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A SYNCHRONOUS COOPERATION SYSTEM FOR LEARNING ENTITY-RELATIONSHIP DIAGRAM

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Abstract. *Collaborative e-learning via Internet is becoming popular because it certainly improves learning effectiveness. Moreover, real-time communication further enhances the efficient sharing of knowledge and experiences within a collaborative group. Therefore, this paper proposes a premier synchronous collaboration system for learning entity-relationship model, called SCLERD, to enable students to learn data model in the database field in a real-time cooperation manner. This paper first describes the design methodology of SCLERD, including network protocol and software architecture. Then system performance and educational evaluation are conducted to verify the system's feasibility and efficiency. The results of performance evaluation show that current devices and bandwidth can easily afford the needs of SCLERD. The results of educational evaluation unveil that most of students in the experiment group have better learning achievement than those in the control group. Also, all evaluated items receive positive feedback from the results of questionnaire.*
Keywords: Entity-relationship diagram, Real-time communication, Cooperative learning

1. **Introduction.** Due to the increasing number of computers and Internet users, computer-assisted learning via the Internet have been utilized extensively in academic education [1-19]. One of the efficient learning styles is Computer Supported Collaborative Learning (CSCL) [1,2]. Collaborative Learning means that two or more than two students work together for achieving a certain goal by means of face-to-face interaction and team cooperative techniques; meanwhile, the members' learning efficiency and cognition can be improved during the learning process [20,21].

On the other hand, Entity-Relationship model is a data modeling method in database management, producing the conceptual schema or semantic data model of a relational database [22]. An ERD (Entity-Relationship Diagram) is a critical tool in the design of database schema, helping users to achieve a better understanding of the database schema by displaying the structure in a graphical format [23]. Although, there are several software tools for drawing ERD, e.g., Avolution Abacus [24], CA ERwin [25], Datanamic DeZign [26], Embarcadero ER/Studio [27], Oracle Designer [28] and Sybase PowerDesigner [29]. These products intend for business purpose instead of education aim so that they are merely suitable for the database professionals (e.g., database administrator). Also, they are short of providing a cooperative learning environment, causing that students solely learn ERD in a self-explored way. Under such circumstances, one way to attain the goal of collaboratively learning ERD is that a member may export and disperse an incomplete diagram to other members by an email. Then they import the diagram from the email and continue drawing it. Microsoft Office Visio has provided on-line collaborative operation by calling NetMeeting application [30]. However, the users joining the conference have their own diagrams, meaning that they cannot operate on the same diagram. DeZign and ERwin only allow users to locally compare and merge two versions of ERDs.

In fact, the ability to receive graphical content (e.g., slides and any annotations made on them) or messages, or to originate live video and audio, can be provided by any modern personal computer. Snow [5] emphasized that ability, combined with a connection to the Internet, can offer students a strong sense of participation in E-Learning environments. Yang [6] also pointed out that most of existing E-Learning materials are presented in terms of text and graphic. The learners do not get human expressions and oral explanations (i.e., live video and audio respectively). Without the interactive environment, the learners could miss out the impact of teachers' or peers' gestures in their learning process.

Notably, the greatest advantage of traditional face-to-face education is the personal interaction with learners [6]. At present, there is no work focusing on addressing peer interaction in collaborative ERD learning. Consequently, this paper proposes a design methodology and develops a premier Synchronous Cooperation system for Learning ERD, called SCLERD. In order to provide more interactive environment for collaborative learning, the system is capable of (1) drawing collaboratively: team members of a group are able to learn ERD concurrently and collaboratively; (2) offering face-to-face environment: a member is able to communicate with teammates by means of the live video, audio and instant message. The system performance evaluation and educational evaluation have been conducted. Regarding to performance evaluation, two major factors, CPU utilization and bandwidth consumption, were measured for ensuring the system feasibility. Regarding to educational evaluation, a quasi-experiment was employed within two classes of college students. The results unveil that most students in the experiment group not only have better learning achievement than those in the control group, but also are satisfied with the operation and functionality of SCLERD.

The rest of this paper is organized as follows. Section 2 briefly introduces some related works and ERD. Section 3 elaborates the design of SCLERD and its inner software structures. Section 4 illustrates some graphical user interfaces (GUIs) and the typical manipulation process. Section 5 presents the performance and educational evaluation results of SCLERD. Finally, conclusions and future works are given in Section 6.

2. **Background.**

2.1. **The related works of collaboration learning.**

Gillet presented a collaborative Web-based experimentation system, enabling students to perform laboratory experiments, providing a Web workspace for students to store, retrieve and share their documents or experiment results among them, but it cannot provide the collaborative operation of an experiment [7]. Thus, we presented a design methodology to allow students to perform remote lab experiments in a collaborative way, so that the members can collaboratively conduct the same experiment at the same time via a user interface of virtual instruments [9]. Liu also presented WiTEC (Wireless Technology Enhanced Classroom), in which students are able to practice homework collaboratively via electric whiteboard on mobile devices [10]. Sheremetov presented a Web-based learning system whose functions contain knowledge presentation (e.g., artificial intelligence course), collaborative learning via chat room and on-line practice [11]. Rebolj established a collaborative learning system where a Web site offered course lists and their timetable, syllabus, material, discussion and chat rooms [12]. Su proposed a Web 2.0-based collaborative annotation system which enabled students to share personal annotations of the articles with group members and discuss simultaneously by instant messages [13]. In summary, collaborative learning has been applied in many education fields and has certain contributions undeniably on improving learning motivation and efficiency.

A handful of experimental prototypes have been proposed for collaborative learning in a real-time way [31-35]. Baghaei [31] presented an system, called CORRECT-UML, aiming at collaboratively learning object-oriented design and drawing by using Unified Modeling Language (UML). Soller [32] also used a software tool, namely OMT editor, to aid collaborative learning in solving object-oriented design problems. Avouris [33] used a system, called Synergo, to understand the insight of collaboration interaction.

However, these prior researches were merely focused on collaborative drawing and messages chatting among peers. Thus, this paper focuses on presenting a collaborative learning environment with more interaction functionality.

2.2. **Entity-relationship diagram.** Through ERD, the relationships implicitly concealed behind knowledge structure can be visible readily [23]. ERD has been the most successful tool for communication between the designer and the end user during the requirement analysis and conceptual design phases because of its ease of understanding and its convenience in representation [36]. Note that ERD is the most popular data model which paves the way for creating physical database. That is to say, once finishing ERD correctly, it is a critical reference to create physical relational table and the relationships between tables (e.g., one-to-many or many-to-many) in a database system [37]. Amid several conventions of ERD [38], the most popular Chen's notation, whose symbols and their meanings are summarized in Figure 1, is selected in this paper.

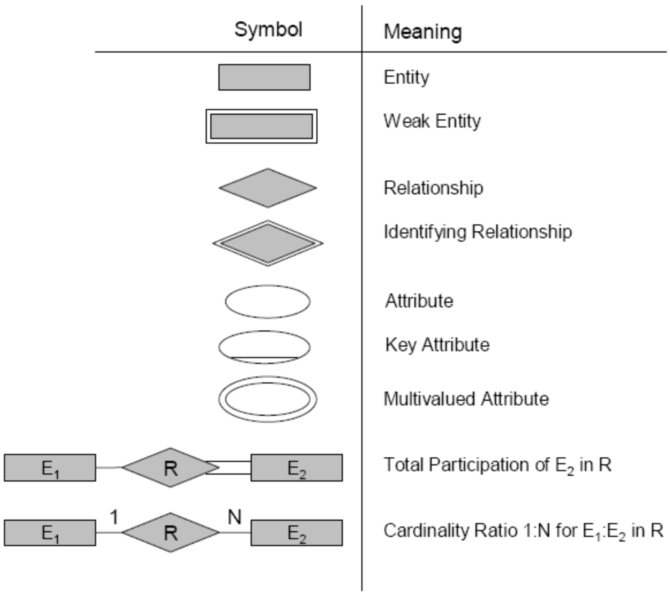

FIGURE 1. Symbols for Chen's ERD notation

Taking database Company as an illustrated example, as shown in Figure 2, the steps of establishing an ERD are listed as follows.

(1) Creating Entities: In accordance with the applied field, precisely picking up the entities (e.g., Employee and Project).

(2) Determining Relationship: identifying the relationships between entities. The relationships within Company example include "employees work for departments", "departments control projects" and so on.
(3) Drawing the ERD: writing the name of each entity inside its own rectangle and writing the name of each relationship inside its own diamond, as well as drawing lines between entities and their relationships.
(4) Identifying Attributes: Drawing the corresponding attributes for each entity. Also, drawing attributes for each relationship if necessary.
(5) Determining the cardinality of the relationships. Denoting a cardinality of "many" by writing "N" or "M" next to the entity while a cardinality of "one" by writing "1" next to the entity.
(6) Executing refinement: modifying the ERD iteratively.

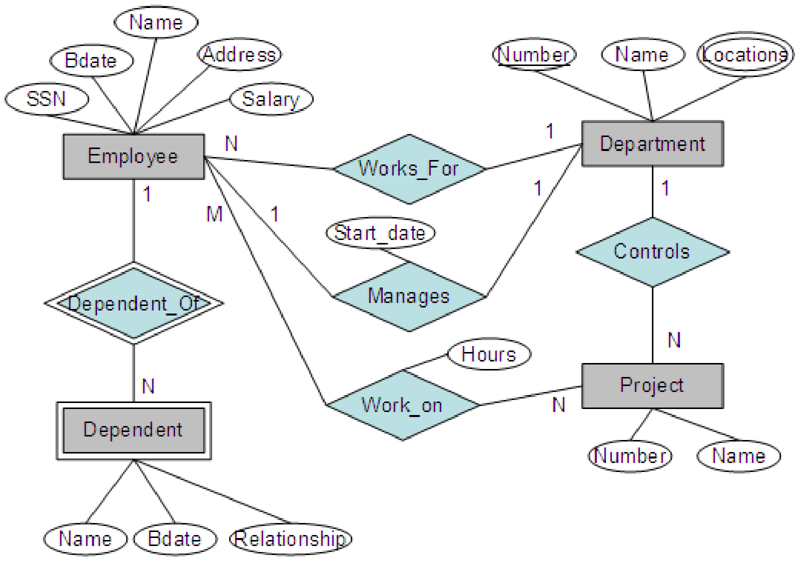

FIGURE 2. A ER schema model for database company

3. **The Design Methodology.** In this section, the software architecture and network protocol for SCLERD are proposed. The Object-Oriented program language, Microsoft Visual C#, is adopted as a development tool, which is based on Microsoft.NET platform.

3.1. **Network protocol.** In order to accommodate multiple users, the concept of network protocols is involved to facilitate the whole system design. To simplify the explanation, the scenario of three users is illustrated for explaining the communication flow in the system. The flow follows the same procedure when participators more than three users. Notably, even when the server hosts multiple collaborative groups simultaneously, each group follows this scenario.

As illustrated in Figure 3, in the initial phase, user 1 issues a register request to join the collaborative environment. Then the server keeps the information of this request, such as user name and IP address, and returns a register confirmation at acceptance. When user 2 enters, the server also keeps its information, returns a confirmation message, and further forwards a member list cached locally to all members. Likewise, the joining procedures of subsequent users are tantamount to the above. The server stores the information of all members, so it can renew the information and then dispatch to all members once a member arrives or leaves.

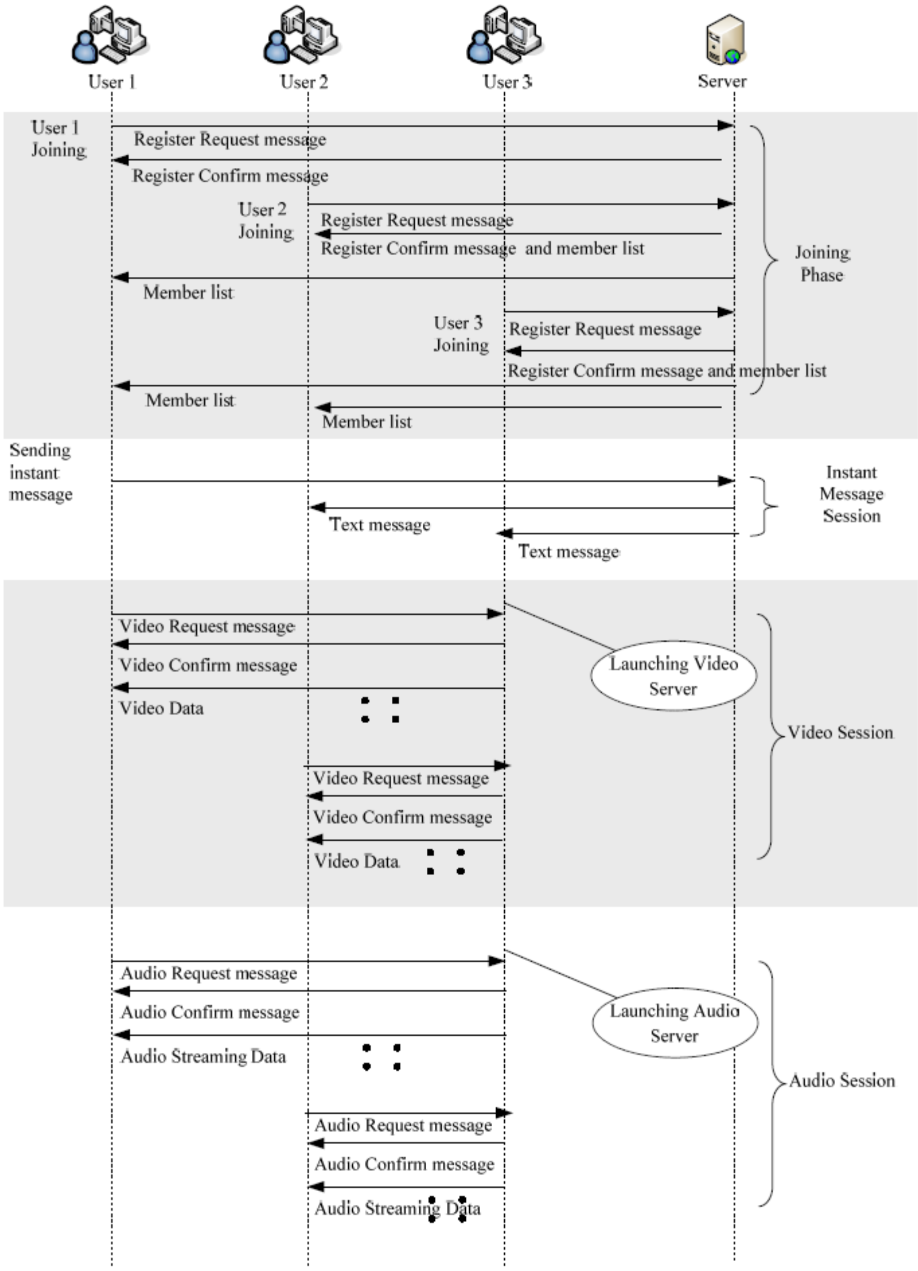

FIGURE 3. The network protocol

Regarding to instant message exchange, text messages sent from a member will be routed to the server and then be forwarded to all members.

For video transmission, a member has to first launch his video service so that other members can directly request this video. Under this circumstance, a member's video is directly transmitted to requestors without being routed to the server, significantly reducing the server's load. Similarly, the audio transmission also adopted this concept as video transmission.

3.2. **Software architecture.** The software architecture, shown in Figure 4, consists of five major modules: Call Control, Audio, Video, Instant Message and Cooperative Drawing modules. The client side uses all modules while the server side only uses three of them (i.e., lack of Audio and Video modules). At the beginning, the Call Control, Instant Message and Cooperative Drawing modules in the server side have to be launched via GUI for accepting clients' connection requests, processing instant message and coordinating concurrent drawing actions from different members, respectively. All modules' messages back and forth between a client and the server are transmitted via TCP Socket interface. The following describes each module in detail.

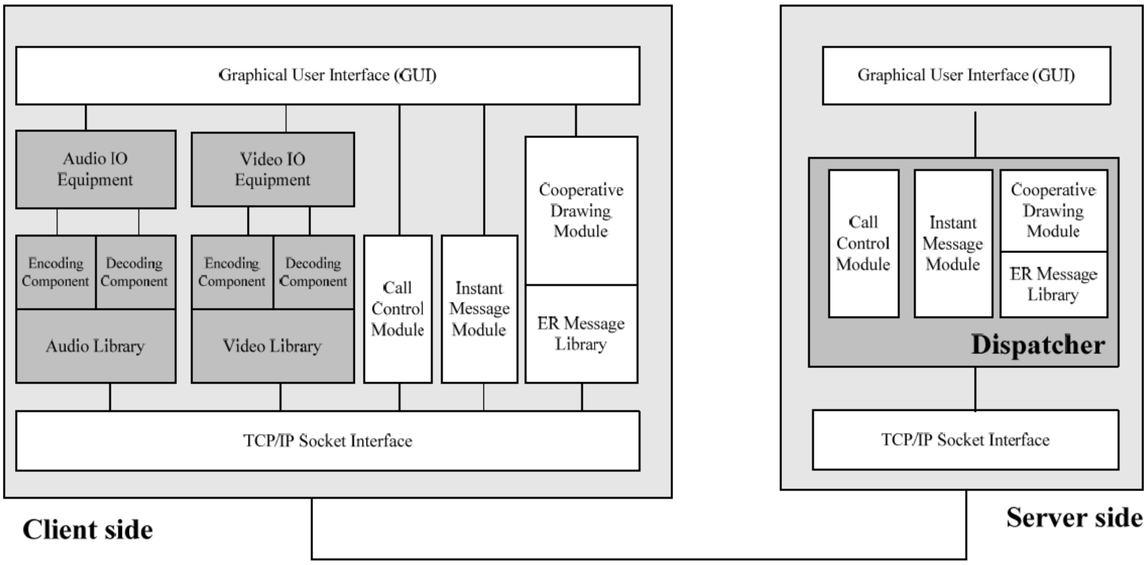

FIGURE 4. The software architecture

3.2.1. *Call control module.* This module is mainly responsible for clients (members) to connect or disconnect the server (i.e., join or leave the system). When the number of users in a group exceeds the limit (current default is five), the server will reject the client's request of creating a connection. Once accepting a request, the server will keep the client's information. In our implementation, a client class is declared in the server side for storing a client's information. Once the connection is established, a client object is created in the server for saving client's name, IP address and socket information. Also the server further adds the new client in the client list. Once disconnecting, the client object will be removed from the list. Such object-based saving scheme diminishes the programming complexity and facilitates the server to manage all connected clients.

3.2.2. *Video module.* To minimize the server's processing loading and increase transmission efficiency, a member's video is directly transmitted from the video provider to the requestors without passing through the server. According to our previous work [17], a video streaming server consumes considerable bandwidth and CPU utilization especially when the number of clients increases. Consequently, instead of streaming technique, we transmit static personal image periodically.

The video module is composed of Encoding and Decoding components. The former is primarily responsible for generating local video for dispatching while the latter one is primarily responsible for receiving remote video.

A member may act as a video provider or a video requestor or both. When acting as a video provider, the member has to launch the Encoding component which is responsible for dispatching video captured from the local video I/O equipments (e.g., webcam) to all requestors. In detail, the Encoding component will capture local image periodically and create a thread for accepting incoming video requests. The image size will be sent ahead of its corresponding image data in order to facilitate the requestors to reconstruct each image.

When acting as a video requestor, the member will launch the Decoding component. The component will issue request message to the desired video provider. Once acceptance, the provider will respond a confirm message, as shown in Figure 3. After receiving confirmation, the Decoding component will launch a thread for receiving the consecutive images dispatched from the provider.

3.2.3. *Audio module.* To minimize the server's processing loading and increase transmission efficiency, the audio data is also directly transmitted from the audio provider to the requestors. Thus, Audio Module is very similar to Video Module. In this module, the literature [39] is referred for processing audio signal and enabling full-duplex audio communication which means that a user can voice and hear simultaneously.

3.2.4. *Instant message module.* This module is responsible for exchanging instant message within a cooperative group. Since processing text message imposes the server loading slightly, the text message sent from the sender is first routed to the server. The sender does not need to know whom the message should be sent to because the server is responsible for this dispatching.

3.2.5. *Cooperative drawing module.* This module is response for drawing ERD among a cooperative group. To cope with different ER symbols, an ER Message Library is created for encoding/decoding ER messages. In this library, a parent class ERMessage is created for being inherited by child classes, including LineMessage, NewPageMessage, ImageMessage, TextMessage, EraserMessage, EntityMessage, WeakEntityMessage, RelationMessage, WeakRelationMessage, AttributeMessage, AttributeKeyMessage and AttributeMultivalueMessage. An XML-based serialization and deserialization technique, called Soap Formatter, has been utilized to transport ER messages among the server and clients back and forth. That is, a client serializes an Entity message into a SOAP message and then passes through an opened socket. A destination unpacks the message with a deserialized routine.

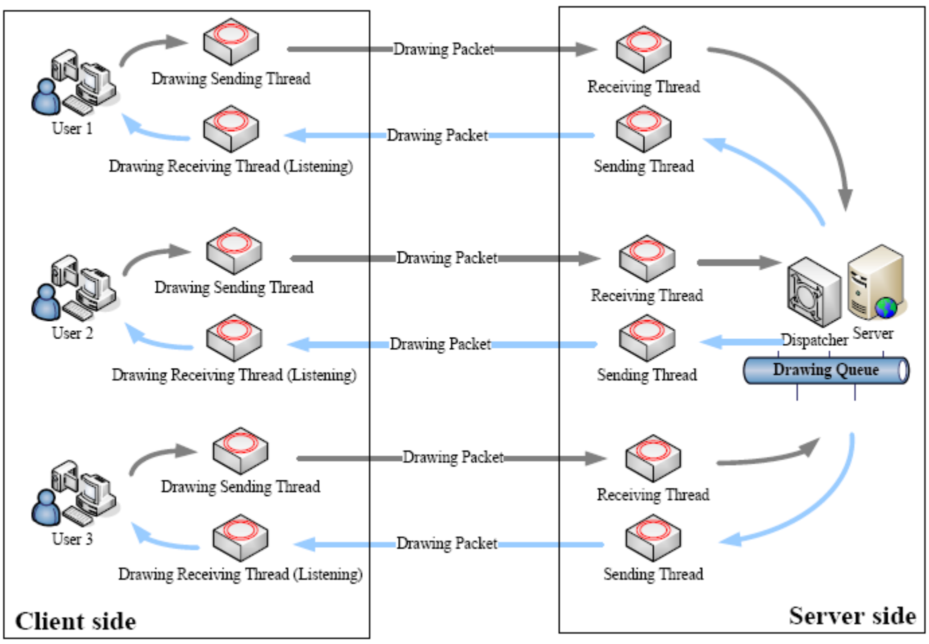

FIGURE 5. The operation mechanism of cooperation drawing

Under such cooperative environment, the server network socket management and multi-thread techniques are involved in the server side to cope with drawing data transmission back and forth circulating among multiple users, as shown in Figure 5. When any user performs an action (e.g., drawing or deleting an element), the corresponding message will be routed to the server for dispatching to other members through their connected sockets. This methodology ensures all members can draw cooperatively and obtain the identical screen.

Currently, the drawing actions support (1) adding and deleting a drawing element which could be ER elements, text or picture; (2) clearing the screen. When a user's action is adding an element, the server will receive the element, add it to the drawing queue, and dispatch to all members. When deleting an element, the server will receive the message, remove it from the drawing queue, and announce all members to delete it. At clearing the screen, the server will remove all elements in the queue and then announce all members to clear their local screens.

Once a new user arrives at cooperative drawing, the server is aware of this arrival and then forwards all drawing elements cached in the queue to the new one. By the server sequentially fetching all elements in a queue and forwarding them, the new user can receive them and entirely reproduce the current working ER screen. At this time, he/she is able to cooperatively draw with the group members.

4. **System Functionality.** This section concisely presents the basic manipulation and demonstrates main drawing functions.

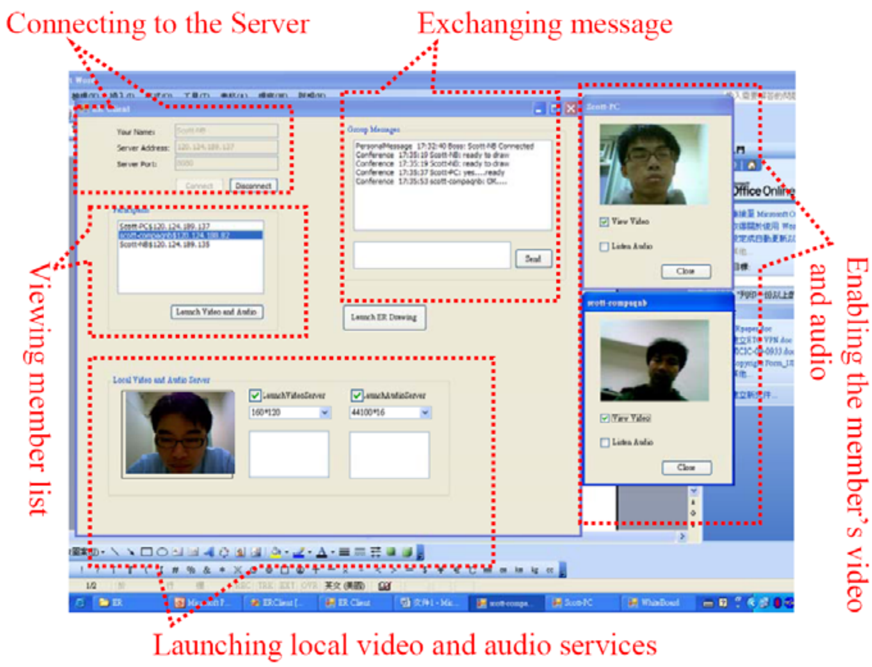

FIGURE 6. A snapshot of communication tools of SCLERD in the client

In the client side, a user first has to input his name, the server's IP and port to connect to the server, as shown in the upper-left area of Figure 6. Once connected, the user will receive the list of current participants, as shown in the middle-left area of Figure 6. Meanwhile, the client can exchange message with members, as shown in the upper-middle area. The user can select the desired members or all members from the participant list and further views their video or listens to their voice. Figure 6 shows a user talking with two members while viewing their video. During a learning session, a user can suspend or resume a member's video or audio at any time by enabling or disabling the corresponding checking box, as shown in the upper-right area of Figure 6.

To allow other members to view local image and listen to local voice, a user has to launch his video and audio Encoding components, whose GUI is located at the bottom of Figure 6. Before launching video Encoding component, the captured frame size can be adjusted if needed. After launching successfully, local video is also displayed, shown in lower-left area. Similarly, before launch audio Encoding component, the audio sample rate should be selected if necessary.

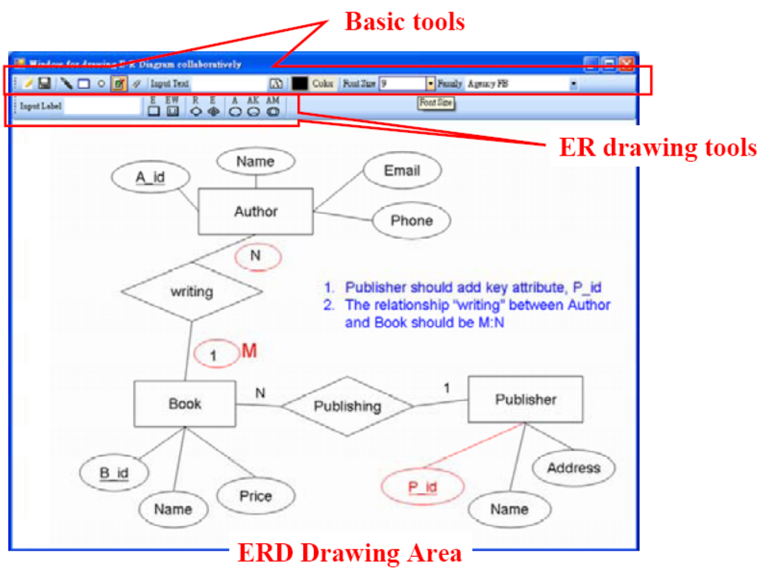

Figure 7. The window of drawing ERD collaboratively

Figure 7 illustrates the operation window for drawing ERD. Note that all involved members share an identical screen, meaning any member's drawing action will reflect on all members' screens. The offered functions belong to two categories:

(1) Basic tools: These functions intend for providing general painting tools, including creating a new page, saving the drawing result locally, importing pictures, deleting objects (e.g., entities, text and relationships), inputting text, etc. These functional buttons exhibit in the first toolbar of Figure 7.
(2) ER drawing tools: These functions are specific for drawing essential elements of ERD, including Entities, Weak Entities, Relationships, Identifying Relationships, Attribute, Key Attribute and Multivalued Attribute, which are represented in terms of their acronym as shown in the second toolbar of Figure 7. The label name of any element needs to be inputted before it is laid out.

Other miscellaneous edition functions include renaming labels, setting text color, font and size. Figure 7 shows an example in which collaborators corrected the diagram in red and annotated in blue.

Figure 8 illustrates an ERD work which is cooperatively completed by three members. Once a user connects to the ER server, the user gets involved in the current cooperative group automatically and will receive the group's current diagram work that has been drawn by other members. At this time, the user is able to add and modify the received diagram cooperatively. Once the user disconnects the server, the cooperative drawing will be suspended; however, his/her local drawing action is still effective.

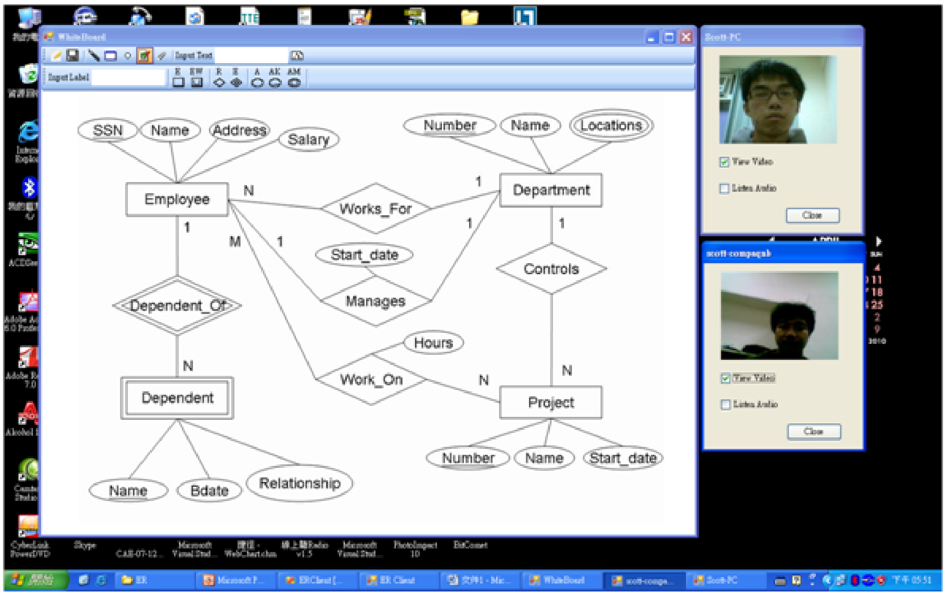

Figure 8. An example of drawing ERD cooperatively

5. System Evaluation.

For evaluating the system, this section presents two investigations, system performance evaluation and educational evaluation.

5.1. Performance investigation.

Under such system structure, the server is in charge of delivering and dispatching text messages and drawing elements while a client has to deal with the video and audio services. Consequently, a client endpoint demands more system resources and suffers more loading than the server side. Thus, in order to evaluate the system's feasibility, we stress on evaluating performance on the client side rather than on the server side. The concerning performance includes CPU utilization and bandwidth consumption. For evaluation, a computer, equipped with Intel Core Duo 1.66 GHz, 1 GB RAM and Window XP Pro, is acted as a client endpoint.

Among these investigations, two different services, video and audio, are independently tested in order to individually analyze their effects.

5.1.1. *Video service.*

In this evaluation, five scattered users connect to the computer that only launches video services. Additionally, our developed program has been installed in this video server to acquire CPU utilization caused by running the video service.

The relationship between CPU utilization and the number of users connected to the video server is shown in Figure 9 while the relationship between bandwidth consumption and the number of users is shown in Figure 10. The output image size is varied in the range $[160 * 120, 320 * 240, 640 * 480]$.

Figure 9 manifests that the CPU utilization have positive correlation with the number of connected users and the output image size. However, the growth rate of CPU utilization from $160*120$ to $640*480$ or from 1 to 5 users is small since we only periodically transmit images instead of adopting streaming technique. Given such circumstance, the maximum CPU loading of even five concurrent users with the largest output image size $640 * 480$ is still situated within acceptable scope (below 20%). Figure 10 also exhibits that the bandwidth consumption is raised when the number of users and image size are increased. Even with the largest output image size $640 * 480$, the maximum bandwidth consumption aggregated from five concurrent users still falls into affordable range (around 1Mbps).

Practically, output image size 160 ∗ 120 is highly recommended because it can provide rather clear view of a user.

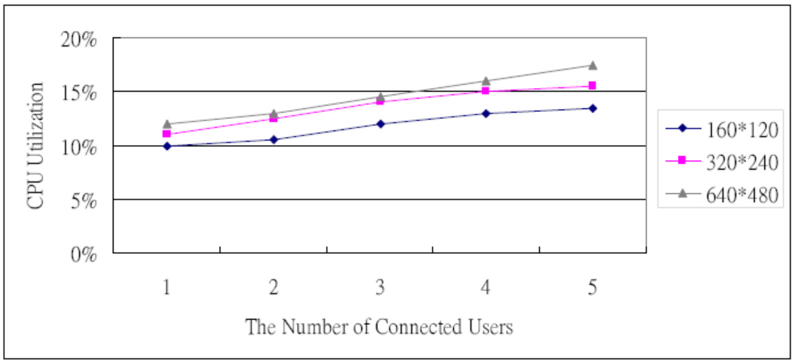

Figure 9. CPU utilization vs. the number of connected users

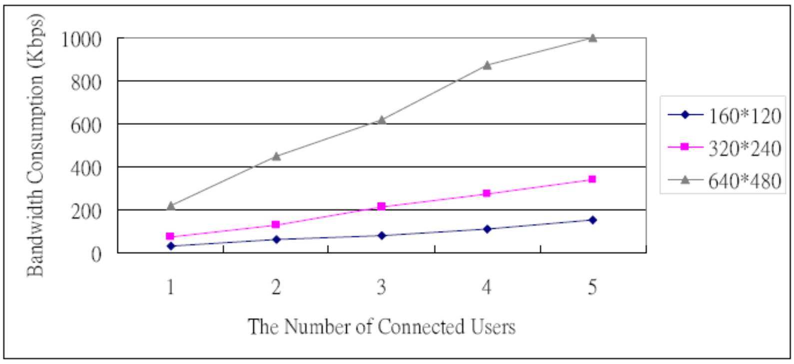

Figure 10. Bandwidth consumption vs. the number of connected users

5.1.2. *Audio service.* In this evaluation, five scattered users connect to the computer that only launches audio services. The results of CPU utilization and bandwidth consumption of this audio server are shown in Figures 11 and 12, respectively. The number of concurrent listeners is varied from 1 to 5. The audio sample rate is varied in the range [8k, 16k, 24k] Hz and each sample consists of 8 bits.

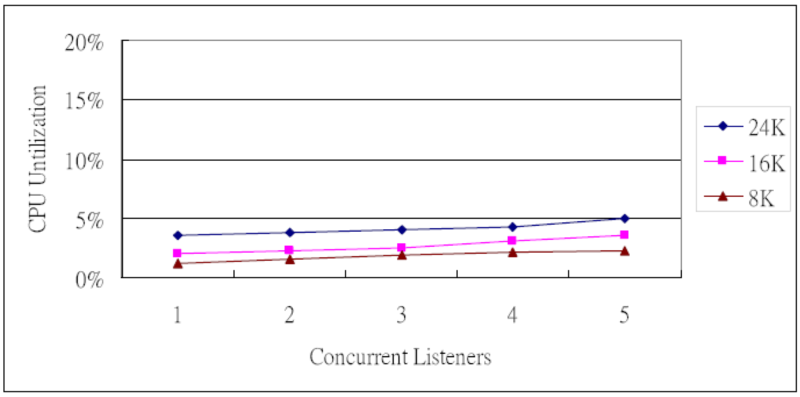

Figure 11. CPU utilization vs. the number of listeners in audio service

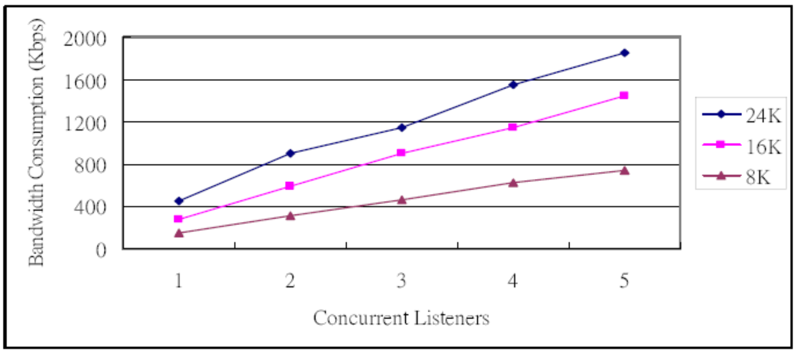

Figure 12. Bandwidth consumption vs. the number of listeners in audio service

Figure 11 illustrates that CPU utilization is proportional to the number of concurrent listeners and sample rate. Given such circumstance, the maximum CPU loading of even five concurrent users with the highest sample rate 24k is still situated within acceptable scope (around 5%). Figure 12 also exhibits that the bandwidth consumption is raised when the number of listeners and sample rate are increased. In practice, sample rate 8k is highly recommended because it can provide rather clear voice.

5.2. **Educational evaluation.** This experiment is designed to examine whether SCLERD can effectively facilitate undergraduate in studying ERD. The explanation of this evaluation contains six parts: sampling, research procedure, research tools, data processing, result and discussion, and analysis of the questionnaire.

5.2.1. *Sampling.* This study was administered to two first-graded classes of the Department of International Business in Ching Yun University. 36 students randomly selected from one class were assigned to the experimental group in which they used SCLERD, while 36 students randomly selected from the other class were assigned to the control group in which they used traditional cooperative learning (i.e., using paper and pencil and gathering together physically for discussion). A cooperative team (i.e., group) consists of 3 students, meaning that each of the control and experimental groups has 12 teams.

5.2.2. *Research procedure.* This study adopted a quasi-experimental design method to examine how SCLERD influences the effectiveness of assistance of learning ERD. This experiment applied the nonequivalent pretest-posttest control group design to evaluating learning effectiveness, whose procedure is shown in Figure 13. This experiment lasted one month in total. Prior to one-month experiment, all students in both groups took the pre-test and the students belonging to experiment were taught to be familiar with SCLERD. Afterward, the students in the experimental group used SCLERD to learn while the students in the control group used a traditional method to learn in their free time (after school). After one-month experiment, all students in both groups had to take the post-test. Beside, the students in the experimental group were further asked to fill out the "Questionnaire of SCLERD learning".

5.2.3. *Research tools.*

- SCLERD: This evaluation uses the proposed SCLERD system as experiment platform, allowing students to learn ERD knowledge concurrently and cooperatively via Internet without time and location limitation.

- Achievement Test: Based on the database management textbook [23], the evaluation initially makes the pre-test achievement test, which is comprised of 32 questions. Furthermore, two teachers who teach database management course in universities are invited to examine these questions and to confirm whether the test content is representative. Regarding with the reliability analysis of the test, the pre-test was conducted by 36 first-graded students of the Dept. of International Business in Ching Yun University. Cronbach α coefficient was adopted to analyze the internal consistency. After removing inappropriate items, 20 questions were retained as formal questions and the whole Cronbach α is 0.81. Similarly, the author also made the 38 questions as for post-test achievement test. After removing improper items suggested by the same two experts, 22 questions were retained as the formal questions whose Cronbach α is 0.79.
- Questionnaire Test: The content of the questionnaire is divided into five major parts: "system operation", "system functionality", "learning motivation", "learning efficiency" and "overall". The Five-Point Likert Scale is adopted for response options, comprised of Totally Approval, Approval, Neutral, Disapproval and Totally Disapproval. For the reliability analysis of the questionnaire, the pretest was conducted by 32 first-graded students. After removing inappropriate items, Cronbach α of the whole questionnaire is 0.9.

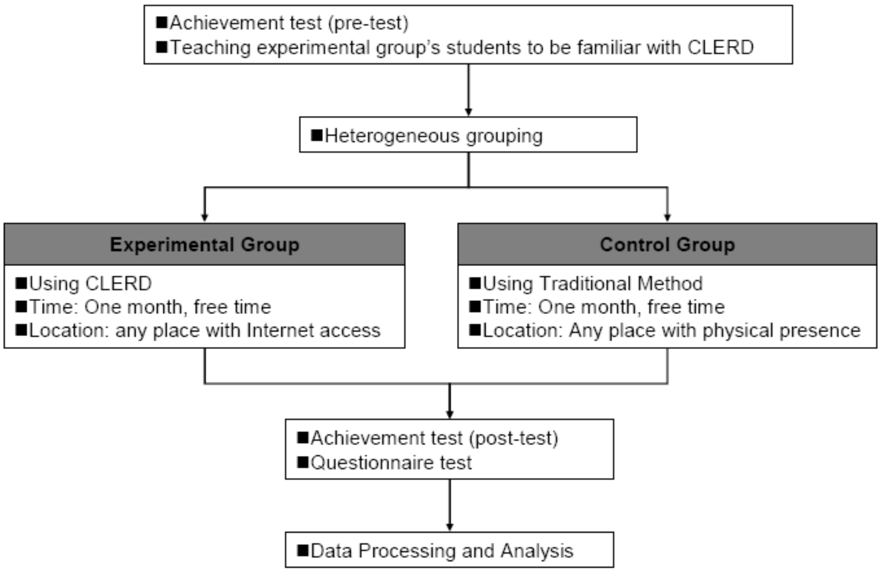

Figure 13. The flow chart of the research procedure

5.2.4. *Data processing.* Any incomplete or guessing sample is discarded before statistical analysis. SPSS Ver.12 is used to conduct the statistical analysis.

Single-factor Analysis of Covariance (ANCOVA) is chosen to examine the influence of different cooperation techniques (SCLERD versus traditional method) on learning database ERD. The pre-test is taken as the covariate, the post-test is as the dependent variable, and the different groups are as the fixed factor. Before analyzing covariance, homogeneity of regression coefficients is tested to examine whether homogeneity exists in the intra-group (test of the homogeneity of intra-group regression coefficients).

5.2.5. *Result and discussion.* Table 1 shows the descriptive statistics regarding to mean scores and standard deviations of achievement on the pre-test and post-test. In the process of the analysis, the experimental treatment is regarded as the independent variable, the scores on the post-test from both groups of students are seen as the dependent variables, and the scores on the pre-test are taken as the co-variables. An analysis of covariance is then conducted. The homogeneity of regression coefficients is tested before the analysis. SPSS analysis demonstrates that the F value of the regression coefficients is .821 ($P > .05$) so that the hypothesis of homogeneity can be accepted. Thus, covariance analysis is further conducted.

The scores on the post-test are adjusted by removing the influence of the pre-test from the scores on the post-test. From Tables 2 and 3, we find that the learning effectiveness of one group exceeding another is significant ($F = 22.869$, $P < .05$), indicating a great difference in achievement between the experimental group and control group in the learning of ERD. That is, SCLERD effectively elevates the learning achievement of the first-grade undergraduates in learning database ERD.

Table 1. Mean scores and standard deviations of the pre-test and post-test

		Pre-test		Post-test	
Group	Number of students	Mean	SD	Mean	SD
Control Group	36	43.53	12.63	65.06	11.42
Experimental Group	36	42.58	11.50	69.42	9.80
Total	72	43.06	11.99	67.24	10.79

Table 2. Summary of the analysis of covariance between experimental and control group

Dependent Variable: Post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
PreTest	6501.960	1	6501.960	316.234	.000	.821
GroupName	470.202	1	470.202	22.869	.000	.249
Error	1418.679	69	20.561			
Corrected Total	8262.986	71				

Table 3. Mean scores and standard deviations of ERD achievement after adjusting post-test

Dependent Variable: Post-test

			95% Confidence Interval	
GroupName	Mean	Std. Error	Lower Bound	Upper Bound
Control Group	64.679	.751	63.170	66.187
Experimental Group	69.794	.730	68.285	71.302

5.2.6. *Analysis of the questionnaire.* The major items of the questionnaire are outlined as follows:

- System operation: whether SCLERD provides the convenient and handy way for learning ERD? (e.g., easy-to use and friendly user interface.)
- System functionality: whether SCLERD provides the sufficient functions for achieving the cooperative learning of the ERD? (e.g., video, audio, message communication and cooperative drawing tools.)

- Learning motivation: such SCLERD can prompt my interest in learning the subject?
- Learning efficiency: such SCLERD can improve my learning efficiency and can enhance knowledge on this subject?
- Overall judgment: whether the SCLERD is a useful auxiliary tool for learning ERD?

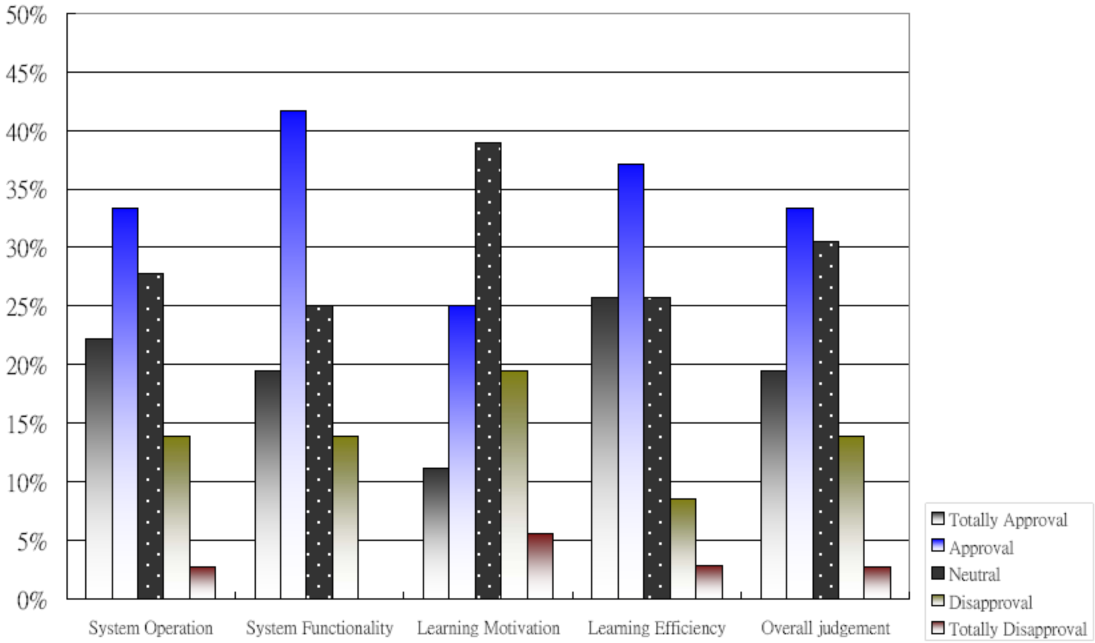

Figure 14. The result of the questionnaire

The questionnaire results, illustrated in Figure 14, unveils that most of the evaluated aspects received positive feedback. The majority agree that SCLERD is a practical auxiliary tool for learning ERD and indeed improves learning efficiency. However, in regarding to learning motivation, around 40% of the students are unsure if SCLERD can really promote their motivation. Their concerns include lack of computers, network stability and that they got used to face-to-face discussion with pencils and paper. Meanwhile, they also recommend several concrete suggestions, including adding more detailed online help and printing function, and being capable of recording their cooperative learning process.

6. **Conclusion.** This paper presents a cooperative learning system SCLERD, letting learners be able to cooperatively exercise ERD drawing in a more interactive way. The members in a cooperative group can receive instant feedback by means of synchronous technologies, including concurrent drawing, live video, audio and instant message. Performance evaluation has verified the feasibility of SCLERD. The results of performance evaluation show that current devices and bandwidth can easily afford the needs of SCLERD. In summary, regardless of video and audio service, both CPU utilization and bandwidth are still within the acceptable scope, even with five concurrent users and high quality of video and audio. The results of educational evaluation unveil that most of students of the experiment group indeed had better learning achievement than those of the control group. Also, the questionnaire results show that most of the evaluated items received positive feedback.

However, currently there are two limitations in our developed system. First, to use this system, a user must have video and audio IO equipments and has to setup the software successfully in advance. Second, the current proposed system only accommodates ERD. Thus, in order to enlarge applied scope, one of our future works is to accommodate more data analysis model (e.g., Data Flow Chart and State Diagram). In fact, this work does not take up too much time since the proposed software architecture is based on modulization and object-oriented design methodology (i.e., easy to extend). Besides, the educational evaluation was conducted on total 72 students, leading to a relatively small sampling scale. Thus, when the refined vision is completed, we will conduct an experiment with a larger sampling scale. Furthermore, this experiment will also investigate the learning efficiency between with and without audio/video support in the collaborative environment.

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