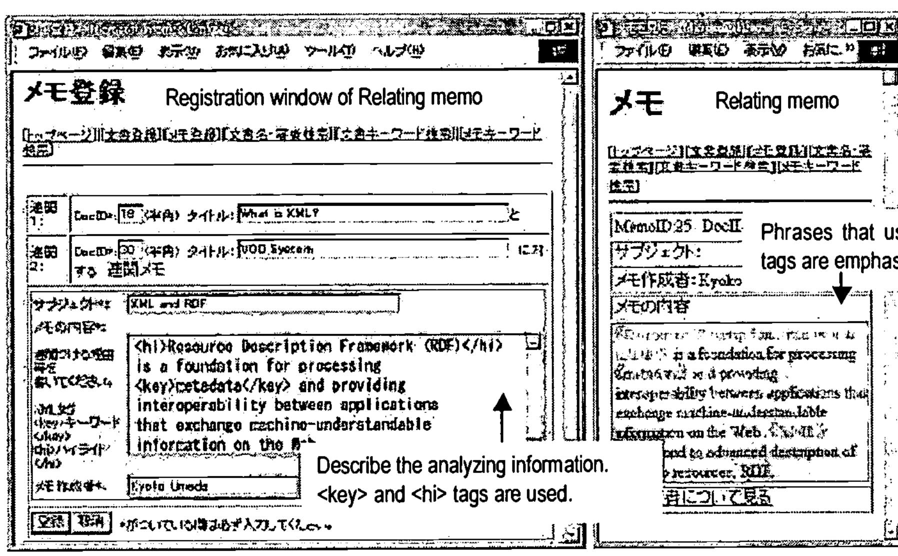

Fig.2 Input screen of "Relating memo" used to input XML tags. (Left)
The "Relating memo" including enhanced expressions created through XSL (Right)

4.2 Knowledge processing system: Connecting the original document and Knowledge-Memo

After collecting un-formalized information, the system connects it with formalized information. Such connection creates a Knowledge repository.

The process of connection is as follows. First of all, this system picks up necessary meta-data from Research DB and stores it in a XML structure. Such information is connected to the Knowledge-Memo which is also in a XML structure. Thus, a Knowledge repository is created. The system employs XLink function to connect un-formalized information with documents. Because of XLink potential, it is possible to make multidirectional links among original documents from a remote resource, that is, from a Knowledge-Memo related to original documents. Moreover, the system also creates lists of linkage information about existing Knowledge-Memos related to one original document. That is, from one individual document all its existing connections are easily obtained (Fig.3). Unfortunately, the experimental utilization of the system in this paper uses Internet Explorer5 which still does not support all these XLink functions. That is why the system utilizes link functions of HTML, reflecting the structure of the XLink. If the XLink was supported, it would be easily possible to make relationships between documents through the above simple structure. The fact that these connections are automatically created by users' simple operation constitutes an advantage of the system.

The Knowledge DB pulls out necessary information, and displays on a Web interface. The system uses XSL templates to arrange and display requested information.

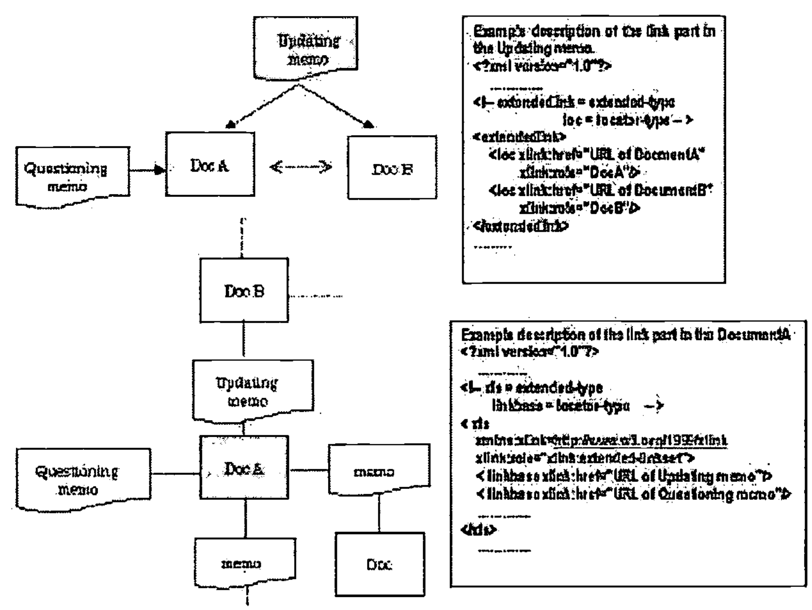

Fig.3 Description examples of relation between documents and Knowledge-Memo based on XLink. The memorandum associates remote documents through extended link (above). The external linkset centralizes the link information (below).

4.3 Interface for knowledge sharing on the Web

Peers use a trial system on the Web as a part of research activities. In order to make a user-friendly interface, we studied the flow of research activities. As the result, three processes, such as retrieving, surveying and analyzing information, are prepared for their research activities.

First, two retrievals are available, which include searching documents and Knowledge-Memos. Document search is a method which is often used, and it searches a document from a title or keyword. If an Updating memo is shown as a result, and there are some corrections on the documents including updated document. In another word, Updating memo provides help of the retrieval. Moreover, a renewal reason has the possibility to become a reference when a peer writes a paper. Retrieving from Knowledge-Memos may be useful for getting information toward vague ideas. I can be more efficient than previous ways, because researched results are sets of documents and memorandums. Further, due to the XSL, it is possible to sort by dates and to filter by types of memorandums.

In a Surveying process, connection between documents and memorandums is visualized, when traversing search results. For example, even if users think that there is no relationship between documents, there might have some kind of relationship after following links. Such new researches can help proceeding researches.

With respect to analyzing information, a new finding, resulted from surveying information, can be used for making analyzing memo in a combination with related and added memorandums. These processes can be continued by adding new information and findings that stimulate utilization. On the Web, a common space, such utilization can increases effective research activities. .

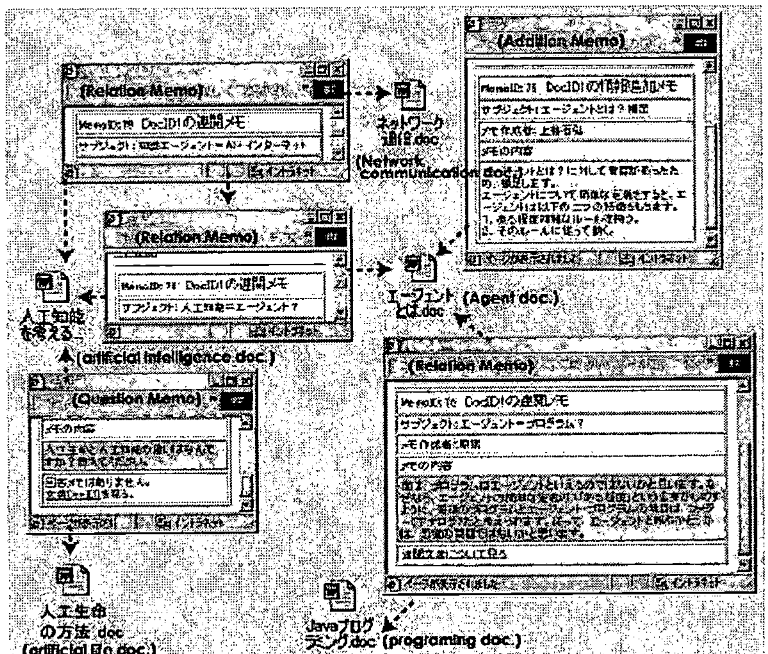

Fig.4 Set of knowledge by Analyzing; Knowledge-Memo and documents related to it.
Documents and Memos are gathered around the "Agent document".

5 Prototype evaluation

Usage of the system and evaluation of the prototype are discussed and reviewed in this section.

5.1 Usage of the system

In order to study further, followings show a way of system utilization, based on discussions and reports in a research group which studies agent technologies in a laboratory. Suppose that there are three members, named A, B and C, in the group.

(1) "A" makes and reads a report, "About Agent" in a seminar. After the seminar he registers the report in Research DB. At the same time, conclusion of discussion, advice, etc. are also registered as Knowledge-Memos.

(2) "B" who was absent for discussion reads the report. Then "B" asks, "What does autonomy mean?" in a Questioning memo. Such question is registered in memorandums of questions related to reports, and at the same time, "A" will get the e-mail.

(3) "A" answers the question from "B" in Answering memos, which is registered in Answering memos, and e-mail is sent to "B".

(4) "C" tries to do a programming of an agent by using Java. He finds a report of "About Agent" written by "A" through a keyword search, "agent". "C" completes his report, referring A' s report. . He makes a Relating memo, for example, describing which part of the agent report is quoted and how it is useful for him.

After repeating these memorandums registrations, it is possible to analyze information as shown Fig.4. Members of agent seminar could gain the following effects at this time.

5.2 Test results

Seven students in a lab used a practical sample test of the system, and answered questionnaires. Table.1 shows the results.

	Yes	No
(1). Helpfulness of the Knowledge-Memo.	93%	7%
(2). Easiness of inputting the Knowledge-Memo.	58%	42%
(3). Acceptance of sharing ideas written in the memo with other users.	93%	7%
(4). Satisfaction of inserting XML tags for emphasizing and changing colors.	67%	33%
(5). Usefulness of the system. (i.e. connecting the Knowledge-Memo with documents, resulting in a set of new documents.)	71%	29%

Table1. Results of questionnaires.

The overall evaluation of the system was positive. In terms of the question (1), students used the Knowledge-Memo for connecting to related documents and getting information of their documents. There were several responses in question (2), which demanded for the improvement of the interface when inputting the memorandums. Some students suggested a possibility of creating more successful system if incorporating with other laboratory members. In the question (3), most students were positive for informing and sharing ideas through memorandum with other users, since they can identify their ideas and get some comments. As for question (4), some students complained the new tag system that requires additional input. However, other students recognize the advantages of the system that can emphasize the keyword and change colors as far as the tags were not so complicated. Finally, most students recognize the structure of relationships centered on the document is useful for research activities.

5.3 Discussion

Test results lead to three fundamental findings.
(1). The system is useful for using and searching documents because it is possible to use information of Knowledge-Memo as well as abstracts.
(2). The system is convenient, since it enables users to make relationships with other preserved documents, to create new sets of documents, and to traverse from memorandums.
(3). The system is effective for informing and sharing opinions with peers because it enables to identify their ideas, to get some comments, and to record the process of studies.

From these results, it is possible to conclude that this management system effectively supports research activities, which collects and accumulates peer's knowledge and promotes collaborative and shared utilization.

Furthermore, we need to evaluate more effects for future research, such as;
- Is there any possibility in this system to give linkage of documents that seem to have no relation with each other?
- Is there any possibility that the results of using this system, such as creation of new document sets and analysis of memorandums, can give deeper understanding and new definition to users?

Additionally, this system should be improved in terms of the following three points.
(1). Revision of interfaces, including the interface for inputting the memo and the interface for classifying documents by theme.
(2). Addition of the level of importance to Knowledge-Memos for arrangement and classification, in order to promote re-use of knowledge.
(3). Exploration and employment of XLink potential. (Current browsers, such as IE or Netscape communicator, do not support XLink functions.)

6 Conclusions

The proposed web-based management system is primarily designed for research activities. Previously, databased and written information, such as papers and reports, were only available for research activities, even though other information, such as ideas and opinions, are also important knowledge. The new management system enables to utilize un-formalized knowledge as well as formalized information.

Positive responses from lab members who used a trial system show that because separated and fragmentary information are collected through Knowledge-Memos, effective and efficient research activities would be feasible. A lot of information and ideas toward papers are collected by members as databases, which creates sets of documents. Researchers can collaborate with other researchers through the system.

From the technical standpoint, the system utilizes the XML in two parts of exchange and preservation. Users' intentions on the WWW can be more reflected by the XML.

For the future usage, since only meta-data is managed in a XML, the utilization of documents as well as digital data is feasible. Further, the system can connect knowledge more easily, since XLink functions will be realized soon. Important advantages of the system include creation of relationships, and searches of information and knowledge. Improvement of the interface and the classification memorandums will be necessary for the long term.

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rTable : A Collaborative Problem-solving Environment for Synchronous Discussion

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This paper describes a prototype of "rTable"(r means Round and Role) that supports collaborative problem solving through a synchronous group discussion. Firstly we take up two general problems concerned with organizing discussion. One is the difficulty to facilitate productive discussion. The other is the difficulty to promote all members' participation. And then two prior systems that support collaborative learning are reconsidered in terms of these problems. Secondly we explain our new design concept: "playing roles by turns", and describe a prototype of our system. In this system, users discuss a problem, taking four roles by turns and visualizing a flow of a discussion. The roles include *the chair* who presides a discussion, *the proposal* who formulates a topic, *the question* who makes first statement on a topic and *the summary* who arranges statements. These roles are expected to prompt users to argue and aim at directing them to equal participation. Results of the pretest show the system design of rTable has possibility of being a solution to two general problems in supporting collaborative problem solving.

Keywords: **collaborative problem-solving, synchronous discussion, role**

1 Introduction

Recently, in Japan, an educational reform has been carried out. "Period for Integrated Study" aims at helping children develop capability and ability to discover problems by themselves and solve those problems properly (Mombusho 1998). These activities are expected to achieve through various learning styles, group learning, cross-grade learning and so on. Thus it is important that learners cope with problem solving activities via discussion and dialogue with other people in the future education. However there are many difficulties to manage group discussion in educational setting. We have developed rTable that is a network-based learning environment to support synchronous discussion for collaborative problem solving. The purpose of this paper is to describe rTable design, functionality and its evaluation through pretest.

2 Problems

We focus on two of general problems in organizing group discussions. One is the difficulty to make group members focused on content-related dialogues and coherent subject matter discussion, and putted forward constructive argument. One of the reasons this problem arises from is a lack of rules that members share in respect of advance a discussion. Hesse and Hron (1999) found that the groups given the rules for discussion showed grater orientation to the subject matter and less off-task talk, compared with a control group.

The other problem is concerned with the equal participation of group members. Eichinger and Anderson (1991) pointed this problem out based on their analysis in the process of collaborative problem solving. In their observation, only the students who were already most skillful at constructing scientific argumentsgot substantial practice and feedback. They suggested that some kind of collaborative problem solving had in it the potential for continuing the inequities of the present system, in which students came to view and success in science as reserved primarily for articulate, intellectually aggressive boys. Therefore Eichinger and Anderson were concerned about finding ways to make sure that all students could get benefits from their participation in the group problem solving (Eichinger and Anderson 1991).

Our system is aimed at trying to solve or reduce these two problems. In this paper, we begin with reconsidering two representative Computer Supported Collaborative Learning• CSCL• environments in terms of those problems.

3 The prior two representative CSCL systems

Collaboratory Notebook: The Collaboratory Notebook was created by the Learning Through Collaborative Visualization (Covis) Project. This system is a shared hypermedia database. It allows users to create a shared workspace called a notebook within that users create pages. Every page in a notebook is assigned a page type by its author(s). The eight page types include questions, conjectures, evidence for, evidence against, plans, and commentaries. The hypermedia links enable users to connect pages together according to the relationships between them. The genre defined by the page labels and links is designed to provide students with a framework for conducting and communicating about the inquiry process that encourages them to be systematic and reflective. It provides students with a structure for their activities designed to reduce their need to focus on the challenges of organization so that they may focus more on the content of their activities (Edelson, D. C. et al 1995).

SenseMaker: The SenseMaker is one software component of the Knowledge Integration Environment (KIE).• SenseMaker provides a spatial and categorical representation for a collection of Web-based evidence. The SenseMaker software allows small groups of students to organize and annotate a collection of evidence associated with a project that can then be shared with others. Within the software, students work with evidence dots representing individual pieces of evidence on the Web and claim frames corresponding to evidence. Claim frames can be interrelated by hierarchically nesting one inside of another. Students place evidence dots within the claims that they are interpreted as supporting (Bell, P. 1997).

Both the systems are based on the same method that users classify their own opinions or evidences for theory using common representations and categories that the systems provide. This way encourage users who have never established standards for discussion to exchange opinions each other and to make a productive discussion. So this method may solve or reduce the first problem, concerned with making members putted forward constructive argument. But with regard to the second problem, related to making members participated equally, and Collaboratory Notebook and SenseMaker systems are not likely to consider. This is illustrated by a fact that, in a study of Collaboratory Notebook use, there was reliable correlations between the number of different pages and answers of students to the question: "I enjoy classes in science." and between the connectedness of page in cluster or tree and the same answer (Edelsen, D. C. et al 1995). Besides, as far as synchronous discussions are concerned, it is desirable to accept member' s off-task talks out of categories that systems provide them in a certain extent in order to promote vigorous discussions.

4 Playing roles by turns as an alternative design

We introduce the concept of *playing roles by turns* into development of supporting system for collaborative problem solving. We got the idea from "Question-Asking-Reading" procedure for learning to read. In this procedure, students play five roles by turns to read texts (Cole and Engestrom 1993). Although this procedure is aimed at acquiring full act of reading, it has also the potential that the procedure can facilitate the progress of discussion. Because giving a clear role to a student may facilitates participation of an activity, and taking turn may helps participating equally.

The rTable provides users 4 roles including *the chair, the proposal, the question* and *the summary*. Users cope with their problems in corporation playing roles by turns through discussions. The concept of *playing roles by turns* is expected to solve or reduce above those two problems. On the first problem, these four roles are related to the progress of a discussion work for constructing a productive one. And they don' t restrict user' s statements directly and strongly, so user can make statements without heavy loads. Regarding the second problem, because the roles are assigned in turns by system, all users are encouraged to participate in a discussion without staying on the same roles.

5 Prototype design and functionality

4 to 6 participants can discuss on rTable simultaneously. After log in the server, the names, roles and characters of participants are appeared on the left side of main window (see Figure 1.). There are a textbox into that a user types his/her statement and a history of statements on the bottom of the window. Discussion flows which participants make are

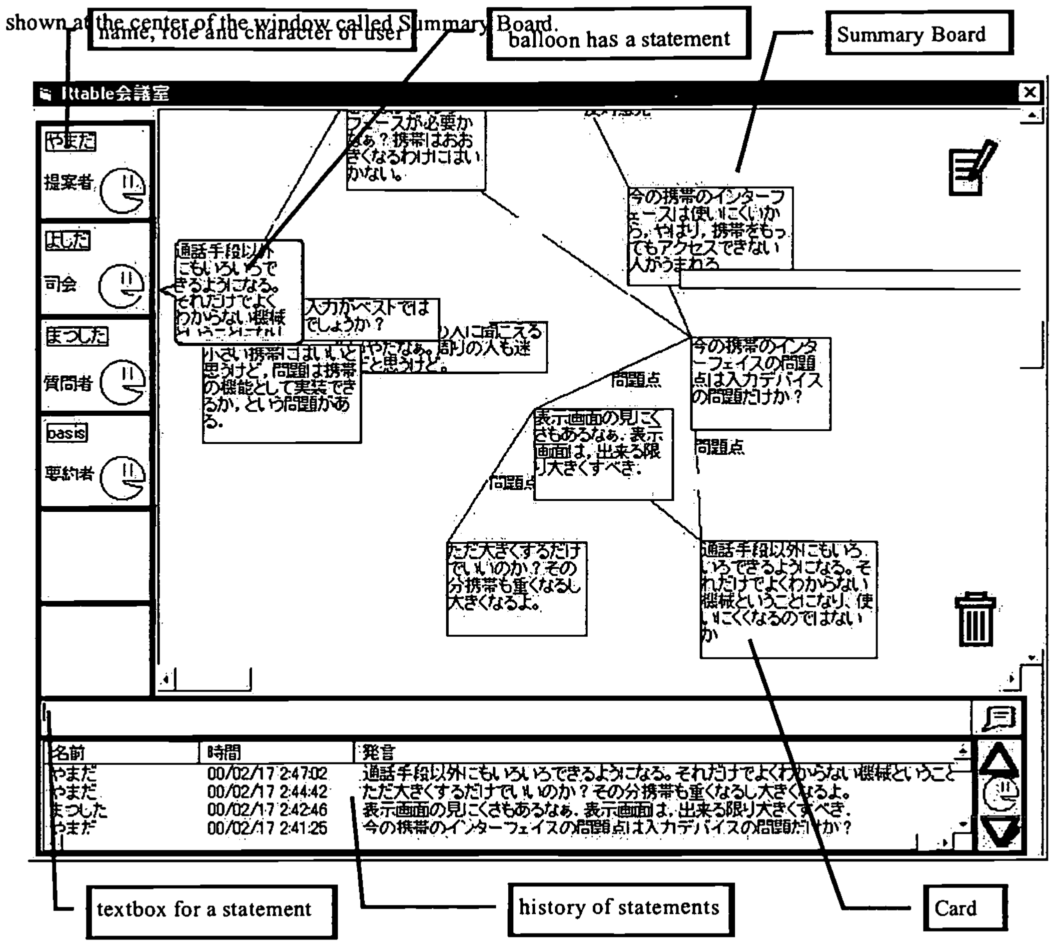

Figure1. Main window of the prototype

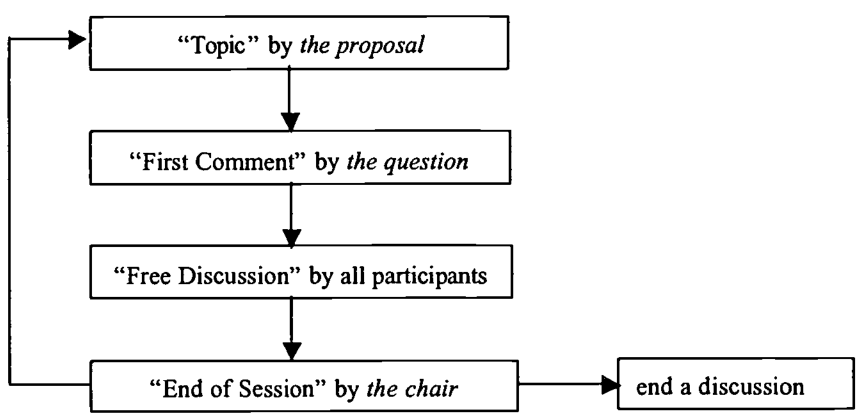

Figure 2. A Session

A discussion on rTable is divided into units of the Session shown at Figure 2. A Session consists of 4 steps. First step is "Topic" by *the proposal*. The second step is "First Comment" by *the question*. The third step is "Free Discussion" by all participants. The fourth step is "End of Session" by *the chair*. Four roles are assigned randomly and automatically by the system at the beginning of a session. But *the chair* switches his/her role to *the proposal* in the next session.

To put it concretely, in the first step "Topic", *the proposal* is required to formulate a topic that participants should discuss in this session. In the second step "First Comment", *the question* is required to give a comment firstly about the topic in order to start discussion. After that, all participants discuss freely in the third step "Free Discussion". *The chair* is required to preside at the discussion through a session. *The chair* can control a voice, so that he/she is able to nominate one to talk suitably. For clarifying a flow of discussion with visualization, *the summary* is required to pick up important statements• from discussion and place them on Summary Board. The participants except *the summary* are not able to write anything on Summary Board.

To write comments on Summary Board, *the summary* just clicks a balloon, which has a participant' s statement, or clicks a statement in the column of the history of statements. And then a Card written the statement appears on Summary Board. *The summary* also makes links (every link has a tag that the summary write something on) to connect a Card with another Card, and makes labels to take notes. Summary Boards of all participants are synchronous, so participants can grasp the discussion flow by looking at them.

The chair needs to decide the end of a session referring the progress of discussion and the discussion flow with visualization. If *the chair* wants to finish the session and to change the topic, he/she is able to declare "End of Session". At the same time *the chair* is required to pick a Card that he/she considers as the source for next topic. If participants judge that there is no necessity to continue the discussion ahead, *the chair* can end the discussion. After *the chair* chooses a Card, the system giving users new roles, the new *proposal* who is the old *chair* is required to formulate a topic from the card. When a new topic is formulated, a Card written the topic is made automatically. Cards chosen as sources for next topics by *the chairs* and Cards written topics are colored.

6 Pretest

We report here our pretest to measure validity of the system design. In this pretest, one undergraduate and three graduate students used the prototype of rTable. The pretest has two objects. Firstly, we want to know whether the system can encourage users to participate discussions. Second is whether the roles restrict user' s statements.

After we explained and demonstrated the usage of rTable to students, students discussed two subjects including a mathematical problem and a social problem for 80 minutes using rTable. There were 4 sessions. We analyzed the number of statements and user's answers to a questionnaire after discussion. The questionnaire included "Did you work on discussion freely?" "How far were you conscious of your roles?" and "Were you encouraged by playing roles in turns?"

Results: Table 1 shows the number of statements per person and per category of statement. "Task-focused" are statements related to the subject or the topics. "Off-task" are statements related to participant's state, feeling, and the like. For example, "Now, I' m thinking." and "It looks like difficult."

Table 1. The number of statements per participants and per category of statement

Persons		Category of statements	
A	42 (27.6%)	Task-focused	142(93.4%)
B	41 (26.9%)	Off-task	10(6.6%)
C	36 (23.7%)		
D	33 (21.7%)		
	152		152

Encouragement users to participation: The total number of statements is 152, and each participant wrote 27.6%, 26.9%, 23.7% and 21.7% of total statements respectively. There is not significant difference between persons (χ^2 (3) =1.42). Also almost user answered "Playing the chair or playing the summary promoted my participation." regarding the question, "Were you encouraged by playing roles in turns?" The fact that almost equal participation rate by each and high agreement rate regarding of "playing the chair or playing the summary promoted my participation" would support that the system promote user' s participation toward the discussion equally in the pretest.

Restriction on statements: All users responded, " I was conscious of playing my roles". They alsoanswered, "I did so." or " I did a little." regarding the question, "Did you work on discussion freely?" There were 10 off-task statements that seemed to make the discussion relaxed. These suggest that assigned roles hardly restrict on making statements.

7 Conclusions

Therefore, we may say that the system design of rTable has possibility of being a solution to two general problems in supporting collaborative problem solving: facilitating productive discussion and promoting all members' participation. There are some complaints in operation of prototype reported by users. We will revise the prototype system, and evaluate it in educational setting.

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Scientific revolutions and conceptual change in students: Results of a microgenetic process study

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A microgenetic process study of dyad learning was conducted with the objective of further understanding conceptual change as students learn. This paper describes the knowledge negotiation, co-construction, and problem-solving efforts between two student volunteers, both aged 15, in a computer-mediated-communication (CMC) environment. We illustrate protocols of the students' problem-solving processes, showing how the students manifested, expressed, defended, abandoned, conjectured, and eventually transformed their (mis)conceptions on various aspects of velocities and distances. In doing so, we address important questions raised about students, their concepts and (lack of) theories, and the types of conceptual change that take place as students learn. This paper provides empirical evidence to show that as long as students do not think in theoretical terms, conceptual change in students will be very different from scientific revolutions. It not only agrees with the theoretical shift to viewing *learning* as *conceptual change*; it also lends empirical evidence in support of this view.

Keywords: **Cognition and Conceptual Change, Collaborative Learning, and Knowledge Construction and Navigation**

1 Introduction

The study and understanding of conceptual change is a field that is significant to the research community [10]. An example of macro-level conceptual change is the paradigm shift [8] from the phlogiston theory to the oxygen theory (commonly dubbed the chemical revolution). There have been numerous attempts to compare and contrast between such scientific revolutions and conceptual change in children and students. For example, Carey [2] contends that the development of the concept *living thing* in a child is analogous to scientific revolution because her study shows that between the ages of 4 to 10, children undergo a cognitive restructuring of their *living thing* concept; this restructuring is tantamount to theory change (from an animist theory to a set of biological theories). On the other hand, Harris [5] argues that "children do not think in theoretical terms, but on the basis of working models or concrete paradigms that serve as a basis for predictions and explanation" (p.303). Given these two opposing viewpoints, it is natural for Thagard [21] to state:

> The questions remain: do children have theories, does conceptual change occur by replacement, and is theory replacement the result of considerations of explanatory coherence? An affirmative answer to each question is a precondition of an affirmative answer to the succeeding one. (p.256)

Before discussing whether conceptual change in students is as revolutionary as scientific revolution, we should be reminded that scientific revolution involves a paradigm shift from one theory (or theories) to another competing theory (or theories). At the risk of oversimplification, we define a theory to be a set of *explicit* and *well-coordinated* principles that yield *predictions* based on their *explanatory mechanisms*. Since all "conceptual structures provide some fodder for explanation", "the distinction between theory-like structures and other types of cognitive structures is one of degree" [2, p.201]; theories embody deep explanatory notions.

Given the above, if students do not possess theories, not only is conceptual change in students fundamentally different from scientific revolution, but we must also offer negative answers to Thagard's questions.

2 Context of Study

This study describes how two student volunteers, Tim and Ming (both aged 15), engaged in meaningful knowledge negotiation and co-construction in a manner that allowed their conceptions and thought processes to be made overt for our analysis. Tim and Ming are schoolmates (but not classmates) in an academically average neighborhood secondary school. Both students have learnt physics in school for one year prior to this study and hence, are familiar with the terms velocity, acceleration, time, and distance. Prior to this, both students have not worked academically with each other.

Tim and Ming were placed in a large room that was partitioned in the middle. Each student occupied onepartition, and conversed with the other exclusively via a computer-mediated-communication (CMC) environment. The CMC environment consisted of a chatbox and whiteboard facility. The chatbox facility allowed the two students to converse via typed text, while the shared whiteboard allowed pictorial drawings and ideas to be depicted and discussed. Figure 1 shows a snapshot of this CMC environment, implemented via Microsoft NetMeeting™. Besides the standard furniture such as tables, chairs, and a computer, each partition housed two unmanned video cameras. The main data collection method comprised the video recordings of the students' interactions through the CMC environment. In each partition, a video camera was directed at the screen, capturing every interaction sequence performed on the computer, while the other video camera was directed at the student, capturing the student's physical gestures and reactions. To further aid the transcription process, both the shared chatbox and whiteboard were regularly "saved."

The questions that we posed to the students to solve were adaptations of the "Context Rich Problems" formulated by the Department of Physics, University of Minnesota (for more information, see http://www.physics.umn.edu/groups/physed/Research/CRP/crintro.html).

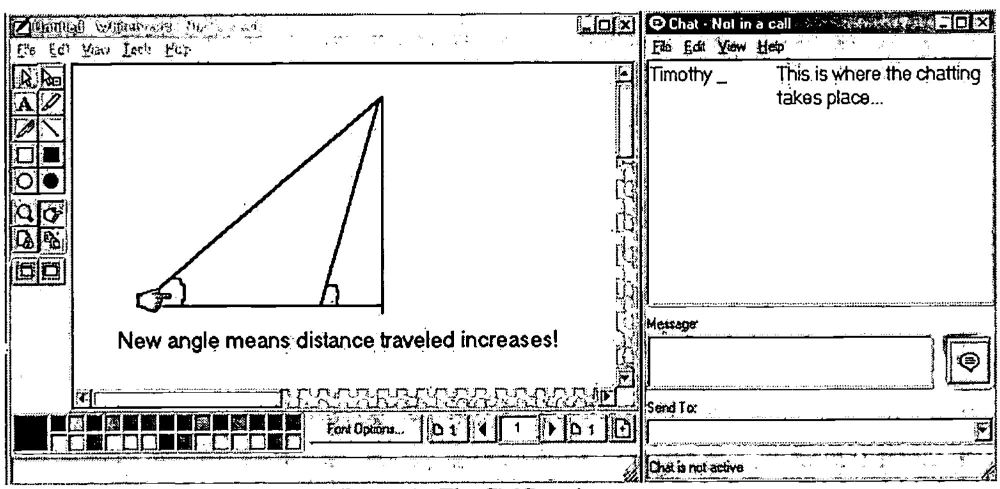


Figure 1: The CMC environment

3 Research Methodology

If we simply engage in endpoints analysis, we would not be able to understand conceptual change [10]. As such, we need to take into account the actual developmental process of conceptual change. A research methodology that focuses on microgenetic (developmental) processes is that of Ethnomethodology [4]. In short, ethnomethodology is interested in interaction sequences and requires that we focus on "participant categories" rather than "third person observer" perspectives [7]. It forces us to ask, "what questions can the data answer" rather than "what data do I need to answer these questions."

Since conversation analysis is the most productive and prolific form of analysis that has been developed with ethnomethodological concerns in mind [1], the protocol data obtained were transcribed into a log format, and then analyzed and annotated in accordance with the practices of conversation analysis (see also [6, 9, 12, 13, 17]). This was a time-consuming process as each tape had to be viewed and reviewed until the gaps in the data were resolved to the fullest extent possible.

4 Study Findings

In the following section, we illustrate portions of Tim and Ming's problem-solving processes through protocols collected in our study. Because this paper only presents portions of the protocols collected, see Soong [19] for full details. The question below details one of the problems attempted by Tim and Ming.

The cycling problem:

You and your physics teacher are cheering your cyclist friends Alex and Bon who are taking part in a straight but uphill bicycle-racing contest. You and your teacher are watching the race from the side-lane just beside the racetrack, 132 meters away from the finish line. It so happened that both cyclists passed by in front of you at exactly the same point in time. Your teacher estimated Alex's velocity to be 12m/s and Bon's velocity to be 11m/s. Given your training sessions with Alex and Bon, you know that from this position, Alex will accelerate at the rate of $0.25 m/s^2$, while Bon will accelerate at the rate of $0.4 m/s^2$, for the next 10 seconds.

- What is the final velocity of both cyclists at the end of that 10 seconds?
- Who will reach the finish line first?

Comments in square brackets "[ ]" are remarks made by the author regarding the protocol statements. These comments aid understanding of the protocols by relaying contextual information not available to the reader. No attempts were made to correct the students' grammatical and spelling errors. Tim, Ming, and the author are represented by "T", "M", and "A" respectively.

```
4.    M: part a looks tha same as what we did in the last session
```
[The first part of this question looks the same as what they previously attempted]
```
5.    T: yes....
6.    M: can we use that method?
```
T: lets try

Both students drew structural similarity between Part A of this question and a question that they previously attempted. In that previous problem-solving session, T and M had agreed that "(acc. x acc. time) + initial velocity = final velocity". However, the reason they agreed on this formula was because "it's the only method where we could get the ans. so far". It is clear that the students lacked a conceptual understanding of the solution, but nonetheless that did not hinder them from solving the problem.

It is noteworthy that M referred to the problem-solving process as "that method", rather than "that theory" or even "that logic". It is clear that in this instance, the students did not think in theoretical terms. In fact, it was a mechanical application of the "method" that the students "did in the last session".

With this, the students worked collaboratively, using the formula *final velocity = (acceleration x acceleration time) + initial velocity*. They then obtained the (correct) solution that Alex's final velocity was 14.5 m/s while Bon's final velocity was 15 m/s.

```
11.   M: 12+2.5=14.5
12.   T: yes
13.   T: and bon = 11 + 4 = 15
17.   M: agree?
18.   T: yup
```

It was clear to both students that Bon was faster than Alex after the acceleration. However, both the students had the conception that an object with a higher final velocity travels further than one with a lower final velocity. This conception is true in some, but not all cases. This is a well-known misconception, and it has been documented extensively by Piaget [11], among others. In the context of our study, we will refer to this as the "higher final velocity = winner" concept.

38. T: bon is faster after the acc.
39. M: yes
40. T: therefore if the speed be constant after the acc., bon would complete the race first
41. T: agreed?
44. M: agree.

Confident that their answer was correct, T checked their answer with the author, only to be informed that their answer was incorrect, since Alex will actually complete the race first. When T related this to M, he was surprised.

47. T: nope.....
48. T: wrong ans....
49. M: huh?
[M is surprised that their answer was incorrect]

When the author informed the students that their answer was wrong, the students tried again. T stuck to the concept that an object with a higher final velocity will travel further than one with a lower final velocity. Since T was basing his problem-solving attempts on this concept, he thought the only possible reason why Bon did not win the race was that his final velocity was lower than that of Alex's. To allow for this, he hypothesized that both bicycles returned to their initial velocities after the acceleration.

53. T: they will only acc. for that 10 s
54. T: after that their speeds will return to the same as b4

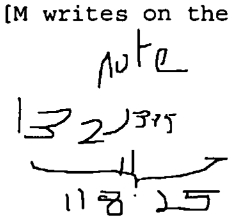
At this point in time, the author informed the students that the bicycles did not decelerate after that 10 seconds. Upon hearing this, both students felt that Bon should win. Their expression was totally consistent with their conception.

62. A to T: They did not decelerate after the 10 seconds.
65. T: the 2 didn't decelerate
66. M: then b should win
67. T: yah........

In the episode above, T was trying to reconcile their findings via qualitative analysis of the situation. However, because their source of reasons came from their "higher final velocity = winner" (mis)conception, this yielded no alternative results.

The episode below shows M's attempt to obtain an alternative answer via mathematical formulations. In so doing, M unwittingly put aside the "higher final velocity = winner" concept.

84. [M writes on the whiteboard]



86. M: a travelled 118.25 to the checkpt
[M was referring to his workings on the whiteboard. See L88, L89 and L92 for an explanation of M's workings]
87. T: y is that so?
[T looks at M's drawing on the whiteboard]
88. M: 0.25+(2x0.25)......+(2.5)=13.75
89. M: the distance travelled during acceleration
[13.75m is the (additional) distance covered due to the acceleration]

The protocol above manifests another of M's misconception. M's workings imply that the bicycles gain speed instantaneously rather than incrementally. In short, M's workings imply that Alex's bicycle covered an additional 13.75 meters due to its acceleration of $0.25 m/s^2$ for 10 seconds. We observe that this exact same working was also exhibited by M in one of his earlier problem-solving sessions.

```
90.   T: ok.....
91.   T: but i still dun get it....
```
[T does not understand M's workings]
```
92.   M: 132(distance from check pt)-13.75=118.25
      [132m - 13.75m = 118.25m]
```
[M is saying that the initial portion of Alex's velocity covered 118.25m]
```
93.   M: there/s no decceleration,then bon should reach first!
```

It is likely that, to M, the distance traveled by Bon due to Bon's higher acceleration was greater than Alex. Based on this method, Bon would have traveled 22 meters due to his higher acceleration. Hence, M drew the conclusion that Bon should reach the finish line first, since Bon was "faster". Clearly M's reasoning was flawed.

```
94.   T: how u get 13.75?
95.   M: 0.25+(0.25x2)+(0.25x3)+(0.25x4)...... +(0.25x10)=13.75
```
Upon further probing by T, M provided a fuller explanation of his conceptualization. M's formulation is as follows:

The velocity of Alex due to acceleration during the 1st second is $= 0.25 m/s^2 \times 1 s$
$= 0.25 m/s$

Hence Alex, moving at 0.25m/s, travels 0.25m/s x 1s = 0.25 meters during the 1st second.

Likewise, Alex's velocity due to acceleration during the 2nd second is $= 0.25 m/s^2 \times 2s$
$= 0.5 m/s$.

Hence Alex, moving at 0.5m/s, travels 0.5m/s x 1s = 0.5 meters during the 2nd second. The same process was extended until the 10th second. As such, M conceptualizes that the summation of the distances from the 1st to the 10th second indicates the total distance traveled during the 10 seconds. Figure 2 and 3 pictorially illustrate M's conception and the actual acceleration process respectively.

Figure 2: M's Conception

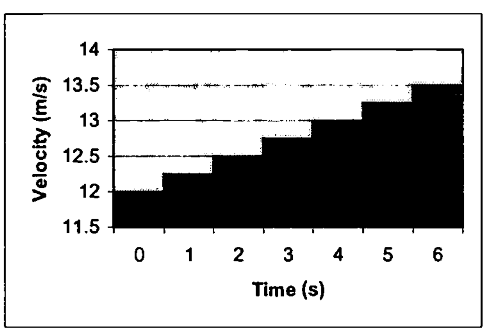
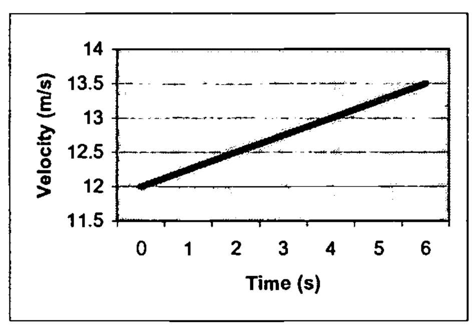


Figure 3: Actual acceleration process



T thought long and hard about M's formulation. After doing the math, he understood and agreed with M's conceptualization. This provides us with evidence that T had this misconception as well.

```
96.   T: [long pause (thinking)]
97.   T does the maths
98.   T: oic
```
[This is a short form for "Oh, I see"]

Discussing the problem-solving process by qualitative analysis failed to provide new insights. As such, M started using mathematics as an alternative source of potential explanation. M's workings reveal that he had a misconception that the bicycles gain speed instantaneously rather than incrementally. We also see evidence that T suffered from the same misconception. Despite the use of both approaches, both students were unable to find any reason why Alex should win. Hence, they concluded that Bon would win. With this conclusion, they checked again with the author, only to be told that they were incorrect.

```
110.  M: no.............................
111.  T: huh?
```
[T is surprised that the answer was incorrect]
```
113.  M: that's no the ans..
114.  T: i don't get it....
115.  M: smae here.....
```

Faced with this bleak situation, both students, perhaps unwittingly, put aside their "higher final velocity = winner" conception. Evidence of this is shown when, without first thinking it through, M suggested that perhaps both bicycles arrived at the same time.

```
117.  M: maybe they arrive at the same time?
118.  M: assume
119.  T: it may be possible but wat is the reasoning...?
120.  M: thinking.......
```

Perhaps unknown even to M, he was putting aside the "higher final velocity = winner" concept by suggesting that "maybe they arrive at the same time". This suggestion was made without even an initial reason, and hence this suggests that the students did not think in theoretical terms.

Because the students had put aside the "higher final velocity = winner" conception, they were able to make progress in solving the question.

```
124.  T: acc. = total dist travelled / total time taken
```
[T makes overt his thought process to M]
```
125.  M: that's speed
```
[M corrects T]
```
126.  T: aye.... yah hor.....
```
[Local expression for "Oh yes, you are right"]
```
127.  M: acc=what formULA?
128.  T: the gradient of the distance time graph....
```
[This is actually incorrect; acceleration is the gradient of the velocity-time graph]
```
129.  M: huh?
```
[M was not expecting this]
```
130.  T: the acc. is the gradient of the distance-time graph
134.  M: could u find the time ?
135.  A to M: Do you agree that "acc. is the gradient of the distance-
   time graph"?
136.  M: acc.=changes in velocity/time taken
```
[After pondering over the author's question, M gives an accurate definition for acceleration]

As T searched broadly for answers, he drew upon the formula of acceleration. However, his definition was incorrect. This set M thinking about the actual formula of acceleration and "the time" (L134). M then started to use the formula *time = distance traveled / (velocity+acceletion)* in order to find the time taken for each bicycle to complete the final 132 meters. While M's actual workings were incorrect (there is no such formula), it nonetheless provided the students with an alternative answer suggesting the conclusion that Alex won the race. More importantly, it allowed the students to derive the relation between the time of race completion and the winner of the race.

```
151.  M: a move faster than b.....reach first.......z???????
```
[M draws the relation between *time of completion of race* and *winner of race*]
```
156.  M: 132/(12+0.25)=132/12.25=10.76
```
[132 is the distance traveled, 12 is the initial velocity, 0.25 is the acceleration]
```
157.  M: A
158.  M: 132/11.4=11.58
```
[132 is the distance traveled, 11 is the initial velocity, 0.4 is the acceleration]
```
159.  M: B
160.  M: i getting a little bit confused
```
[Perhaps M noticed that the formula he used made no sense]
```
161.  T: oic/......these ans are the time taken for the cylist,....
```

```
162.  T: therefore, A takes less time and b takes longer..
164.  T: so A will reach first
```

M's workings were incorrect. He had used a formula that had no basis, but nonetheless, T was able to make sense of it and concluded from M's answer that since Alex took less time than Bon, Alex will reach the finish line first. This provided the students with an alternative answer, and they were excited. M immediately asked the author if they were correct.

```
165.  M to A: Correct?
166.  A to M: The answer is correct, but the working is wrong
167.  M: working XXXXXXXXX
```

Upon hearing that the answer was correct, M deduced correctly that because Alex traveled faster initially, Alex was at a point ahead of Bon such that Bon could not overtake him despite Bon's higher acceleration. This provided the students with a reason why, despite his higher acceleration and final velocity, Bon lost to Alex.

```
172.  M: a travelled faster aT FIRST SO HE'S AT A POINT FURTHER THAN
   WHERE B COULD OVER TAKE EVEN THOUGH B ACCELERATE FASTR.
```

The above problem-solving endeavor took about 50 minutes. From here onwards, the students continued their problem-solving efforts. After considerable struggle, they eventually "corrected" their second manifested misconception (the "stepwise velocity increment" conception). They were also able to obtain a correct mathematical process to show Alex completing the race before Bon. The total time taken to solve this question was 130 minutes.

5 Results

The results of our study show that our student volunteers did not think in theoretical terms when attempting to solve the physics (kinematics) problems. Instead, they used a variety of methods such as simulations, conceptions, and even baseless conjectures. While these students certainly have concepts and based their reasons on these concepts, they were loose, unsystematic and highly fragmented. We may be tempted to call these students "naive learners", but further research by the authors reveal that the vast majority of elementary physics students who were studied worked in this fashion.

The students' "higher final velocity = winner" conception stemmed from their prior knowledge, and because their source of reasons came from this conception, they were unable to understand how it could be that Bon, who had the higher final velocity, did not reach the finish line first. Only upon putting aside this concept were they able to appreciate how it could be possible for an object with a higher final velocity to reach the finish line later than an object with a lower final velocity; it was because the slower object was at a point further than where the faster object could overtake. The protocols strongly support constructivist learning theory, which posits, among other things, that new knowledge is built (or constructed) from prior knowledge [15, 16]. Our study not only agrees with the theoretical shift to viewing *learning* as *conceptual change* [21]; it also lends empirical evidence in support of this. It also shows the conceptual change process (and hence learning process) to be continuous, but non-cumulative. This particular *feature* is strikingly similar in structure to scientific revolutions.

With respect to Thagard's request to "pin down the kinds of conceptual change that occur as children learn" [21, p.260], the kind of conceptual change that occurred here is that of "adding a new strong rule that plays a frequent role in problem solving and explanation" [21, p.35]. Initially, the students had the conception that an object with a higher final velocity (B) implied that it would travel further than one with a lower final velocity (A). Their problem-solving efforts added a new rule to this concept: B would travel further than A *only if* A is not at a point ahead of B such that B could not overtake A despite B's higher acceleration and higher final velocity.

6 Conclusions

Here in Asia (and in many parts of the world), the current method of teaching and assessing primary, secondary, and pre-tertiary students (aged 7-18), is still very much based on the over a century-old Western pedagogy of teaching boys and girls nothing but *facts* [3]. Such a methodology is efficient for dissemination of information, but this decontextualised-content focus causes students to suffer from a lack of deep conceptual understanding of the domain being taught, and immensely decreases their exposure to expert problem-solving processes and strategies. As such, they do not look at problem solving through a "theoretical lens." Since "advancement in science is a continual dance between the partners of theory and experiment, first one leading, then the other" [14, p. 796], as long as students do not think in theoretical terms, negative answers should be offered to Thagard's opening quote.

Learning environments, computer-based or otherwise, should be designed to play a more *strategic* role with the *objectives* of the educational system as their core focus. Since the objectives of educational systems are rarely to produce unadaptable and inflexible graduates concerned only with egotistical benefits, then the learning environment, as well as the evaluation methodology, should be designed to reflect their intended objectives (also see [18]).

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A Distance Ecological Model to Support Self/Collaborative-Learning via Internet

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With the rapid development of information technology, computer and information communication literacy has become the main new ability required from teachers everywhere. For enhancing teaching skills and Internet and multimedia information literacy, a new teachers' education framework is required. Here we propose a Distance Educational Model, as a School-Based Curriculum Development and Training-System (SCOUTS), where a teacher can learn subject contents, teaching knowledge, and evaluation methods of the students' learning activities (subject: "Information") via an Internet based self-training system. We describe the structure, function and mechanism of the model, and then show the educational meaning of this model in consideration of the new learning ecology, which is based on multi-modality and new learning situations and forms.

Keywords: **Distance Education, Teacher Training System, Learning Ecology, School Based Curriculum Development**

1 Introduction

Recently, with the development of information and communication technologies, various teaching methods using Internet, multimedia appeared. Most of them emphasize, in particular, the aspect of collaborative communication between students and teacher during interactive teaching/learning activities. Therefore, now-a-days it is extremely important for a teacher to acquire computer communication literacy [1]. So far, there were many studies concerning system development, which aim at fostering and expanding teachers' practical abilities and comprehensive teaching skills, by using new technologies, such as computers, Internet, multimedia. In Japan, systems using communication satellites such as SCS (Space Collaboration System) are developed and used as distance education systems between Japanese national universities. In the near future, a teacher's role will change from text based teaching, to facilitating, advising, consulting, and his/her role will be more that of a designer of the learning environment. Therefore, a teacher has to constantly acquire/learn new knowledge and methodologies. We have to build a free and flexible self-teaching environment for them under the concept of "continuous education". At the same time, we build a collaborative communication environment to support mutual deep and effective understanding among teachers. In this paper, we propose a Distance Educational Model, which is based on the concept of School Based Curriculum Development and Training System, advocated by UNESCO and OECD/CERI (Center for Educational Research and Innovation), and describe the structure, function, mechanism and finally the educational meaning of this model. Based on such a background, it is necessary to construct an individual, as well as a collaborative learning environment, that supports teachers' self-learning/training, by using Internet distributed environments and multimedia technologies. A teacher can choose the most convenient learning media (learning form) to learn the contents (subject units) that s/he desires.

2 Distance Educational Model based on SCOUTS

Until now, when a teacher wanted to take a class on "IT-education", s/he had to leave the office or school. Now it is possible to learn various kinds of subject contents by building a virtual school on the Internet environment.

2.1 Distance Educational Model

Our Distance Educational Model is built on 3 dimensions. The first one is the subject-contents, which represents what the teachers want to learn. The second one represents the teaching knowledge and skills as well as the evaluation methods of the students' learning activities. From the third axis, the favorite learning media (form) can be chosen, e.g., VOD, CBR, etc. By selecting a position on each of the 3 axes, a certain cell is determined. A cell stands for a "script", which describes the instruction guidelines of the learning contents, the self-learning procedure, and so on (Fig. 1). In the following, I will explain the meaning of each axis in more details.

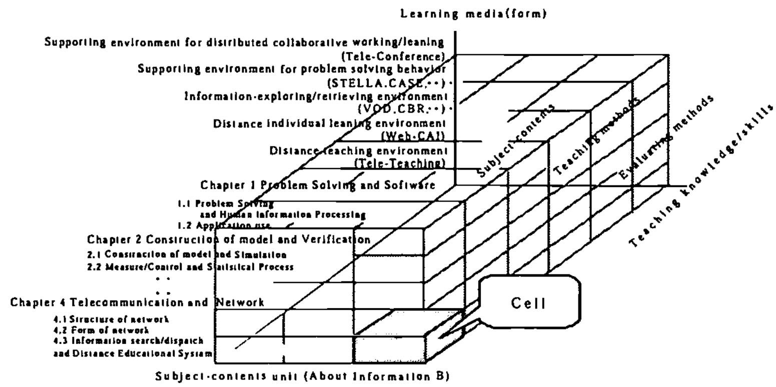

Fig.1 Structure of the Distance Educational Model

2.1.1 Subject –contents unit

In this study, we focus on the subject called "Information", which is due to be established as a new obligatory subject in the regular courses of the academic high school system in Japan. The subject "Information" is composed of three sub-subjects, "Information A", "Information B" and "Information C". The contents of each sub-subject are as follows.

Information A: raising the fundamental skills and abilities to collect, process and transmit "information" using computers, the Internet and multimedia.

Information B: understanding the fundamental scientific aspects and the practical usage methods of "information".

Information C: fostering desirable and sound behavior of participation, involvement and contribution in an information society; understanding peoples roles, and the influence and impact of technology, in the new information society.

2.1.2 Teaching knowledge/skills

On this dimension, we have represented sub-subject contents, teaching methods and evaluating methods for "information" classroom teaching. ' teaching methods' stands for how to use and apply IT, to enhance a student's problem solving ability, involving comprehensive learning activities, like problem recognition, investigation and analysis, planning and design, implementation and executing, evaluation, report and presentation. We aim at teachers acquiring the proper students' achievements evaluating skills, according to each of the above activities.

2.1.3 Learning media (form)

This dimension represents five different learning environments, as follows: 1) "Distance teaching environment (Tele-Teaching)" based on the one-to-multi-sites telecommunications 2) "Distance individual learning environment (Web-CAI)" based on CAI (Computer Assisted Instruction) using WWW facilities 3) "Information-exploring and retrieving environment" using VOD, CBR (Case Based Reasoning) 4) "Supporting environment for problem solving", by providing various effective learning tools 5) " Supporting environment for distributed collaborative working/learning" based on the multi-multi-sites telecommunications. Brief explanations for each environment are given in the following.

*(1) **Distance teaching environment (Tele-Teaching)**: This environment delivers the instructor's lecture image and voice information through the Internet, by using the real-time information dispatching function via VOD (Video On Demand).*

*(2) **Distance individual learning environment (Web-CAI)**: This environment provides CAI (Computer Assisted Instruction) courseware with WWW facilities on the Internet.*

*(3) **Information-exploring and retrieving environment**: This environment delivers, according to the teacher's demand, the instructor's lecture image and voice information, which was previously stored on the VOD server. For delivery, the function of dispatching information accumulated on the VOD server is used. In addition to it, this environment provides a CBR system with short movies about classroom teaching practices.*

*(4) **Supporting environment for problem solving:** This environment provides a tool library for performance support, based on CAD, Modeling tools, Spreadsheets, Authoring tools, and so on.*
*(5) **Supporting environment for distributed collaborative working and learning:** This environment provides a groupware with a shared memory window, using text, voice and image information for the trainees.*

2.2 • Cell" definition

The concept of a "cell" in the Distance Educational Model is quite important because it generates the training scenario, including the information to satisfy the teacher's needs, the subject materials learning-flow and the guidelines for self-learning navigation. The frame representation of the "cell" is shown in Table 1. These slots are used when the system guides the process of the teacher's self-learning.

Table 1 The frame representation of the "cell"

	Frame name	Slot-value
Slot-name	Learning objectives for a student	Subjects which should be understood Subjects which should be mastered
	Subject-contents	The unit topic
	Teaching method	The students' supervision method and instructional strategies
	Evaluating method	The students' evaluation method
	Useful tools	The software used for the training activity
	Operational manual of tools	The software operation method used for the training activity
	Prepared media	The learning media which can be selected
	Guide script	The file which specifies the dialog between the trainee and the system

3 Outline of the teacher training system

The system configuration of the teacher's training environment is composed of two subsystems based on the Distance Educational Model. One of the subsystems is the training system, where a trainee can select and learn the subject adequate for him/her guided by the script in the "cell". The other subsystem is an authoring system with creating and editing functions for "cell" description. The users of the second environment are, e.g., IT-coordinators or IT-consultants, who can design lecture-plans in this environment.

3.1 Training system

The training system aims to support teachers' self-training. The configuration of this system is shown in Fig.2. The role of this system is first to identify a "cell" in the model, according to the teachers' needs. Then, the system tries to set up an effective learning environment, by retrieving the proper materials for the teacher, along with the "guide script" defined in the corresponding "cell". Therefore, the system offers programs for both Retrieving and Interpreting. The training system works as shown in the following.

STEP 1: Record the teacher's needs.
STEP 2: Select a "cell" in the Distance Education Model according to the teacher's needs.
STEP 3: Interpret the "cell" in the guide WM (Working Memory).
STEP 4: Develop the interactive training with the teacher according to the "guide script" in the guide WM.
STEP 5: Store the log-data of the dialog (collect information on the learning histories and teachers' needs and behaviors).
STEP 6: Provide the needed applications for the user's learning activities and set up an effective training environment.
STEP 7: Give guidance-information, according to "cell" script guidelines, decide on the proper next learning step "cell".

The interpreter controls and develops the dialog process between user and machine according to the information defined in our "guide script" description language. This "guide script" description language (GSDL) consists of some tags and a simple grammar for interpreting a document, similar to the HTML (Hypertext Markup Language) on the WWW. The interpreter understands the meanings of the tags, and interprets the contents. An example of GSDL is shown below.

(1)<free>	*Definition: description of the text (instruction)*
(2)<slot (num.)>	*Definition: a link to a slot value in the "cell"*
(3)<question>	*Definition: questions to a trainee*
(4)<choice>	*Definition: branching control according to a trainee's response*
(5)<exe>	*Call: to relevant "cells"*
(6)<app>	*Definition: applications used for training activities (e.g., Tele-Teaching, etc.)*

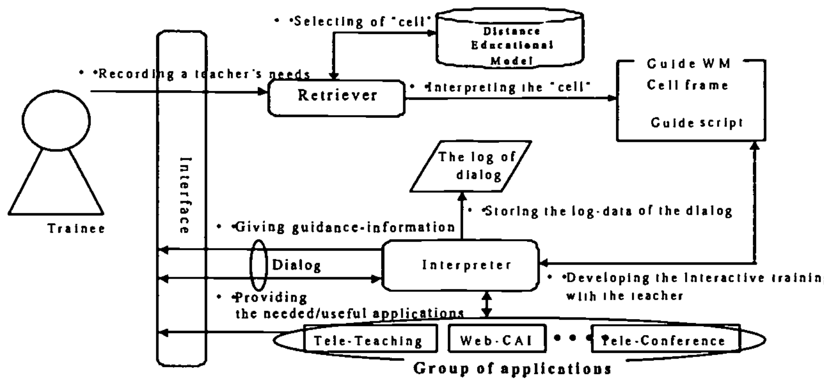

Fig.2 Configuration of Training system

3.2 Authoring system for creating and editing a "cell" description

The system provides an authoring module to create and edit the information in the "cell". This module also offers the function of adding new "cells", in order to allow supervisors (experienced teachers) to design the teachers' training program. The configuration of this system is shown in Fig.3. The tasks that can be performed by this system are: adding new "cells", editing the existing "cells", receiving calls for Tele-Teaching lectures, and managing the lectures schedule. This system is composed of the "cell" frame creating module, and the "guide script" creating module. A cell design can be performed as shown in the following.

STEP 1: Get the slot-values of "student's learning objectives", "subject-contents/teaching method/evaluating method", and "useful tools" from the "cell".
STEP 2: Substitute the return value of the slot of the prepared media with the training-contents corresponding to the user's needs.
STEP 3: Substitute the slot-value in the "cell" for the corresponding tag in the "guide script" template.
STEP 4: If "Tele-Teaching" as learning media is selected, then get some information about the lecture, by referring the lecture-DB and the VOD short movie-DB.
STEP 5: Add the new "cell" to the Distance Educational Model.

The lecture-database consists of "lesson managing files" containing user-profile data, lecture schedules, trainees learning records, lecture abstracts, and so on. The "guide script" template file contains tag-information, written in the "guide script" description language (GSDL), for all subject-contents items in the Distance Educational Model.

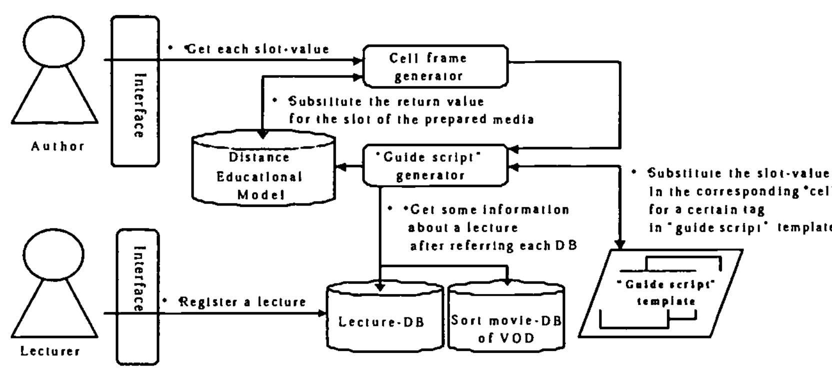

Fig.3 The procedure of "cell" description for creating/editing of the authoring system

4 Conclusions

This paper proposed the Distance Educational Model called the School Based Curriculum Development and Training System (SCOUTS). This model stands for the networked virtual leaning environment based on a three dimensional representation, which has on the axes 1) subject-contents, e.g., "information" for the training, 2) teaching knowledge, skills and evaluation methods and 3) learning and teaching media (forms). This represents a new framework for teachers' education in the coming networked age. We have mentioned the rationale of our system and explained the architecture of the training system via a 3D-representation model. Furthermore, we have described a "guide script" language. This system is superior to a simple rule-based instructional plan, as it allows a better and more natural overview of the global structure, as well as a quick identification of missing parts. The aim of our system is to support teachers' self-learning, provided as in-service training. At the same time, we need to build rich databases by accumulating various kinds of teaching expertise. In such a way, the concept of " knowledge-sharing" and "knowledge-reusing" will be implemented. As a result, we trust that a new learning ecology scheme will emerge from our environment.With this system, we can construct various kinds of learning forms and design interactive and collaborative activities among learners. Such an interactive learning environment can provide a modality of externalized knowledge-acquisition and knowledge-sharing, via the communication process, and support learning methods such as "Learning by asking", "Learning by showing","Learning by Observing, "Learning by Exploring" and "Learning by Teaching/Explaining"'. Among the learning effects expected from this system, we also aim at meta-cognition and distributed cognition, such as reflective thinking, self-monitoring, and so on. Therefore, we expect to build a new learning ecology, as mentioned above, through this system. Finally, we will apply this system to the real world and try to evaluate its effectiveness and usability from experimental and practical point of view.

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The Impact of Learning Style on Group Cooperative Learning

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Cooperative learning has been around a long time and there are many researches and practical uses of cooperative learning. This study is to examine students' attitude toward group cooperative learning processing with individual's underlying learning style. We use Gregorc's Learning Style Delineator to group students heterogeneously and use some factors of Social Cognitive Theory to measure group processing. The findings indicate students with concrete/sequential learning style are tentative to be lack of self-efficacy on setting their goals and therefore teachers should take more care of them while doing group cooperative learning activities.

Keywords: **Cooperative Learning, Learning Style, Social Cognitive Theory**

1 Introduction

Cooperative learning means students working together to accomplish shared learning goals and to maximize their own and their group members' achievements (Johnson & Johnson, 1994). Cooperative learning is widely adopted by the educators since 1980s. Students perceive that they can reach their learning goals if and only if the other students in the learning group also reach their goals (Deutsch, 1962; Johnson & Johnson, 1989). A vast amount of evidence from research in related areas suggest that in cooperative learning situations there is a positive interdependence among students' goal attainments.

Although cooperative learning makes students to learn much better than competitive learning and individual learning in groups, there are still many potential barriers to make group effective, such as lack of sufficient heterogeneity, lack of groupthink, free riding, and lack of teamwork skills (Johnson & Johnson, 1994; Johnson & Johnson, 1996). The basic elements of making cooperative group with high performances are positive interdependence, face-to-face promotive interaction, individual and group accountability, appropriate use of social skills, and group processing (Johnson & Johnson, 1996). Thus how students interacting with other group members and groups processing are the critical successful factors in cooperative learning. By considering individuals' underlying learning style, the purpose of the study is to examine students' attitude toward group cooperative learning processing.

In the Bostrom, et al. (1988) framework individual difference variables define the cognitive aspects of human activities. Thinking process is at the heart of all such activities including learning. Learning style is one of the cognitive traits, which are static aspects of information processing affecting a broad range of variables (Bostrom, et al., 1990). To aim for sufficient heterogeneous grouping, this study chooses learning style as the main variable concerning the impacts of group cooperative learning.

To examine individual's interaction during group processing, this study use Social Cognitive Theory (SCT) (Bandura, 1986), a widely accepted and empirically validated model of individual behavior (Compeau & Higgins, 1995), to reflect the cognitive aspects of students' learning activities, such as self-efficacy. SCT emphasizes the triadic reciprocal causation of behavior, cognitive and some personal factors and environmental events (see Figure 1). Three aspects of Social Cognitive Theory are especially relevant to the organizational field (Bandura, 1988; Wood & Bandura, 1989): the development of people's cognitive, social, and behavioral competencies through mastery modeling, the cultivation of people's beliefs in their capabilities so that they will use their talents effectively, and the enhancement of people's motivation through goal systems.

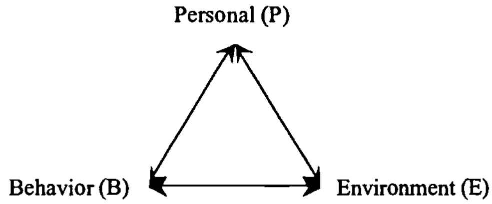

Figure 1. Schematization of the relations among behavior (B), cognitive and other personal factors (P), and the external environment (E) (Bandura, 1986; Wood & Bandura, 1989)

According to Social Cognitive Theory, many researches showed that past performance, self-efficacy and goal setting are the main personal factors effecting performance. Although there are many other factors in the range of the theory, we just discuss the impact of learning style on self-efficacy and goal setting in this study.

There are some other factors exerting considerable influence over group performance. For example, group cohesiveness and group norms. Cohesiveness means all forces (both positive and negative) that cause individuals to maintain their membership in specific groups. Group cohesion means the mutual attraction among group members and the resulting desire to remain in the group. Norms means the rules or expectations that specify appropriate behavior in the group and the standards by which group members regulate their actions (Johnson & Johnson, 1996). Group performance is affected by the combination of cohesiveness and group norms rather than cohesiveness alone (Langfred, 1998). In this study, we also investigate the impact of learning style in group cohesiveness and norms.

2 Method

2.1 Subjects

The subjects were 43 girl's senior high school students who participated in the AJET (Advanced Joint English Teaching, *http://ajet.nsysu.edu.tw*) project, which was supported by MOECC (Ministry of Education Computer Center, APNG-Education (Asia Pacific Networking Group) and I*EARN in Taiwan (*http://www.iearn.edu.tw*). Therefore there are no differences in sex and age among them. The subjects were run in groups and Table 1 is their proportion of learning style. We'll explain the types of learning styles later.

Table 1. Learning Style Frequencies

Learning Style	AR	CR	AS	CS	Total
Students Numbers	15	17	7	4	43

Every group was assigned a project to make English web pages about one topic: Signs or Foods in 6 weeks. Every week they had tow hours on learning how to make homepages by Microsoft FrontPage 98 and doing their group's project as exercises in the computer classroom. Before the experiment, they had learned some basic skills for building their own personal webs.

2.2 Procedure

During the 6 weeks, there were three 2-week sections in the experiment. In the first week, the subjects were asked to fill out the self-efficacy, goal setting and group cohesiveness questionnaires. The same questionnaires were conducted in every section. And in the second week, they were asked to fill out the group norm and satisfaction questionnaires after their performance measurement made by the teachers.

2.3 Measure

According to the procedure, this study assessed learning style and 5 constructs: group norms, group cohesiveness, self-efficacy, goal setting and satisfaction.

2.3.1 Learning Style

In this study, the Gregorc Learning Style Delineator was used to measure the learning style (Gregorc, 1982). Gregorc' s model is one of several models developed to improve understanding of the way students learn and the way teachers teach and is a cognitive model designed to reveal two types of abilities, perception and ordering. Perceptual abilities mean through which information is grasped, translate into two qualities; abstractness and concreteness. Ordering abilities are the ways the learner organize information, either sequentially (linearly) or randomly (non-linearly) (Leuthold, 1999). Thus there are four learning categories: abstract/ random (AR), concrete/random (CR), abstract/sequential (AS) and concrete/ sequential (CS).

2.3.2 Group Norms

Group norms was measured by 5 items on 7-point scales, which indicate the amount of effort put into work, the attitudes toward work load, the willingness to give up free time to work, the feeling of responsibility for work goal attainment, and the feelings of self-worth when work is accomplished well. This measure is developed based on the literature of group work norms (Langfred, 1998). The Cronbach alpha for the group norms measure was .839.

2.3.3 Group Cohesiveness

Group cohesiveness was measured by 6 items on 7-point scales, which defines the feeling of individual group members toward other members and the group. This measure is based on the literature of Langfred (1998). The Cronbach alpha for the group cohesiveness measure is .79.

2.3.4 Self-efficacy

Self-efficacy was measured by 8 items, which asked the respondents to rate their expected ability to accomplish the project with different levels of goal. For example, the respondents were asked whether they could accomplish fifty percent of the project and how much confidence they have. This measure is developed based on an extensive review of the literature of self-efficacy (Compeau & Higgins, 1995). The Cronbach alpha for the self-efficacy measure is .963.

2.3.5 Goal setting

Goal setting was measured by 4 items, which asked the subjects' commitment to their goal of the projects. This measure is developed based on the literature of goals (Locke, 1984). The Cronbach alpha for the goal setting measure was .68.

2.3.6 Satisfaction

Satisfaction was measured by 5 items on 7-point scales, which asked the subjects' satisfaction of the performance of their group project. This measure is developed based on the literature of satisfaction (Dennis, Kinney & Hung, 1999). The Cronbach alpha for the satisfaction measure was .913.

3 Results

Since the Cronbach alpha values of all experiment measures are .891, .8767 and .8646 respectively, this experiment was reliable. An overview of the data is displayed in Table 2, and the results are displayed in Figure 2, 3, 4, 5 and 6.

Table 2. The mean of every measure

Mean	Group Norms	Group Cohesiveness	Self-efficacy	Goal setting	Satisfaction
Section 1	5.16	4.90	529.77	5,66	4,94
Section 2	4.90	4.60	561.16		4,56
Section 3	4.86	3.76	574.42	5,60	5,05

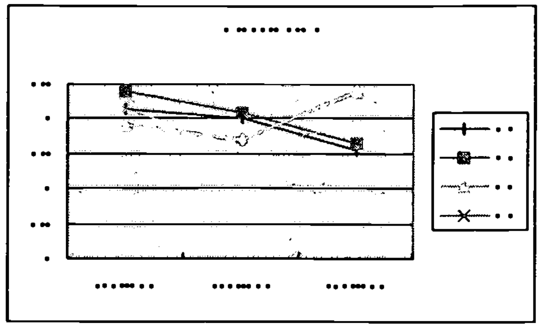

Figure 2. Effects of Learning style on group norms

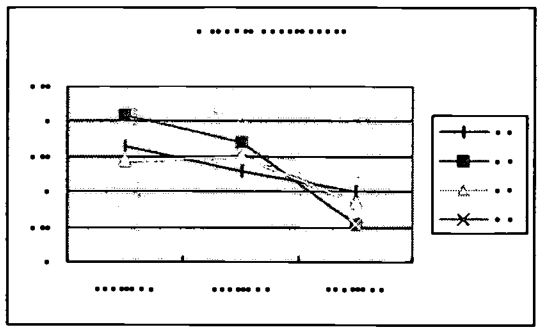

Figure 3. Effects of Learning style on group cohesiveness

The effects of learning style on group norms and group cohesiveness in the three 2-week experiments are not statistically significant, and the results are showed in Figure 2. Because the subjects were grouped since three months ago in the beginning of the semester, the group norms were already statically existed and were identified with group members.

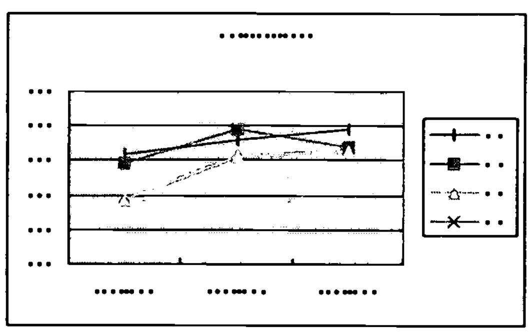

Figure 4. Effects of Learning style on self-efficacy

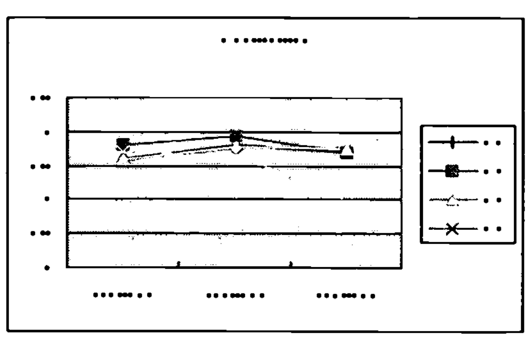

Figure 5. Effects of Learning style on goal setting

The effects of learning style on self-efficacy and goal setting are more significant than group norms and group cohesiveness. The results are showed in Figure 3. Students with concrete/sequential learning style had less self-efficacy during the experiment and were afraid to set their goal higher. Maybe the CS style students feel difficult to make web pages since it is somehow an abstract skill and needs to think randomly.

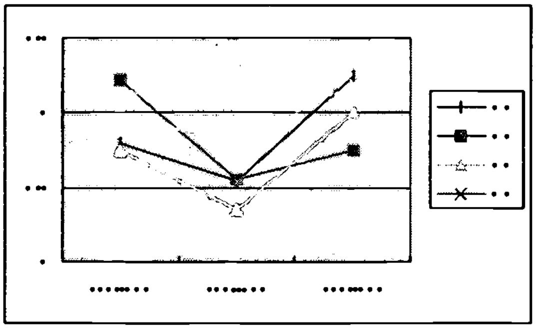

Figure 6. Effects of Learning style on satisfaction

The effects of learning style on satisfaction don't have significant differences, and the result is showed in Figure 4. It showed that all students enjoyed group cooperative learning and were satisfied in this way of learning.

4 Conclusions

In general, all students performed well in the group cooperative learning and felt satisfied with group processing. Although the students with concrete/sequential learning style were few and far between the subjects in this experiment, a quarter of general students would be this kind of learning style. Teachers should give them more encouragement to make them getting more self-efficacy and setting the right goal. Moreover, this study only uses Gregorc Learning Style Delineator to examine students' learning style. There are many other kinds of learning style evaluations, such Kolb's (1976) Learning Style Inventory (KLSI), Canfield's (1988) Learning Styles Inventory, etc. Future researches may use these questionnaires to examine which one is more suitable for cooperative learning.

And about the Social Cognitive Theory, there were many studies showed that the triadic aspects could form some models, which would affect each other in some relationships. Since the sample size is too small, this study doesn't prove the model by statistic methods. This is a limitation of this study. Understanding the effects between group norms, cohesiveness, self-efficacy and their performance will be an interesting research topic.

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The Project-based Cooperative Learning on Internet -- A Case Study on Geology Education

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We have conducted an experiment on Internet learning in geology by high school students in Taiwan. A total of 74 students from 17 high schools enrolled in the beginning. 50 of them completed the 23-day program of learning activities. The experiment was designed on the concept of project-based cooperative learning on Internet. The overall topics for learning were the geologic landscapes of Taiwan. Four sub-topics were chosen to serve as the central themes for Topic Groups. Furthermore, the students were asked to enter on of the three Expert Groups. The sequence of learning activities was consisted of three stages: first stage in Topic Groups, second stage in Expert Groups, and third stage reassemble in Topic Groups. In contrast to traditional class learning mode, the Internet learning can leave complete records of the learning process of each student so that we can track their learning achievements. We found that the students liked the new Internet learning method because it gave freedom to exchange questions and answers among themselves without fears of embarrassment. We also found, by comparing the preconcept map and postconcept map, that the students have gained wider and more complete understanding of the overall geologic topic chosen for this experiment: The Geologic Landscapes of Taiwan.

Keyword: **Project-Based Cooperative Learning, Topic Group, Expert Group and High School Geology.**

1. Introduction

Internet is useful and getting more popular with the booming information technology. People can get any kind of information through Internet. If the benefits and convenience of Internet could be utilized in teaching, then students could go on learning by themselves when they feel free. It is likely that this learning method may become a main stream in the future. The present research project is designed based on this concept. Therefore, the emphasis is not only to evaluate student' s learning achievement but also to find out how much he/she learns geology through learning process.

Exploration is a core activity in science learning. Constructivists believe that learners can not get true understanding without going through stages of asking question – designing research collecting data-presenting the results (F.C. Chen and H.M. Jiang, 2000). Based on the above believes, we designed a project-based learning model of five steps for senior high school students. The students are enrolled in different senior high schools located in different parts of Taiwan. The separate locations minimized face-to-face communication. Learners were obliged to involve in Web-based learning. As a result, they left rich information and complete records documenting each student' s learning process through Internet.

2. Method

2.1 Participants

Seventy-four students from seventeen senior high schools in four regions (Taipei city, I-Lan county, Tao-Yuan county and Hsin-Chu county) participate in our experimental project. However, only 50 students from 13 senior high schools completed the entire experiment. Among these students, 47 are in the first-year class and 3 in the second-year class. Gender-wise 19 are boys and 31 girls.

2.2 Procedures

The 50 high school students and one college graduate majored in geophysics serving as a mentor formed a network-based learning community. The students studied mainly on Web (http://glyedu.gep.ncu.edu.tw). There major tasks included browsing the Web pages, reading and writing articles in group discussions, finishing homework, talking to their classmates or teachers at school, and finding more information in library. But the student' s major learning activity is to focus on group discussions (reading and writing articles) on Internet and collecting data. The purpose of collecting data is for group discussions. The students will find more information by going to library, asking their teachers and talking with their classmates to reinforce the data needs for group discussions. We saved all the articles in the hard disk of our server to keep complete records on the learning process. Those articles are the raw data for the following analyses and discussions.

The topics for group discussion in the project are assigned as "Geologic Landscapes of Taiwan". All learning activities are centered around these topics. This topics is further divided into four groups, namely, Rock' s Story of Yeh-Liu, Coast Tourist Group, When Mountains Meet the Sea and Promise Taiwan A Future. These groups are called "Topic Group". At the beginning, 7 misconceptions related to the Topic Groups are given to the students to raise their interests in learning. Furthermore, the students are required to choose one of the "Expert Groups" that interested them. There are three Expert Groups designed in this experiment: Wind Effects, Water Effects and Geography & Human Effects. These Expert Groups will be elucidated in details in follow section.

The entire experiment lasted for 23 days in this project. At the first and last days of the experiment, the students are required to come to National Central University (Chung-Li, Taiwan, R.O.C.) and attend classes designed to entice their involvement in this project. For rest of the days during the experiment, the students learning by themselves through Internet at home or at school. The self-learning days are further divided into three stages; each stage lasted for seven days. First stage started with the "Topic Group". In the second stage, "Expert Group" is preceded. Then, the third and final stage returned to the "Topic Group" again. (Fig 1)

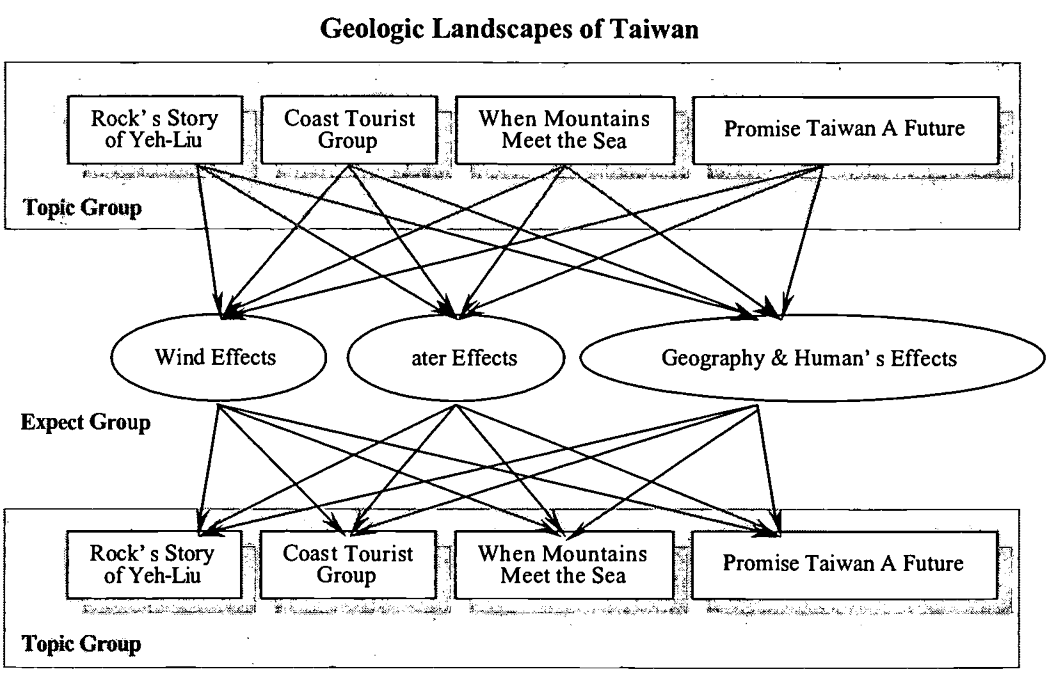

Fig1. Process of Cooperative Learning

During the first stage in Topic Groups, the same group' s partners must help each other to set clearly several assumptions and to design research strategies. During the second stage, everybody needs to join one Expert Group and gathers enough knowledge and information for solving the problems met in the first stage. In the third stage, the students in Topic Group share what they learned in each Expert Group with their partners. Through this process, the members in the same group team up and solve the problems cooperatively just like putting together pieces in a puzzle. All discussions are posted in the Web site of this experiment through Internet. In such circumstance, the students are compulsory to learn by asking and discussing with other participants in addition to the teacher.

2.3 Data collection

The data collected in this study include:

1.Results from the Multiple Factor Aptitude Test and Exploratory Test of Ge ology carried out before the experiment.

2.Students' homeworks including preconcept map, misconceptions, term paper, and postconcept map.

3.Discussion records on Internet: the students communication and learning through group discussion on the discussion board on Internet. The records are saved and used to analyze the gradual changes for each student.

4.Questionnaires: Every student is required to answer a questionnaire before the end of the project. There questionnaire provide the project more clues to understand how students record to this new leaning method.

2.4 Data analysis

In this study, the data collected from the open questions through the questionnaires and concept maps before and after the experiment have been used to study the merits of cooperative learning through Internet. With regard to the results from the tests of Multiple Factor Aptitude and geological background, they are treated as representatives of student' s capability.

3. Results

Through analyses of the data collected so far, some preliminary results are present here.

3.1 Advantages of cooperative learning in science

From student' s questionnaires we can find that, almost all students feel fresh, interesting, and useful about this learning experience. They can accept this learning mode. They have gained most achievements from group meetings, because

- *Through group discussion I cam understand partners' question, and I can review my own knowledge.* (No. S-18 of questionnaire)
- *I can ask any questions that I don't know.* (No. S-31 of questionnaire)
- *In discussion, my question can get the answer. Sometime I can get more information and knowledge, unexpectedly.* (No S-35 of questionnaire)

From their questionnaires we know that almost all the students interested in this learning mode that is very different from the regular classes. They consider this learning mode can trigger them to think about learning contents. Regarding traditional class learning, the students don' t consider it will trigger them to think because "the knowledge is corre ct, certainly".

In fact, student is very enthusiastic in writing. The ask questions willingly. They can ask questions they don' t understand, and answer that they understand. For answering partner' s questions, they must search more information, and read more books. Through this cooperative learning mode, students can get more knowledge by themselves.

3.2 Advantages of studying science by cooperative learning on Internet

While students agree this new learning mode, it also means that they don' t like traditional learning mode. We can find such answer from student' s response to questionnaires:

- *Everybody can express their opinion on Internet eagerly, perhaps because the student doesn't have to be face to face with people.* (No. S-50 of questionnaire)
- *On face to face learning, it lets me fear and want to escape the teacher's eyes with care and upbraid. You can find your thinking has more free space on Internet Learning. You don't have any restrain and don't feel tense for talking face to face, because you only face a computer.* (No. S-31 of questionnaire)

- *This is the first time to try learning on Internet on my life. It was tensest moment in face-to-face learning, because talking face to face is always a barrier that I can't break up. I will be very tense, can't speck very well, and can't express my mind clearly. On the other hand, on Internet learning, I can talk with confidence and composure, don't have to care about their facial expressions.* (No. S-45 of questionnaire)
- *I will increase the interaction, especially, to us eastern Asians who are more reserved.* (No S-19 of questionnaire)

We can find a distinct characteristics of our students from above words. Most students are shy, tense, and conservative. They will need time to open their minds. They are not accustomed to express their opinions under other people's watching eyes. They worry about what can they do if their answers are wrong. These results can be referred to school teachers to improve traditional teaching mode. When the students don't answer teacher's question, it does not necessarily show they can't or don't understand, it maybe because they are just shy. Teacher can design a learning project knowing these characteristics of students to help them free from shyness and passiveness.

3.3 Evaluation of learning achievements

Before starting of the Internet learning, all students were required to finish a homework on "preconcept map". At the end of Internet learning, they were again required to finish on other homework on "postconcept map" (refer 2.3). We can find the following tendencies by comparing the preconcept map and postconcept map.

1. The most obvious difference is that student's concepts became more numerous. They used few concepts when doing the preconcept map. And they can use more concepts when doing the postconcept map.

2. The concept's range and level became wider and framework because more complete. The preconcept map maybe just focuses on narrow geological topics. In the postconcept map, the geological understanding became much wider.

3. Wrong concepts are corrected. There were some misconceptions in the preconcept map, For instance, they might use a wrong connective word with two concepts; it means the student doesn't know the relation between those concepts. In learning process, all mentors didn't talk to any student about his/ her mistakes. But eventually the mistakes become corrected in postconcept map. It means he/she has learned correct concepts and knows the relation between different concepts.

4. Conclusions

This experiment on Internet learning in geology by high school students in Taiwan has a total of 74 students from 17 high schools enrolled in the beginning. 50 of them completed the 23-day program activities. Based on analyses of the collected data so far, some preliminary results are presented here.

1. Almost all students were interested in the learning mode centering at Project-Based Cooperative Learning on Internet. They thought this learning mode could stimulate them to think about wider range of learning.

2. We found distinct characteristics of the participating students. Most students were shy, tense, and conservative. Teachers can design a learning project knowing these characteristics of students to help them free from shyness and passiveness in learning process.

3. Through this learning process, the students can get more knowledge. We can draw this conclusion from the following observations:

i. The most obvious difference is that individual student's ideas become more numerous.
ii. The range and level of student's ideas become wider and more complete.
iii. Wrong concept are corrected, through group discussions.

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Tracking and Guiding Tools for Learning Groups in a Web Collaborative Learning System

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Owing to prevent a learning group from failing, teachers need to observe the group learning situation, and discover its causal dependence in a web collaborative learning system. Therefore, teachers need to record the web logs and try to analyze these row data. However, the web logs amounts are often exceeding the teachers' readability and becomes to be meaningless. This work presents some assisting tools of Bayesian belief network supported another window to observe the leaning situation objectively, and predicts the probability of the learning situation before the end of semester. This work was experimented on managing a web collaborative learning with 706 students online. The results represents these tools relieved the teacher of tedious data collection and analysis, analyzed the causal dependence of each learning features, discovered the hidden learning features related with the social interdependence, and prevent the students learning from failed.

Keywords: **Bayesian Belief Network, Collaborative Learning, Learning Features, WWW**

1 Introduction

In existing web learning systems, students may feel lonely without learning companions. Many researches have indicatethat students will learn better when they learn in a group [1] [2] [3]. Thus, the group learning mechanism can be adopted into web learning to overcome the lonely study issue. A web collaborative learning system requires the teacher to put lots of efforts in tracking and guiding these groups on the web. It is difficult for teachers to capture the group learning status from the huge amount of unorganized web logs. The situation is even worse when hundreds of students are involved in collaborative learning, and it is difficult to get information from them [16]. Therefore, many assisting tools for analyzing the web logs were developed. [4]

However, most of these tools focused on providing summary of how the website is being accessed, for example, the statistics of access time, access frequencies, and the access location of web page. In fact, these numeral results and statistics are not enough for a teacher to obtain the status of learning groups in a collaborative learning system. Teachers ask for information to help them promote the collaborative learning performance. Example information includes whether a group leader success in fulfilling her/his role; whether there is distrust existing among group members, and low perceptions of help and assistance [5].

Moreover, a teacher needs information to track the social interdependence of a learning group. Johnson [1] identified that *social interdependence* is a key factor that affects the success of learning groups. The *social interdependence* includes the goal, reward, resource, role and task interdependence. The problem is these impact factors cannot be captured directly by analyzing access logs. Furthermore, the inter-group communication context is not apparent. Therefore, it is a challenge for a teacher to obtain the status of these impact factors immediately when tracking and guiding a web collaborative learning system.

Once the impact factors of a web collaborative learning is detected, the graphical model for representing the causal relationships is required for teachers to make a decision to teach strategies and intervene groups' learning online. In order to preventing a group from failing in the early semester, an appropriate invention is needed. After constructing such causal map for several times, teacher will accumulate some experiences of how to prevent groups from failing in time. However, this kind of individual experience is not reusable for other teachers or teaching assistants.

There we summarized two issues mentioned above when teachers try to manage the web collaborative learning.

- Discover the impact factors of learning situation:
  Since the social interdependence affects the collaborative learning deeply, teacher need some assisting tools to find out the impact factors hidden in web logs and group portfolios.
- Prevent groups to be failed by experience analysis:
  At the end of semester of a collaborative learning, the experience and logs could be an important reference for the next semester. If teacher could find out the impact reason of specific states, her/he could prompt the group to learn or prevent the group from failing.

To resolve the issues listed above, our research tried to employ some data mining techniques and supported some useful information for teachers to manage the web collaborative learning.

The participators in this research included 7 teachers, 5 teaching assistants and 706 students. All of these participators teaching and learning via video compacted disc (VCD), and collaborated the group works and discussed to members on web. Students were divided into 2 classes: Class-A and Class-B. Both classes were used the same teaching strategies and curriculums. In this research, the learning logs of Class-A were used for constructing the relational map between each learning feature. It was the simulated past-experience for predicting the learning states of Class-B. The result shows that with the assistance of these useful tools, teacher could track and guide the web collaborative learning with meaningful learning states, discover the impact factors associated with the social interdependence, and predict the learning state and make a teaching decision online.

2 The Bayesian Believe Network

This work employed the Bayesian belief network (BBN) [6] to model the learning situations and represented the causal relationship between these situations in a graphical map. The BBN is a directive map composed by some nodes and arcs, these nodes and arcs represent the joint probability distribution for a set of variables. In this research, the nodes represent the group's *Feature Space (FS)* [7], and the arcs represent the relationship and the joint probability of two FS. It is named as "FS-based Bayesian belief network (FSBBN)". In Figure 1, it is an example for illustrating the FSBBN of a web-based collaborative learning: the "Learning Failed" node represented the group grade less than 60 at the final of semester. The "Homework Late Submitting" node represented the group homework were submitted after the deadline. The "Less Discussing" node represented the discussion amount in discussion place were less than 3 post each day. The "Less Login" node represented the average login times of a group less than 1. The "Leader Failed" node represented the group leader were failed in his jobs. The arcs in BBN represented the causal relationships between each node, and were constructed by the Bayesian Classifier. The Bayesian Classifier figured out the probability of each node that was affected by the previous nodes.

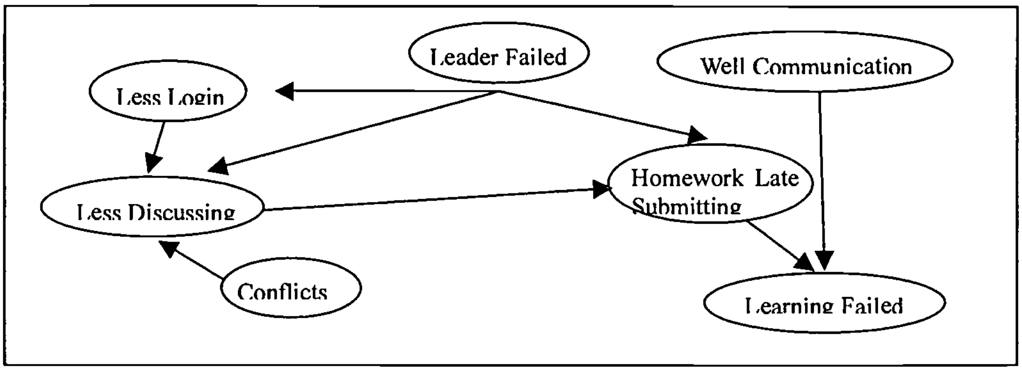

Figure 1: The example of Bayesian belief Network

Some probability tables deducted the directive arcs in FSBBN. Table 1 presents the probability of "Learning Failed" of a group, where "Learning Failed" is abbreviated to F, "Homework Late Submitting" is abbreviated to H, and "Well Communication" is abbreviated to W. The direct effects of "Learning Failed"included the probability of "Well Communication" and "Homework Late Submitting" both. Moreover, the direct effects of "Homework Late Submitting" included the probability of "Leader Failed" and "Less Discussion". In this way, the effects of "Learning Failed" included the probability of "Well Communication", "Homework Late Submitting", "Less Discussion", "Less Login", "Conflicts and Leader Failed".

	H,W	H,¬W	¬H,W	¬H, ¬W
F	0.35	0.93	0.02	0.54
¬F	0.65	0.07	0.98	0.56

Learning Failed

Table 1: The probability of Learning Failed

The FSBBN makes assistance for teachers finding out the relationships between each learning FS. It also supported the need for teaching decision in a web-based collaborative learning system, and will be illustrate in the following chapters.

3 Applying the Data Mining Tools in Learning Tracking and Teaching Guidance

To track students' learning status, teacher must to obtain the relationships between each impact factors of collaborative learning. In this chapter, several BBN tools support a directive map that illustrate these FS and help teachers to discover the objective causal relationships between these FS. These causal relationships support teachers to make a decision and promote the group to learn, prevent the group to be failed at the end of semester. This chapter will introduce some of free-wares and show how to apply these public tools in constructing a FSBBN and managing a web-based collaborative learning.

3.1 Observing the collaborative learning states and find out the impact factors

Bayesian Knowledge Discoverer (BKD) is noncommercial classification software for research, released by Knowledge Media Institute of Open University of UK. [8]. The aim of BKD is to provide a Knowledge Discovery tool able to extract reusable knowledge from databases, without expecting any particular methodological background from the user. To this aim, BKD uses BBN as a graphical representation of the dependent model in the database. Once the BBN generated from data, the network can be used as a self-contained reasoning system, able to provide observation, predictions and support decision making for a teacher.

The BKD needs a text file exported from database for constructing the BBN. The input data could be numeric or discrete data. To generated the complete causal network of a web collaborative learning, the input data of BKD should include the learning FS, personal profiles, online access statistics collaborative portfolios, and discussion situation. In Table 2, it illustrated that the teachers' interesting items about the learning situations. There are two groups of items: (1) learning FS (2) online statistic. All the values in this group were discrete Yes/NO or a label of level. The other items in second group were the online statistic from database, including the students' profiles, web accessing and discussion.
In Table 2, the "Conflict" means if the members have ever conflicted on the project goal with members, it represented the goal independence of a group. The "Lack Leadership" means the group leader failed in her/his role, it represented the leaders' role independence. The "Poor Comm" means the members made the communications with others rarely on the issues of project. The "Distrust" mean students have low trust with members about the discussion content and sharing resource, both of above FS represented the resource interdependence of a group. The "Poor Help" means if members did not like to help others in collaborative

project, it represented the reward independence of a group. The "Query Work" means the number that member query the current result of group project. It represents task interdependence of a group. Finally, the "Lower Grade" means the group failed in learning and got lower grades.

Group id	Conflict	Lack Leadership	Poor Comm	Distrust	Poor Help	Query Work	Disc Online	Email	Disc Lonely	Lower Grades	...
1	N	N	Y	N	N	64	6	6	48	Y	
2	Y	N	Y	N	N	165	4	21	14	N	
3	Y	Y	N	N	Y	0	0	13	19	Y	
4	N	N	N	N	N	44	3	19	13	N	
5	Y	N	Y	N	N	196	4	26	25	N	
6	Y	N	N	N	N	198	57	6	170	N	
7	Y	N	Y	Y	N	91	4	27	33	N	
8	Y	N	Y	N	N	175	3	6	41	N	
9	Y	Y	Y	N	N	68	1	8	16	N	
10	N	N	Y	N	N	70	7	13	23	Y	
...											
35	Y	N	Y	N	Y	12	2	3	15	Y	

Table 2: The input file for BKD (Class A)

After the input file import into the BKD, the system will construct a FSBBN for teachers to observe the relationships and the probability model for decision-making, like the example in Figure 1.

3.2 Experience reuse to prevent groups to be failed

To prevent groups to be failed early, the teacher would like to predict the group's learning state at the end of semester by the current states and her/his past teaching experience. The ideal to predict the learning states is to classify the new FS into the classes divided by the past FSBBN. In traditional classification tools, it contains two steps for prediction: first the system is trained by teacher's experience on a set of past data. The second, system will classify the cases by the trained set. The Robust Classifier (Roc) [8] is also noncommercial classification software for research, released by the Knowledge Media Institute of Open University of UK. It supports an efficient tool for teachers to classify the past FS into several classes, and predict the new FS into these classes.

There are four steps of Roc to predict a set of real-time FS illustrated as follows:

1. Define the Bayesian classifier from a database:
2. Class selection and discretization:
3. Learning the past learning FS:
4. Predictions the real-time FS:

There is an example how a teacher using the four steps to prevent the group learning failed:

Step1. Collecting the learning FS and online access data as the input file. Table 2 illustrated the teacher collected the input data of Class A for constructing the classifier. The input file has the same file format as the input file for BKD system.

Step2. Select one of the FS of input data as the class. For example, the teachers are interesting to obtain which group with the real-time FS will get lower grade at the end of semester.

Step3.After the Roc learning procedure proceed in this step, it generated the probability of each FS to the selected classes (Lower_Grades). In Table 3, two of FS: "Conflict" and "Leader_Failed" was listed and illustrate the probability of the group to be failed and get lower grades (Lower_Grades)

Step4. Predict the probability of learning failed via the online data of Class-B. Although Class-A and Class B were hold at the same semester, for prove the ability of prediction in this paper, the online FS of Class B were used as the test data. In case of the prediction were hold before the end of semester, some data were absent until the end of semester when predicting. In this research, several FS of Class-B were marked as '?' for simulating this situation.

Class Lower_Grade

N	Y
(0.690)	(0.310)

Attribute Conflict

	Y	N
N	(0.621)	(0.379)
Y	(0.385)	(0.615)

Attribute Leader_Failed

	Y	N
N	(0.172)	(0.828)
Y	(0.231)	(0.769)

Table 3: The results of Roc learning procedure

In Table 4, the coverage shows all the cases of Class B are predictable in RoC. The column "Lower Grades" is the original FS of Class B. It must be noted that in a real life case, this value of "Lower Grades" of Class B will not be known until the end of semester. The column "Predicted Result" is predicted by RoC with the input data in and the learning data. It is clearly that the system predicted group 1 would not get a Lower Grades at the end of semester. And the fact matched this prediction. However, the prediction of group 2 mismatched the fact. The column "Probability" represents the probability of such predictions of each group. In this experiment, the predicted result showed that the accuracy is 77.77% (28 correct, 8 incorrect). This credible result of RoC provides teachers not only predict the probability of each group to be Lower Grades, but also all other FS groups of social independence and will be discussed in next chapter.

Group id	Predicted Result	Lower Grades	Probability
1	N	N	0.561
2	N	Y	0.977
...	...	...	...
36	Y	Y	0.897
Correct:	28		
Incorrect:	8		
Accuracy:	77.77 %		
Coverage	100.0 %		

Table 4: The output file of predicted result (Class B)

4 Experience and Result

In this chapter, teachers exhibit a web-based collaborative learning on the "Introduction of Computer Network and Applications" course. The data mining tools such as BKD and Roc were employed and help teachers to observe the learning states, intervene the learning to promote collaborating and illustrated the ability to prevent the group to be fail before the end of semester.

4.1 The participants and the grouping on web

The participators included 7 teachers, 5 teaching assistants and 706 students in Taiwan. The 63% of students are teachers in high school, and all graduated form colleges or above. The 706 students were divided randomly into tow class named Class-A and Class-B. After the first month for students to be used to the environment, functions and operations, students were grouped into several heterogeneous groups by the grouping tools [9]. The grouping criterion included the personal profile and thinking style [10]. There were 35 groups in Class-A and 36 groups in Class-B, average 9.9 students in a group. The 63.5% of students are also the teachers in high school and all graduated from college or above. It represents most of the students did not have the difficult to get on-line. The students read the curriculums from video compacted disc (VCD). After the reading work, students must register in the NCUVC [11][12][15] collaborative learning system. The NCUVC support a web discussing space, collaborative project space and sharing resource in space, etc. The first group task is to elect the cadres, included the leader, co-leader and the clerk, and check-in the group private working space. The group private working space supported the online and offline discussion room, a resource sharing space, a portfolio space, a project scheduler, and a window for querying the member working states.

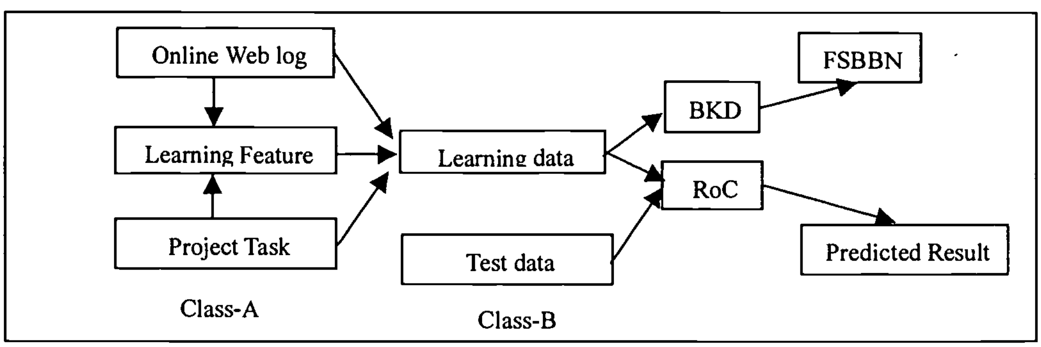

Figure 2: The process for observing and predicting the learning situation

Figure 2 illustrates the process for teachers to observe the learning FSBBN and predict the learning situation. For observing the learning states, teachers collected all the online/offline data to be the learning data and the input data for BKD system. The output of BKD is the form of graphical FSBBN. For predicting the learning situation of Class-B, teacher employed the training data to be the first input data of RoC system. The online data of Class-B is the test data and second input data of RoC. The result classified the cases of Class-B into the classes of Class-A, and support probability of each class for teachers.

4.2 Observe the learning states

After all the groups were ready to work together, teachers assigned the first project to each group. It is a collaborative project for constructing the web site for teaching the techniques of web programming. In the progress of project, teacher would like to observe the learning and working states of each group. There two type of observing method supported NCUVC. First, the subjective FS: teachers could construct the FS subjectively and focus on the specific group learning/working states, which are interesting for individual teacher. Because different teachers will define different FS for each group, it is the subjective observing tool dependent on teachers. Second, the objective FSBBN: it is a causal map based on the FS and all the accessing logs on web, the BKD system will construct the FSBBN for each group. Therefore, teachers could track the learning states and the causal relationships between each FS and access log. Because the causal map was constructed by the Bayesian method, it support the objective observing tool. The following figure is an example for observing the learning Class-A.

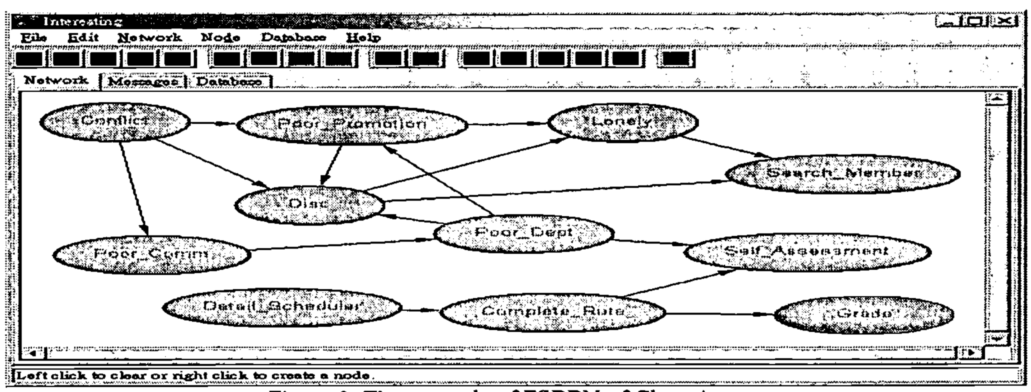

Figure 3: The example of FSBBN of Class-A

In Figure 3, teachers were interesting the causal relationships of homework grades (Hw_Grade) of each group. This FSBBN illustrated that the homework grades were influenced by the complete rate of homework (Complete_Rate). The BKD also figured out the probability of each level of Complete_Rate (high,mid,low) and the level of Hw_Grade(good,general,poor). It was illustrated in the following table.

Grade / Complete_Rate	Good	General	Poor
High	0.956	0.022	0.022
Mid	0.006	0.990	0.004
Low	0.028	0.042	0.930

Table 5: The probability of Complete_Rate and Hw_Grade

It is clearly that the group with higher complete rate, it has higher probability (0.956) to get good grade at the end of semester. In contract, the lower complete rate has higher probability (0.930) to get poor grade. Thus, teachers could observe the causal relationships of each learning features with the help of FSBBN.

4.3 Discover the causal relationships between FS and social interdependence

The social interdependence exists when the outcomes of individual are affected by each other's action [1] [13]. It plays an important role for the success of a collaborative learning. However, teachers have difficult for observing the social interdependence without face-to-face interaction on web. In this chapter, all the social interdependence was transformed into the form of FS and the FSBBN, these representation could be a window for observing and predicting the level of social interdependence. With the categories made by Johnson's *Interdependence Typology* [1] the five type of *positive interdependence* must be discussed first. The next table illustrated the web collaborative learning FS related to John's positive interdependence. Johnson's positive interdependence was not evident These FS were classify by teachers' subjectivity

Positive Interdependence	Feature Space
Goal interdependence	Goal_discuss, Query_group_portfolio, Query_members_work, ...
Reward interdependence	Grades, Help_members ,Answer_discussion,...
Resource interdependence	Discussing, Upload_resource, Query_resource, ...
Role interdependence	Allot_task, Leader_failed, Individual_responsibility, ...
Task interdependence	Portfolio, Query_scheduler, ...

Table 6: The associated feature space for observing the positive interdependence

However, some FS associated with these positive interdependence was hidden and not listed in the teachers' subjective FS. The Bayesian method could discover these *missing data* [14] and the causal relationships. In this experiment, teachers tried to collect all the web logs and the result of questionnaires, transformed these data into 70 FS as the input file of BKD. The BKD could discover the missing related FS associated with this social interdependence. First, teachers classified the groups into two classes: goal interdependence and poor goal interdependence. The new class was added into the system as the new FS and named as "Goal_Interdependence". Teachers could selected all the FS or a set of FS including the new FS as the input data of BKD. After the analysis of BKD, the new related FS associated with "Goal_Interdependence" could be discovered in the FSBBN.

4.4 Prevent the group to be failed

In chapter 4, the Roc system supported the credible prediction for the FS of Class B with the experience of Class A. In this experiment, the correct rate is 77.77% is good enough for a teacher to prevent the group to be failed. In fact, some irrelative learning data will reduced the correct rate. For saving time and increase the correct rate of prediction, teachers would like to migrate the redundant FS and remain the necessary FS. The issue is which FS should be migrated and which FS should be remained? The positive interdependence supported a good idea about this issue. In Table 7, teachers tried to predict the probability of learning failed (Low_Grades) with different FS associated with the positive interdependence.

Learning data	Correct Rate of Prediction
Goal interdependence FS	100%
Reward interdependence FS	88.89%
Resource interdependence FS	88.89%
Role interdependence FS	66.66%
Task interdependence FS	86.11%
All the FS	77.77%

Table 7: The correct rate of prediction with different type of FS learning data

The result illustrated that teachers selected different part of FS related with the social interdependence and improve the correctness of prediction. It is interesting that in this experiment, the FS related with goal interdependence has the most dependent relationship with the group grades. The FS related with role interdependence has the least dependent relationship with the group grades. Therefore, teachers could observe the goal interdependence FS at next semester to prevent the group from being failed. Teachers could not only predict the fail probability of a group, but also predict any FS with the subset of all the FS in this system.

5 Conclusion

To assist a teacher in tracking and guiding a web collaborative learning this work has presented the assisting tools for observing the group states, discovering the impact factors of learning situation, and reuse the experience to predict the learning state. The Bayesian method supports an efficient way to achieve these purposes. Without the proposed mechanisms, a teacher must spend considerable time in trying to analyze situation from huge amount of unorganized web logs. The causal relationships of learning situations were hard to track. To predict the learning situation depended on teacher's individual experience that is imprecise and could not be reused for other teachers. This work (1) transformed the huge amount of meaningless web log into the form of readable and meaningful feature space, (2) supported the graphical FSBBN for observing the learning states and discovering the hidden impact factors of web collaborative learning, (3) predicted the learning situation successfully before the end of semester with the online learning situation and experience of past semester.

Observation and tracking the group's learning situation help teachers determine instructional strategies and group's learning performance. With the advantage of feature space and FSBBN, teachers can observe learning performance and analyze the influence of learning situations. The learning space is constructed as a hierarchical graph and teachers can define features for themselves via the instructional domain knowledge, doing to easily and meaningfully. The FSBBN illustrated the causal map of learning situations. With the past experience of tracking and guiding, teachers could predict the learning situation before the end of semester. Therefore, teachers could intervene the group learning to prevent the group from being failed.

Finally, the experiment result demonstrates that teachers' tracking and guiding a web collaborative learning with 706 students were successful and efficient.

Acknowledgement

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What kind of interaction and reflection emerged in a teachers' learning community?

Development and evaluation of computer supported collaborative learning (CSCL) software for teacher education

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This study aimed at developing a CSCL software for a community of teachers and evaluating its effects. This CSCL software called Teacher Episode Tank has two interfaces called "Journal Window" and "Reflection Board". Through each interface, teachers can talk about their lessons and can reflect upon several aspects such as their lessons, their concepts of learning and teaching, and several educational points. Moreover, teachers are able to share ideas and benefit from interesting relationships among such ideas. In order to evaluate this software, twenty voluntary teachers participated in the research project along which two main points were analyzed: what kind of interaction and reflection emerged among teachers. The analysis led to two important conclusions. Firstly, in a virtual learning community on computer network, teachers could talk about teaching themes and share their views. Hence, the gradual increase of their interaction indicated the effectiveness of CSCL for teachers' education. Secondly, the software interface helped teachers to reflect upon three aspects: teaching methods, the concept of lesson and the concept of learning. Therefore, such reflections indicated that teachers were actively involved in the use of this software.

Keywords• **CSCL, Computer network, Learning community, Reflection**

1 Introduction

Some researchers have recently recognized the importance of Information Communication Technology for teacher education. The Computer Supported Collaborative Learning (CSCL) is one of the virtual learning environments for the school teachers. The purpose of this research is to develop and evaluate CSCL software as learning environment for teacher education. In this environment, teachers talked about their lessons, and also reflected upon them. In order to evaluate it, this research project was conducted by a voluntary teacher group. Two main aspects were analyzed: what kind of interaction and reflection emerged.

CSCL research is generated inside the field of cognitive science, which contains situated learning theory, and Information Technology. Situated learning theory suggests that learning is seen not as an individual's acquisition of Knowledge but as individual's participation in a learning community. Learners can learn in a community by means of practice, discourse, and activity. The importance of situated learning theory is that it generated an educational practice that is quite different from the traditional one which aimed at accumulating knowledge into individuals' heads. For example, Brown & Campione(1994) organized collaborative learning project to build a learning community in a classroom . In this project, learners were expected to inquire their topic of interest and exchange their expertise among them. Likewise, CSCL is designed to build a learning community through computer network.

Many CSCL research projects have been organized mainly in North America. In particular, Teaching TeleApprenticesships(Levin, Waught, Brown and Clift 1994) and TAPPED IN(Pea 1998), are mentioning CSCL projects for teachers. Teaching TeleApprenticeships is the CSCL research project that supported the interaction among pre-service teachers, newly-appointed teachers and researchers who used e-mail and Bulletin Board System(BBS). As regards, TAPPED IN project, a virtual teachers' professional development center is built on the web site. In this case, many teachers can use BBS and chat system on this site to communicate with other teachers simultaneously. The design concept of both CSCL shares certain similarities, as the interaction among many teachers is the resource for teachers to enhance their professionalism.

However, there are two aspects related to prior CSCL research that have to be mentioned. Firstly, what kind of interaction emerged among teachers on CSCL project for teacher education? The interaction among teachers is not only emphasized but also required so as to clarify the quality of the interaction for further study. Recent teacher education research emphasized three point of teacher's activity to improve their teaching activity: externalization, sharing, and reflection. Teachers must externalize their everyday educational practice, share it with other teachers and reflect upon it so as to enhance their professionalism. Schön(1983) stated that the reflection upon their teaching is an indispensable element of their professionalism. For example, teachers write diaries everyday, and share this writing with other teachers to reflect upon their teaching (Conneley & Clandinin 1988). Secondly, previous CSCL research is not enough to characterize teacher's interaction on computer network and fails to consider the development of software interface to support it. In prior research, e-mail, BBS, and simple chat system were the channels used to support teachers' communication.

Murayama & Oshima(1999) stated that it is not enough to communicate by e-mail and BBS to discuss a topic about teaching, and concluded that it is necessary a specific interface which can display teachers' idea. Link or tag-attached as most of CSCL software's interface functions have contributed to establish the relations of the interaction among learners with visualization(for example, Scardamalia & Bereiter 1996), however, these interface functions in CSCL software are not developed yet for teacher education research.

Thus, we developed the CSCL software, which has the interface with visualized functions. This CSCL software was designed with the purpose that teachers could discuss their lessons with other teachers, and could also reflectupon several aspects such as their lessons, their concepts of learning and teaching and other educational matters.

2 Research Method

We developed a client-server shared database called Teacher Episode Tank (TET). TET client works on Windows 95/98/NT 4.0. TET server works on Window NT.

With regard to evaluation in educational technology, Bruce & Rubin (1993) concluded that we must inquire the realization process when the innovation leads to social practice. This kind of evaluation is called Situated Evaluation and aims to evaluate the effect of the new artifact in the real situation. This analysis requires collecting the data about behavior and practice of the when people are in the situation of using the new artifact. In order to evaluate this software, two main aspects were analyzed: what kind of interaction and reflection emerged. The subjects of evaluation were twenty teachers who were interested in collaborative learning by TV conference system. Those twenty volunteer teachers had been using TET everyday for three months. Not only teachers but also a faculty staff member of university and three graduate students participated in this project and properly joined teachers' discussion. Data for analysis were collected from learner's message on TET server, log data on TET client, and informal interview to teachers who participated in this project. The term of data collection was from September 1st. to November 28th. 1999.

3 Component of Teacher Episode Tank (TET)

3. 1. Journal Window

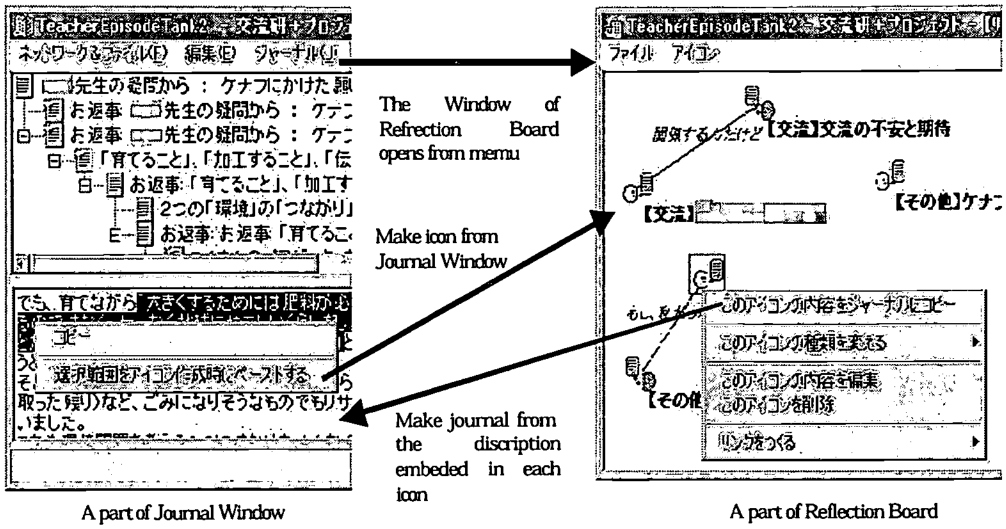


Fig. 1 Journal Window and Reflection Board

TET is composed of two interfaces called "Journal Window" and "Reflection Board". TET users can exchange messages with other users on "Journal Window "through network, and clarify the relations of interactions among users via "Journal Window "on "Reflection Board "so that TET users can reflect upon their teaching quite freely. TET users can change two interfaces alternately when using of this software.

Teachers can write their messages, specifically called "journal", about their teaching matters and comments regarding other teachers' journals on "Journal Window". Teachers who join this research project can look at and share their journals among each others on " Journal Window". The journals that teachers send are automatically categorized according to the topics of interest and categorized journals are displayed on "Journal Window" chronologically.

3. 2. Reflection Board

"Reflection Board" was implemented for teachers to clarify the relationship between journals by using some visual objects such as icon and link, and to put their comments about other journals. Teachers are expected to reflect upon their teaching methods and the concept of teaching on this interface. The characteristics of this TET software, a developed CSCL software, are that a teacher can privately use it for his reflection on this interface with visualization. It should be noted that this kind of interface function has not developed in TAPPED IN or Teaching TeleApprenticeships. As shown in Fig.1, each learner can extract from partially or completely other teacher's journal from "Journal Window" and paste it on "Reflection Board" as icon. The learner can also copy the content of icon on "Reflection Board" and move it to "Journal Window". Tags guiding teacher's interaction are attached to icon and link on Reflection Board. These tags are specific to the research project, and support teachers' relationships exteriorized in journals and ideas that can be concretely visualized. There are two main tags and five sub-categorical tags of icon. For example, two main tags are "My Idea" and "Your Idea", and sub-categorical tags are "Topic about Children", "Topic about Teacher", "Topic about TV Conference System", "Topic about Collaborative learning" and "others". According to the kind of these tags, the teacher can write the title and contents of icon when he makes icons. Besides, there are four kinds of links which are attached to tags. For example, four tags are "If I teach", "Relation", "Suggestion", "but". Learner can use this link to clarify the relations among icons and visualize the contents. The idea of the kinds of link derives from Engeströms' prior research. Engeström(1994) pointed out that one of the characteristics of communication among teachers was that they were fond of the subjunctive mood like "If I teach" rather than the formal constast like "However".

4 Evaluation of TET

TET was evaluated from two points of view: what kind of interaction emerged among teachers and what kind of reflection teachers exchanged on TET.

4. 1. What kinds of teachers' interaction were emerged on TET?

What kind of interaction emerged among teachers involved in learning community of TET? At first, let us begin to analyze the quantity of teachers' interaction on TET.

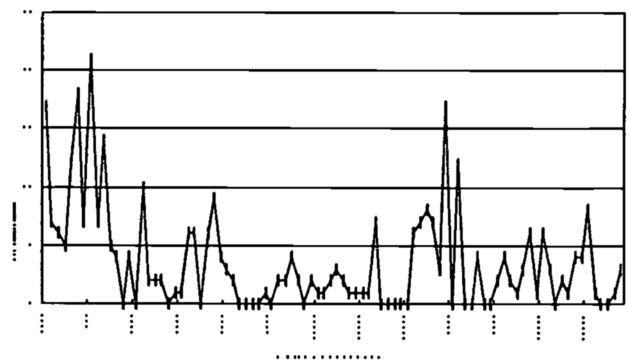


Fig. 2 The quantity of journal a day (N=330)

For the accomplishment of this research project, 25 professionals participated in and 330 journals were written. The daily average quantity of journals was 3.66 messages, the average quantity of journal per person was 13.2 messages. Fig. 2 showed the daily quantity of journal during our research project.

Category	The standard of classification
0. Project	Account of evaluation generally
1. Tool	The Topic of TET
2. How to use	The question on how to use TET
3. Formal report	Report of everyday practice in Japanese conventional format
4. Narrative	Teachers' reflection from everyday practice freely
5. Education	Topic of education
6. Material	Topic of learning material for example, TV conference system
7. Opinion	Opinion of education
8. Question	The question of other teachers' journal
9. Summary	The summary of other teachers' journal
10. Negotiation	The negotiation between two teachers about their lesson
11. Advice	Advice for other teacher
12. Note	The note of observation of other teachers' lesson
13. Others	Other content

By the following step, the analysis of journal contents was done by categorical classifications as shown in Table 1. Two researchers determined fourteen categories after reading the content of journals. For the sake of classification into categories, two researchers worked independently in the categorization of 330 journals. When those do not agree with the category classification, we discussed the content of journal so as to decide an appropriate category. The percentage of agreement was 74%.

Among 14 categories, "Formal report" and "Narrative" are the two most important ones. Here, "Formal report" represents the journal report about everyday practice in conventional format which consists of lesson title, lesson time, and lesson outcome. The characteristic of "Formal report" in the journal is that there is no emotional comment or reflection of the teacher in it. For example, the following journal fits into this category.

September 8th. , Wednesday
(Content) collaborative learning using TV conference system
(Time) AM 11:00 - 11:30
(Outcome)The purpose of my lesson today is have children get accustomed to TV conference system, Today, my students have experience of this system for the first time. In fact, students had no trouble in today's lesson, and enjoyed introducing and talking about insects and singing a school song all together
(99/09/08 Teacher Y's joumal No. 98)

In this journal , teacher Y reported his lesson to other teachers ina conventionalstyle, which isa popular style in Japan. In his writing, there is no emotional reflection and comment.

Regarding "Narrative" category, it is attached to the journal, and its content reveals teachers' reflection upon their teaching and lesson from their episode of everyday classroom activities. As described in the introduction, the purpose of TET is that teachers can talk about their lessons among each other and also reflect upon several aspects such as their lessons and their concepts of learning and teaching. The following journal is categorized into "Narrative".

Now, I divided my students into 4 groups and led them to plan independently projects of Kenaf (Kenaf is tropical tree and the most popular learning material of Problem-based learning in Japan). I think, it is desirable that each student communicates with students from other group about this Kenaf projects. However, I am beginning to question whether Kenaf as learning material is appropriate for this activity or not. You know, we can cook Kenaf and make papers from Kenaf, but each group is doing its activity independently, so it is difficult for students to collaborate with other groups. I wonder what makes each group collaborate with other.
(99/11/01 Teacher M's Journal No. 261)

A teacher's reflection on his practice was described on this journal. In a problem-based learning activity, the teacher had trouble related to integrate groups and how to have students communicate among them. So that way, "Narrative" journal contained teacher's reflection upon his classroom activity.

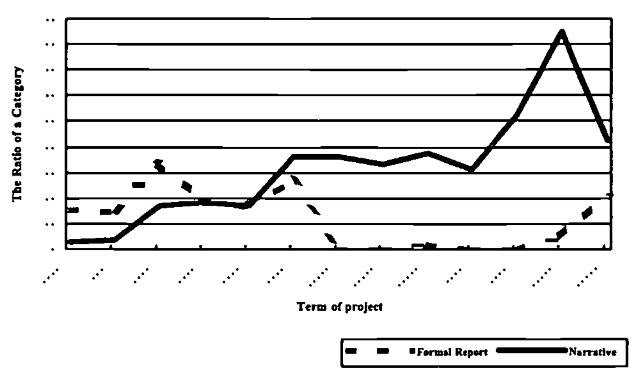


Fig. 3 showed that the quantity of "Narrative" was very low at the beginning of this research project, but gradually increased. On the contrary, the quantity of "formal report" was high at the beginning of this project, gradually decreased. Consequently, the tendency of the ratio "Narrative" to " Formal report" was low at the beginning, and the fact that it was high at the end of this research project showed that the teachers' learning community where many teachers talked about their teaching on CSCL was gradually formed.

4. 2. Teachers' Reflection

Here, the kind of reflection that emerged among teachers was examined by analyzing the data of "Journal Window " and "Reflection Board" on TET. Eleven teachers cooperated in the analysis. On Reflection Board, there are 23 icons (S.D.=11.3) and 18.7 links(S.D.=10.6) on average.

	Teaching Method	The concept of lesson	The concept of Learning	Others	Total
A	1	3	2	14	20
K	1	4	4	16	25
M	0	6	8	16	30
C	0	4	1	5	10
T	0	2	1	2	5
K	1	13	2	31	47
G	0	4	3	11	18
W	1	5	0	12	18
S	1	4	2	16	23
J	1	5	0	19	25
O	1	9	6	16	32
Total	7	59	29	158	253

Table. 2 Three kinds of reflection

There are many icons which teacher write about their reflections overall. Those icons were classified into three kinds of reflection as shown at Table. 2. First category was "Reflection upon Teaching Method". Second category was "Reflection upon the concept of lesson". Third category was "Reflection upon the Concept of Learning". The icon of "Others" category as shown at Table. 2 was added after discussion between two researchers. "Others" category was the icon that collected several comments, and was used as brief memo of teachers. In the paragraph, details about the three kinds of reflection about teaching methods, the concept of lessons, and the concept of learning are examined by quoting some cases.

4. 2. 1. Reflection upon Teaching Methods

"Reflection upon Teaching Methods" was observed on teacher's writing. "Reflection upon Teaching Methods" can be defined as the teacher's reconsideration of their teaching. By this stage, teachers consider whether teaching method has been effective and valuable or not. For example, Teacher W who conducted a presentation of children's scientific inquiry wrote the following journal.

> (Today, Children made a presentation of scientific inquiry.) But, their presentations were not interesting to me. Why? I considered this question.
>
> 1.Did I motivate them properly to make the presentation in front of classmates?
>
> 2.Did I pursue children to prepare their presentation?
>
> (99/09/03 a part of Teacher W's Journal No. 56)

Regarding this journal, two project members sent their replies. They gave Teacher W valuable advice and hints. The journal comments like as"Reflection upon Teaching Method" were more frequently observed on "Journal Window" than on "Reflection Board".

4. 2. 2. Reflection upon the concept of Lessons

"Reflection upon the concept of lesson" can be defined as teachers' reconsideration and question about the self-evident concept in everyday teaching. This kind of reflection was observed more often on Reflection Board than on Journal Window. For instance, Teacher G's journal was as follows.

> For example, well...everybody was writing about Social Studies on journal. But, by using "Reflection Board", I found that we did not discuss the essence of Social Studies. Teachers did not discuss what Social Studies is, and how it should be taught. After noticing that aspect, I realized that in fact, whenever I read others' journals, I found different meaning in them.
>
> (99/12/11 Teacher G's interview)

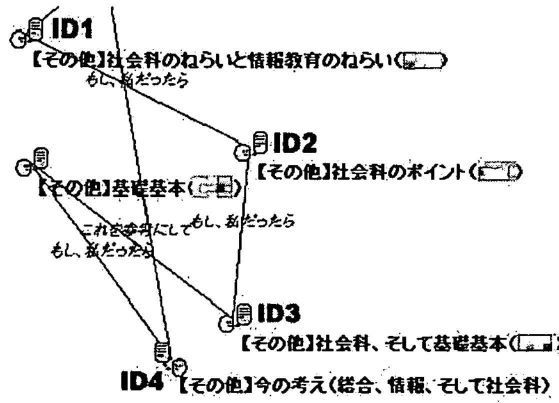


Fig. 4 A part of Teacher G's Reflection

In our research project, many teachers that major in Social Studies talked about their topic out of their own lessons. However, as Teacher G pointed out in his journal, although teachers using this CSCL software have interaction among them, no one was able toexplain what the essential core of Social Studies . Teacher G noticed it by using Reflection Board. Fig. 4 showed a part of Teacher G's Reflection Board.

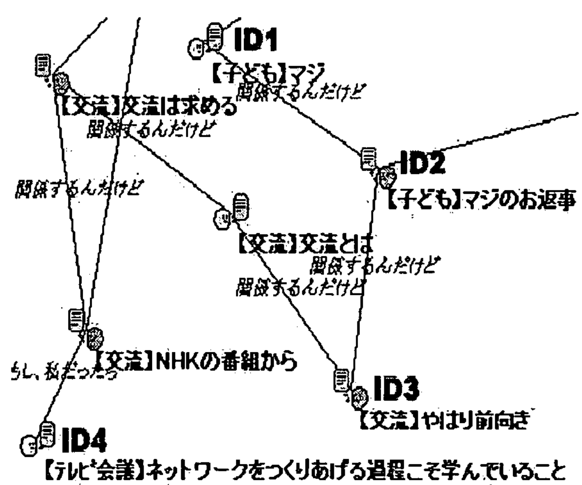
On this board, Teacher G visualized other teachers' opinions (ID 1, ID 2, ID3, clarified the connections among such ideas and expressed his conclusions as icon (ID 4). In fact, we can conclude that "Reflection Board" supply teachers with effective support about questions regarding self-evident everyday practice.

4. 2. 3. Reflection upon the concept of learnin

"Reflection upon the concept of learning" can be defined as teacher's reconsideration of his own learning. In other words, teachers consider themselves as learners. This kind of reflection was more often observed on Reflection Board than on Journal Window. Teacher M's journal serve as an example of this reflection;

At first, Teacher M wrote about children's collaborative learning through TV conference system on some icons (ID1, ID2). Then, he wrote about the reflection upon his learning from other (ID 3, ID 4). Finally, he linked the icon of children's learning and those of teachers' learning. Hence, in some cases, the reflection upon teacher's learning derived from the reflection upon children's learning.

Fig. 5 A part ofeacher M's Reflection Board



5 Conclusion

Let us summarize the main point of our research. In this paper, we developed the CSCL software so that teachers can have online talk about their lesson and teaching, reflect upon their teaching and the concept of learning and teaching. To evaluate of this software, we adopted the evaluation method called Situated Evaluation, and analyzed what kind of the interaction and reflection emerged from teachers. From what has been discussed above. We can conclude as follows:
(1) In a virtual learning community on computer network, teachers can talk about their teaching and share their opinions among each other gradually. We can conclude from this fact that CSCL is an appropriate environmentto facilitate teachers' learning.
(2) Therefore, it seems reasonable to express that as interfaces allow visualization, members of the learning community are effectively supported to interact and to clarify relations among ideas and comments.

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