Proceedings of 2nd International Conference on Information Technology Based Higher Education and Training, Kumamoto, Japan July 4-6, 2001

Modeling and System Design for Web-Based Collaborative Learning

Zhao Jianhua, Li Kedong[1] and Kanji Akahori[2]
The United Nations University, Institute of Advanced Studies, Tokyo, Japan
South China Normal University, Educational Technology Institute, Guangzhou, China[1]
Tokyo Institute of Technology, Graduate School of Decision Science and Technology, Dept. of Human System Science, Tokyo, Japan[2]
Jianhua.zhao@ias.unu.edu, likd@scnu.edu.cn, akahori@ak.cradle.titech.ac.jp

Abstract

Modeling and system design for web-based collaborative learning system (WebICL) was described in this paper. There are two main sections are referred, one is system framework modeling and another is systematic framework of WebICL. WebICL system was modeled and designed based on collaborative learning theory and collaborative learning process. The objective of WebICL is to design and implement a flexible and integrated collaborative learning system to facilitate student learning in web-based learning environment. In system framework modeling section, six components are designed, which they are register, learning group, knowledge learning, teacher's role, evaluation, and collaborative learning tools. These six components are integrated in the systematic framework together.

1. Introduction

Collaborative learning approach has dealt primarily with standard, classroom-based environment, not web-based environment, which raised the question of web-based environment of how well the benefits of collaborative learning will translate to the web-based environment (Brandon, D. P., 1999). Collaborative learning means that knowledge is not something that is 'delivered' to students, but rather something that emerges from active dialogue among those who seek to understand and apply concepts and techniques. Student-student interaction in collaborative learning communities may contribute to the achievement of educational goals by influencing educational motivation and aspirations through peer relationships (Hiltz, 1993; Johnson, 1981). To collaborate means to work together, which implies a concept of shared goals, and an explicit intention of "add value" –to create something new or different through a deliberate and structured collaborative process, as opposed to simply exchanging information or passing on instructions (Kaye, A., 1994). Collaborative learning would be the acquisition by individuals of knowledge, skills, or attitudes occurring as a result of group interaction, or put more tersely, individual learning as a result of group process (Kaye A., 1992). The key elements of collaborative learning, which the most outstanding experiments to date clearly show that, to a large extent, group leaning is based on making individuals feel responsible towards the group, whether because the task involves explaining something to other group members or because group communication has the purpose of producing a common item or solving a common problem (Trentin, G., 1999). The idea that collaborative learning is the development of shared meaning among group members reflects the larger CSCL (computer supported collaborative learning) perspective on learning, a perspective that emphasizes the social creation of knowledge as the basis of learning. Meaning is not pre-packaged and delivered to the student for memorization; rather, it is negotiated among group members (Pea, 1994; Roschelle, 1992).

According to the description above, the main important components of collaborative learning in web-based environment is how to realize social context, group learning process, communication each other (collaboration), and performance evaluation. Web-based collaborative learning is not only one computer programming, but also one system integrated collaborative learning essential spirit, process, social context, and more flexible and suitable, which as Brandon stated (1999) for on-line group learning that the collaborative development of shared meaning requires a substantial amount of communication, perhaps even more so in on-line than in face-to-face groups. Meanwhile, whether the intelligent learning method was integrated into web-based

collaborative learning system or not is more important to realize the objective of WebICL system because the intelligent characteristic is the basis of other feathers, e.g., flexible, suitable, practical, and available.

2. Related Works

Web-based collaborative learning system can be divided into two categories, one is asynchronous system, and another is synchronous, which many practical systems were developed. The influential asynchronous system includes First Class, CSILE/Knowledge Forum, Learning Space, WebBoard, and WebCT; synchronous system includes Conference MOOS, WebChat Broadcasting System, and Microsoft Netmeeting.

First Class is a very popular conferencing system accessible through a browser. Its features include 'software is quite a rich environment that offers both real-time (synchronous) facilities and delayed time (asynchronous) resources. They include chat, shared documents (can be created and edited amongst a group of people), bulletin board facility, mail, and conference and discussion groups etc (McConnell, D., 2000). CSILE/Knowledge Forum was developed by a team of cognitive research scientists in Toronto and teachers across Canada (Scardamalia, et al., 1989). Typical notes in Knowledge Forum include a question, a problem, a graphic illustration, a research plan or a summary of information found from resource material (Simons, 1999). CSILE offers an open learning system where students and teachers can share their knowledge and work collaboratively in building new knowledge notes. Each database is open to all Knowledge Forum users. This model of learning supports a constructivist approach to knowledge (Scardamalia, 1999). Learning space is a course-authoring environment for web-based teaching and learning. It includes both synchronous and asynchronous facilities as well as group and individual spaces. There are a lot of different facilities and can also contain documents in many different formats. Links to other parts of the course environment and beyond are also easily included. The features of learning space include CourseRoom, Schedule, MediaCenter, Profiles, AssessmentManager, and Learning Server. WebBoard is a web-based system that can run as its own server. Discussions are structured into Forums and threads. Features of this system include chat facility (real-time discussion), conferencing facility (threaded discussions amongst a group), attach files to messages, and web server functionality. WebCT is a web-based authoring and electronic communications system developed at the University of British Columbia. There is a bulletin board system, which allows users to discuss matters of interest and post information to each other. The feathers of WebCT include web-based tools (authoring pages of text, graphics, etc), Chat (real-time discussions that can be logged), email facilities for individuals (as well as group mailing list facilities), and conferencing facilities (threaded discussions) (McConnell, D., 2000).

Conference MOOs are Multiple Object-Oriented systems which are text based. Many users can link into a MOO and communicate at the same time, using text dialogue boxes divided into classrooms, hallways and other virtual meeting places. Link many chat systems, users can prepare their text in a window without others seeing it before sending it. Once sent, it appears in the shared chat history. Students can also carry out other actions, such as waving, smiling and so on, through recognized non-verbal gestures. MOOs are sometimes used to support decision making and other tasks that benefit from synchronous communication. Diversity University MOO is one of the most well-known of these environments tailored for educational purposed. It is organized around a campus metaphor, which its features include writing tools, communication tools, exploration commands, manipulation commands, bulletin board, videoconferencing handler, VRML view, ghost view, and MOO map. WebChat Broadcasting system allows the user to communicate in real-time with other users via text-based messages. Recent versions of the application also support the uploading of images during chat. In addition to supporting chat, the home web site incorporates a number of other features which support the community orientation of its service, including: the ability to search the profiles of those currently online; setting up your own homepage; a news stand; instructions on establishing a Net Circle; and an electronic mail account. Since its arrival in 1993 WebChat has attracted over 3 million users. In 1998 WebChat was acquired by the Internet service Infoseek. Its features include browser-based, organized into topic forums, real-time discussion, different chat models: steaming chat, frames, no frames, allows uploading of images during chat, and allows private chat, etc. Microsoft NetMeeting that it is Windows-based collaboration tool incorporating data, and video conferencing in one package. Its features include collaboration through windows-based applications, data conferencing, electronic

whiteboard, file transfer, text-based chat, audioconferencing, videoconferencing, and support communication with users using compatible products (McConnell, D., 2000).

Intelligent instructional method can be used into collaborative learning electronic system to enhance its efficiency and flexibility. Some promising issues in this perspective have been addressed, e.g., intelligent pedagogical agent, student models, tutor models, diagnosis strategies, knowledge intelligent representation etc. The important issue which applying intelligent method to collaborative learning system is to find its integrated position and approach based on collaborative learning features. CITS (Collaborative Intelligent Tutoring System) provides an environment where the student can interact with one or more, simulated collaborative partners and/or fellow students, to progress towards a common goal of learning (Kumar, V. S., 1992). GSS (Group Support Systems) is a set of techniques, software and technology designed to focus and enhance the communication, deliberations, and decision making of groups. In GSS, software intelligent agent that can facilitate and streamline group problem solving in organizations is applied (Jay F. Nunamaker Jr, 1997; Sen, S., et al, 1997). Brna & Burton (1997) described modeling students collaborating while learning about energy, which has the potential for providing better computer-based support in the future – both in respect of providing improved quality dialogues and in terms of comprehending the student's activities. Miyahara & Okamoto (1998) studied how to develop an information filtering system, which gathers, classifies, stores various kinds of information found on the Internet. Our work is related to what it is described above, which it is integrated collaborative learning and intelligent method. According to our study, intelligent method is very important to enhance the quality of web-based collaborative learning, e.g., flexible, efficient, and suitable. and to facilitate students learning.

3. WebICL System Modeling

WebICL is an instruction system, so system analysis and design method will be applied to realize it. The framework of web-based intelligent collaborative learning system will be designed based on the following phases.

3.1 The Objective of WebICL

According to Slavin (1995), the goal of collaborative learning is for student to help each other succeed academically. To be successful, all members in a group must achieve mastery of the material or contribute to the completion of a group assignment. Theoretically, collaborative learning fosters a cooperative atmosphere in classrooms, rather than a competitive one, because students are invested in each other's learning, not just their own. Edelson et al (1995) stated that student participation in collaborative, open-ended inquiry is a central goal of many current science education reform efforts. McManus (1996) indicated that several goals of cooperative group learning have been identified in the literature. Two primary goals for all students are (a) to assume leadership responsibilities in the group, and (b) to participate equally and actively in the group process. Additional goals of collaborative learning include fostering academic cooperation among students, encouraging positive group interaction, increasing academic achievement, and developing self-esteem.

The main objective of WebICL is to design and implement a flexible and integrated collaborative learning system to facilitate student learning in web-based learning environment, which the rationales and strategies of classroom-based collaborative learning and intelligent methods were integrated together. The objective of WebICL can be divided into three categories, which they are collaborative leaning objective, learning group's objective, and peer's learning objective. Inaba et al (2000) described how to use learning goal ontology to form effective learning groups. Their perspective is very useful to find a new way to clarify and define the objective of WebICL.

3.2 Necessary of WebICL

Necessary of WebICL includes systematic necessary, tutor's necessary, and peer's necessary.

Systematic necessary

Systematic necessary focus on development, implementation, operation, and interaction, etc, which they will impact flexibility and adaptability of WebICL.

Tutor's Necessary

Within WebICL environments, the role of the tutor is in most respects no different to their role in face-to-face cooperative learning situation (McConnell, D., 2000). Tutor's necessary includes how to facilitate teaching effect, how to organize instructional approach, and how to realize the teacher's role of leader, designer,

facilitator, guider, assistant, and evaluator and assessor.

Peer's Necessary

Student's necessary includes learning content (curriculum knowledge), learning resource, interaction approach, learning tools, learning environment, and systematic interface.

3.3 Strategies and Principles of Systematic Design

According to McConnell's (2000) experiences, the useful and important aspects of CSCL design includes openness in the educational process – the learning community, self-determined learning, a real purpose in the cooperative process, a supportive learning environment, a collaborative assessment of learning, and assessment and evaluation of the ongoing learning process.
The strategies and principles can be used in system design includes objective determining, research area and object, system function, investigation about user, control and monitor strategies, and evaluation strategies.

3.4 Framework Modeling

There are eight modules in WebICL system, which they are peer module, group module, interface module (peer and tutor), database module, curriculum knowledge module, evaluation module, tutor module, and CL tools module. The working mechanism and processes of each module is described as follows.

3.4.1 Register

When student login through *student interface*, WebICL system will search his register account no in *student records database*. If his account is found, it will be used to search the learning history records from *student models database*, then the data of student model was acquired and sent them to *student grouping module*. If student's account no cannot be found in *student records database*, a new account no will be appended in the *student records database* when student finish his register form. Generally, when new student register in WebICL, he will ask to participate the pretest or psychological survey based on his knowledge background. The result of pretest or/and psychological survey and personal messages that come from register form will be used to form student model. Student learning history records or his new learning records are called nature data (ND), which it can be used to form student model and group model. This process can be simply described as figure 1.

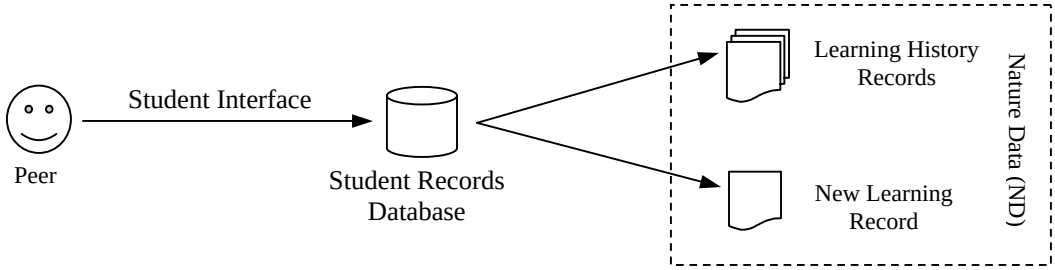

Figure 1. The Register Process

3.4.2 Learning Group

Organizing learning group process includes two statuses. The first status is that the data of learning group structure will be fetched from *group structures database* based on ND from learning history records. This data can be exchanged with *student grouping module*. ND from learning history records can be sent to *student models database*. Student model will be formed based on ND. There are many strategies and principles deposited on *student grouping module*, which they can be used to organize learning group based on student model. The second status is related new learning record. Student model will be simulated in student models database based on ND. The data of student model can be sent to *student group module*, which it can be transmitted to *group structures database*. Then it can be organized into a group in term of grouping strategies and principles. If the number of student who login the system is smaller than necessary of learning group or the knowledge background is not suitable of strategies and principles of group learning or other relevant questions, WebICL can simulate virtual student model based on the necessary of group learning and organize it into specified learning group with online student. The organizing learning group process can be described as figure 2.

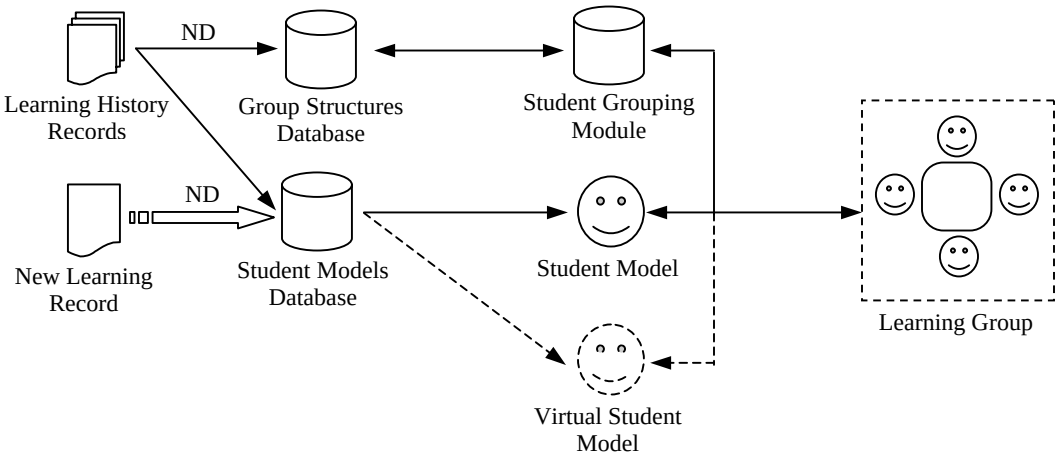

Figure 2. Organizing Learning Group Process

3.4.3 Knowledge Learning

Learning Knowledge in WebICL includes two knowledge databases, which one is learning task database and another is learning resource database. The form of the learning task in WebICL is problem-based knowledge, which it can be divided into two categories that one is curriculum sequence knowledge and another is integrative curriculum knowledge. Learning resource includes various knowledge background, picture, graphic, audio, essay, video, and animation, etc, which they are multimedia styles related learning task. Learning contents are saved in the *learning task database*, which they can be presented on *knowledge presentation module*. The presented contents to learning group can be selected based on the ND from *student records database* and *group structure database* in *learning talks database*. Student in learning group can freely get learning resource based on the learning task resolving. The process of learning task presentation can be described as figure 3.

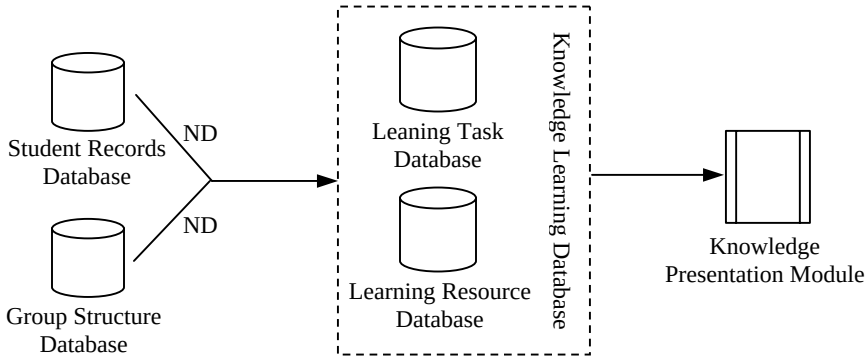

Figure 3. The Process of Learning Task Presentation

3.4.4 Teacher's Role

Teacher's role in WebICL is most similar with face-to-face collaborative learning environment. Teacher is one of the most important elements in web-based collaborative learning environment. When Teacher (tutor) login the system, he can control and monitor collaborative learning process through *tutor interface*. Four service modules are provided to teacher in WebICL, which they are *student model service module*, *group structure service module*, *virtual teacher service module*, and *knowledge database service module*. Teacher can delete or append student model, group structure, virtual tutor, and learning material through *tutor interface*, which he/she can modify their data through these four services modules. When teacher login the system through *tutor interface*, he/she also can join the collaborative learning process. *Tutor model* can be established based on the teacher's personal message, academic speciality, and experiences. *Virtual tutor* in WebICL undertakes real teacher's task, which it will be facilitator, leader, designer,

guider, mediator, assistant, and evaluator and assessor for student collaborative learning performance. In WebICL, virtual tutor is regarded as tutor agent, which it can act like real teacher. Tutor or virtual tutor also can control knowledge database to present the specific content to learning group or specific student. He also can assume student to specific learning group. Figure 4 described the teacher's role in WebICL.

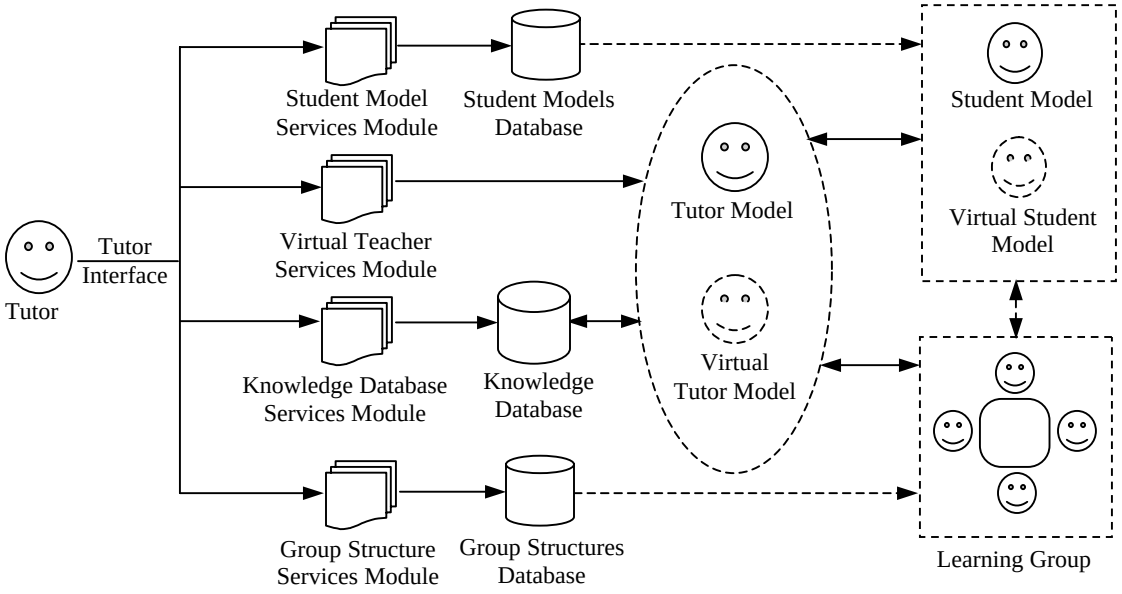

Figure 4. Teacher's Role in WebICL

3.4.5 Evaluation

The achievement of web-based collaborative learning embodied in essay, report, or presentation (home page or PowerPoint production, etc), which they are the outcomes of learning group and the principal part for evaluation. Evaluation in WebICL for peer collaborative learning is more concerned collaborative learning outcomes and process.

The process of evaluation for collaborative learning outcomes includes two levels, which one is learning group level and another is peer individual level. In the learning group level, when learning group finish one task, teacher (tutor) and other learning groups will assess their outcome and assign one score and remark to it. This score is normally called learning group score. In peer individual level, the learning group score will be averaged to each peer mate in learning group. This is peer's basic score for his collaborative learning.

The process of evaluation for collaborative learning process can be divided into three categories. The first is for learning knowledge presentation. The result of evaluation for *learning group* can be used to control the learning material in *knowledge database* to groupmates based on the learning group score and discuss, collaborative, debate, and conflict, etc feedback messages. There are some deducing strategies and principles are saved on the *deducing mechanism*. The second is for peer individual learning performance, which it is very important for how to determine the different peer's learning performance. Evaluation for peer individual learning performance can be done by tutor and peer mates in the same learning group, which tutor assign his assessment score based on his observation (not for every peer mate) and peer mates give his peer mates (except himself) learning score based on his feeling. The main criterion of evaluation is one's contribution for his learning group. This score can be added on the peer individual's basic score. The third is related how to save the evaluation data. When peer in learning group logout from WebICL or during the collaborative learning process, the evaluation data will be saved in the *student records database*. This data can be used by *student models database* to form peer model and to organize them into specific learning group. The process of evaluation in WebICL can be described as figure 5.

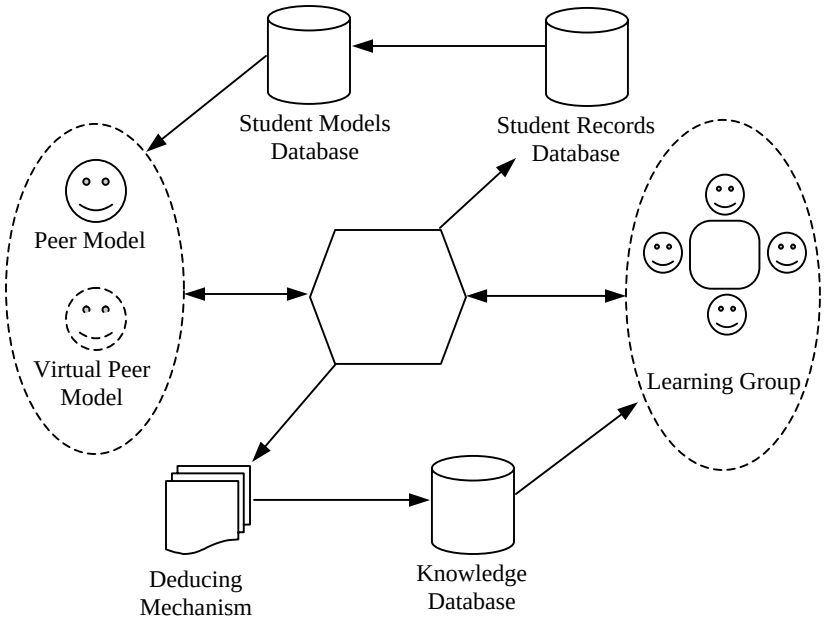

Figure 5. The Process of Evaluation in WebICL

3.4.6 Collaborative Learning Tools

Peer in collaborative learning group can use collaborative learning tools to communicate with his learning partners. These collaborative learning tools can be divided into two categories, which one is asynchronous learning tools that it includes email, presentation tools, bulletin boards, and search engine, etc and another is synchronous learning tools that it includes internet phone, chat room, video conference, and seminar room, etc. These learning tools can be used to facilitate and to enhance peer's learning performance.

The categories of collaborative learning tools can be described as figure 6.

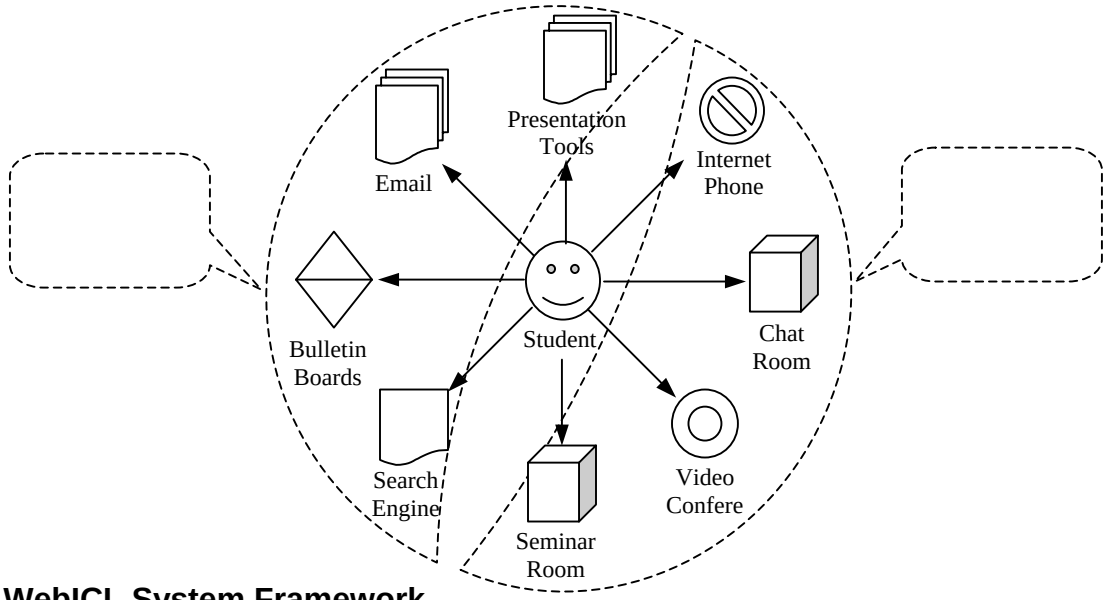

Figure 6. Categories Collaborative Learning Tools

4. WebICL System Framework

According to the description above, the systematic framework of WebICL can be designed as figure 7.

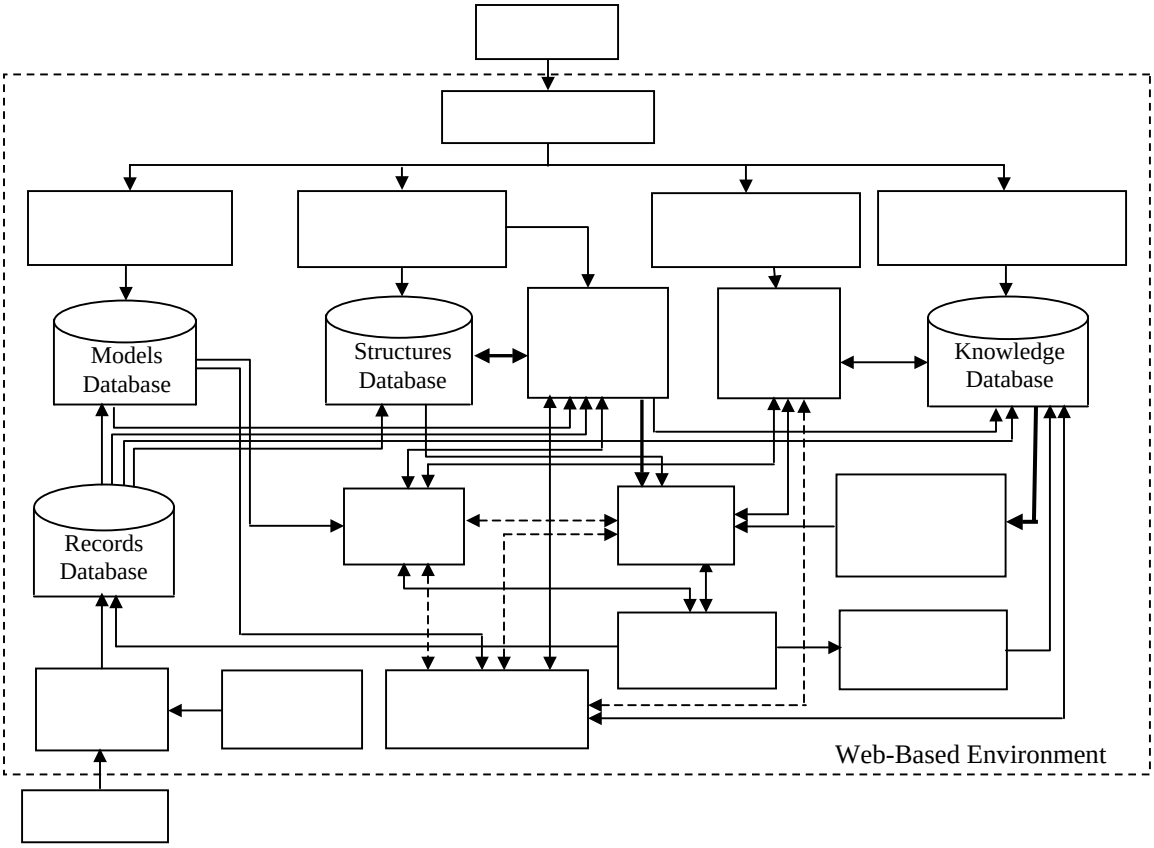

Figure 7. Systematic Framework of WebICL

5. Further Research

In this paper, we introduced the system modeling and system design in WebICL system. There are a lot of further works will be done, for example, how to elaborate and refine the system modeling and system design, how to use computing method to model various components of WebICL, and how to realize systematic framework based on programming, etc. The works finished are the fundamental for further study.

6. References

Inaba, A., Supnithi, T., Ikeda, M., Mizoguchi, R., and Toyoda, J. (2000). *Learning goal Ontology to Form Effective Learning Groups.* In proceedings of the International Workshop on New Technologies for Collaborative Learning. 27-29 Nov 2000, Kyoto, Japan.

Brandon, D. P. & Hollingshead, A. B. (1999). Collaborative Learning and computer-Supported Groups. *Communication Education.* Val. 48, pp. 109-126, Issue 2, ISSN 03634523.

Brna, P. & Burton, M. (1997). Modelling Students Collaborating While Learning About Energy. *Journal of Computer Assisted Learning*. Vol. 13, pp. 194-205.

Edelson, D. C., O'Neill, D. K,, Gomez, L. M., and D'Amico, L. (1995). *A Design for Effective Support of Inquiry and Collaboration.* School of Education and Social Policy, Northwestern University.

Hiltz, S. R. (1993). Correlates of Learning in a Virtual Classroom. *International Journal of Man-machine Studies.* Vol. 39, pp. 71-98.

Jay F. Nunamaker Jr. (1997). Future Research in Group Support Systems: Needs, Some Questions and Possible Directions. *International Journal of Human Computer Studies.* Vol. 47, pp. 357-385.

Johnson, D. W. (1981). Student-Student Interaction: the Neglected Variable in Education. *Educational Research*. January, pp. 5-10.

Kaye, A. R. (1992). Learning Together Apart. In A. Kaye (Ed.), *Collaborative Learning and computer Conferencing.* Series F: computer and system Sciences. Vol. 90. Berlin: Springer-Verlag.

Kaye, A. R. (1994). *Computer Supported Collaborative Learning*. TD-Rivista Di Tecnologie didattiche. Vol. 4, pp. 9-21.

Kumar, V. S. (1992). *Collaborative Intelligent tutoring System: A Learning Environment*. National Center for Software Technology, Bombay, India.

McConnell, D. (2000). *Implementing Computer Supported Cooperative Learning*. London: Kogan Page Limited.

Miyahara, K. & Okamoto, T. (1998). Collaborative Information Filetering in Cooperative Communities. *Journal of Computer Assisted Learning*. Vol. 14, pp. 100-109.

Pea, R. D. (1994). Seeing what we build together: distributed Multimedia Learning Environments for Transformative Communications. *The Journal of the Learning Sciences*. Vol. 3, pp. 285-299.

Roschelle, J. (1992). Learning by Collaborating: Convergent Conceptual Change. *The Journal of the Learning Sciences.* Vol. 2, pp. 235-276.

Trentin, G. (1999). Network-Based Collaborative Education. *International Journal of Instructional Media*. Vol. 26, Issue, 2, ISSN 00921815.

Sen, S., Haynes, T., and Arora, N. (1997). Satisfying User Preferences while Negotiating Meetings. *International Journal of Human Computer studies.* Vol. 47, pp. 407-427.

Scardamalia, M. et al. (1989). Computer Supported Intentional Learningn Environments. *Journal of Educational Computing Research.* Vol. 5, pp. 51-68.

Scardamalia, M. (1999). *Engaging Students In a Knowledge Society.* Paper Presented at the Bi-annual conference of the European Association for Research on Learning and Instruction (EARLI), Gothenburg, August 24-28, 1999.

Simons, R. (1999*). CL-NET: Computer Supported Collaborative Learning Networks in Primary and Secondary Education.* Paper presented at the Bi-annual Conference of the European Association for research on Learning and Instruction (EARLI), Gothenburg, August 24-28, 1999.

Slavin, R. E. (1995). *Cooperative Learning: Theory, Research, and Practice.* (2nd Ed). MA: Allyn & Bacon.

McManus, S. M. & Gettinger, M. (1996). Teacher and Student Evaluations of Cooperative Learning and Observed Interactive Behaviors. *The Journal of Educational Research*. Sep/Oct 1996, Vol. 90, Issue. 1, ISSN 00220671.