A Web-Based Collaborative Learning System

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BIOGRAPHY

Meiqi Fang is a Professor of Computer Information Systems at Renmin University, Beijing , China. She got her B.S. of mathematics in Tsinghua University of China, and the M.S. of computer science in Renmin University of China. Two books among the five she authored or co-authored, are Computer Simulation, published by Renmin University and Software Developing Tools, published by Economic Science Publishing House. She wrote over 40 articles that appeared in journals in China and the US. She had over ten of computer industry experience where she directed or participated in major software development projects for Chinese state owned enterprises before becoming an educator. Her research interests include management information systems, computer aided education, software, computer simulation and e-commerce.

Jinghai Rao, Xiaomeng Su and Tieyan Li are currently graduate students at the Information School of Renmin University. They have been the major developers of SIM_EDI since 1995. Their research interests also include: analysis and design of MIS, Electronic Commerce (EC) and Complexity Adaptive System (CAS)

Abstract

Computer Aided Education (CAE) is one of the most important methods of modern educational technology. The Internet and the World Wide Web (WWW) have provided a wider context for this field, which has already attracted a lot of attention. In the early 1990s, the Constructivist Theory of Education and Collaborative Learning were introduced, which emphasize student-centered instruction.

This paper discusses relevant topics in this field, including architecture, logical design, interface design, implementation strategies and maintenance. The discussion is based on a real project named SIM-EDI, which simulates an Electronic Data Interchange (EDI) system and provides many useful functions for students and instructors. This system was completed two years ago and has been installed in several sites located in different cities, with good result

As conclusions, several suggestions for this field have been provided at the end of the paper.

Keywords

Computer Aided Education (CAE), WWW, Constructivist Theory of Education, Collaborative Learning

From a contemporary point of view, education, in essence, is a kind of information transfer between generations. The educational system is now focused on learning rather than on teaching. For decades, computers have been used to assist education, first through CAI (Computer Aided Instruction) and then CAE (Computer Aided Education). It is no wonder that the development of IT has made a great impact on educational reform; at the same time the requirements for a new form of education are altering strategies for designing educational Systems. As the Internet becomes a fully robust environment, more and more learning activities are making use of the widely available WWW, which has led to a profound change in education as well as to the traditional structure of CAE software.

1 INTRODUCTION

Nowadays the major popular theories of education are Behaviourist Theory, Cognitive Theory, and Constructivist Theory. The behaviourist believes that environment shapes behaviour. They are concerned with the changes in a student's behaviour that occur as a result of learning. Behaviourist theory emerges in the form of operant conditioning, using reinforcement. Cognitive theorists are concerned with the changes in a student's understanding that result from learning. They believe that learning must be meaningful. Cognitive learning is based on schemata or mental structures by which students organize their perceived environment. Schematic structures of cognitive development change by the processes of assimilation and accommodation. Assimilation is the process by which a learner integrates new information and experiences into existing schemata. Accommodation is the process of modifying existing schemata or of creating new schemata.

Within these three educational theories, we focus primarily on Constructivist Theory which is the academic basis of a WWW based collaborative learning system. We believe that "motivated learning" rather than "unmotivated learning", and a "collaborative environment" rather than an "isolated environment" are two main advantages that the Web has brought about. Consequently, the design of educational systems in this area should also be guided by these principles and the theory. In the latter part of this article, we explain the main idea of the Constructivist Theory and then present as an example a simulation learning environment, SIM-EDI, which we have implemented, and in which these advantages are exploited.

According to Papert(1993), Constructionism is both a theory of learning and a strategy for education. It states that learning should be an active and motivate process, in which people construct knowledge from their experiences in the working. This is based on the constructivist theories and ideas of Jean Piaget. In this way, student (learner) can design and build his/her own knowledge, and Constructionism asserts that people create new knowledge with particular effectiveness when they are engaged in constructing personally meaningful things. Constructivists believe that learning is constructed by a student through two processes: the resolution of conflict and reflection about theory. Discovery learning is preferred over expository teaching. The learner determines his or her own best way of learning, and that learning should not be externally determined and controlled. Discovery learning increases motivation to learn, and also produces better long-term memory. Constructivism does not necessarily mean hands-on learning. What the learner already knows determines what he/she will learn. Knowledge is personally meaningful construction.

Construtivsts promote a student’s free exploration within a given framework or structure, in which

student can acquired greater understanding and meaning. This is a transition from traditional idea of education—the center of education transmitted from teacher to student, and from teaching to learning. This form can inspire the individual to develop a passion for learning, problem solving, and understanding, as well as a long-term memory. In such learning environment student can use his/her own knowledge and experience to learn and acquire the skills to resolute a variety of problem actively, as well as assess and value his/her own works and ideas. In conjunction with these skills, the constructivist learner must also be able to work collaboratively, which can not only train his/her skills in real life but help him/her learn more from others.

The key components of constructivist learning environment are circumstance, consultation, session, and content construction. It appears that the WWW can serve these goals very well. Networking make available asynchronous or synchronous communication between people wherever they may be and no matter when. WWW constitutes virtual communities of students and teachers. Even if this technology concerns only a restricted community (mainly universities & research institutions), it nevertheless appears as a new concretization of the global village on a worldwide scale. Usually the WWW can be used to establish a creative environment for learners, where students can work collaboratively by creating projects for other students to see and reuse. The Web, however, is very limited in the types of constructions it can support. Computer network can be used to support distributed construction activities in several different ways. The three major categories of distributed construction activities include:

1) Discussing Construction - the most basic constructionist use of computer networks, and involves a forum for discussing construction activities;
2) Sharing Constructions - this goes beyond simply discussing constructions, and students can use computer networks to share certain types of constructions with one another. In that way, students can try out one another's constructions, and perhaps copy and reuse parts of each;
3) Collaborating on Constructions - this enables students not only to share ideas with one another, but also to collaborate directly on design and construction projects.

There are many programs available, including the World Wide Web, which facilitates the learner as a builder. The WWW provides an interactive environment where students can solve real life problems and be actively involved in learning concepts and gaining skills in context.

An excellent outcome of the collaborative environment is the Multi-User Dungeon (MUD) paradigm, which has been used for the purpose of education throughout Internet for about two years now. MUD is a form of virtual reality designed for network use that offers participants an opportunity to interact with other computer users in real time. MUD, originally developed to support online role-playing games, depend only on a few simple rules and situations, but attracts many people just because there are active human beings on the other side of the computer network. They are alive and adaptive, and their adaptiveness supports complexity as well as attracting other players. MUD are now being replaced by more flexible Multi-user Object-Oriented environments (MOO), which are being used as a reference to develop educational IS.

In applied subjects, especially those that emphasize fostering professional skills and practical experience (usually through simulation), the collaborative learning model can help positively by providing diverse modes of communication and access to a creative, virtual collaborative space for students. Also, this kind of computer-supported learning creates a mirror in which the learner sees an image of him/herself working with other learners, and consequently enables self-development.

To achieve the goal of a highly functional collaborative learning system, certain extra points need to be considered besides the routine ones. Here is a list of some of the conclusions we have reached during our development.

(1) Being a learning system, the first step is to design the script. As we have mentioned above, learning is a special activity and it is important to cooperate with the faculties in order to specify the requirements. You will also need to consider to what degree your future system can simulate the real situation. A perfect simulation must be a burdensome and complex task; at the other pole, an extremely simple one will reduce the final effectiveness; a balance is needed between these extremes.
(2) A careful designed interface is crucial in this type of system since the premise is simulation.
(3) Certain automatic roles can be developed to serve both the needs of the simulation and to simplifying the system, always provided that system performance will not be affected too much.
(4) There is a relatively lower requirement for security, and a higher requirement for concurrency.
(5) The system must include components to monitor and keep track of the participants.

(6) As in a game, there must be proper rules and a valid simulation method.
(7) All the above points will have an impact on the choice of platform, tools, and media. Since most schools are not equipped with advanced facilities, the minimal hardware requirements should be for a lower end platform, but it is important to take advantage of additional resources.

In the remainder of this article, you will see a sample of the collaborative learning environment SIM_EDI. It simulates the trading process around a steel factory and its partners, allowing students to be acquainted with Electronic Data Interchange (EDI), commercial routine and the international trading pattern, through performing trading activities in this simulated environment. The system has installed in five cities and the respond is quite good.

2 ARCHITECTURE OF SIM_EDI

We describe the system which we have designed in order to show how the above principles may be integrated with a real system.

Now, the details.

SIM_EDI uses a two-tier structure as shown in Figure 1. The inner frame represents a LAN in each school, the resources include Windows 3.x/95, Novell Netware 4.11 or Windows NT as LAN sever. The Severs use Internet to connect with SIM_EDI Management Center(SEMC) that is located in Renmin University and works on SUN SPARC Enterprise 3000 + Solaris 2.5.1.

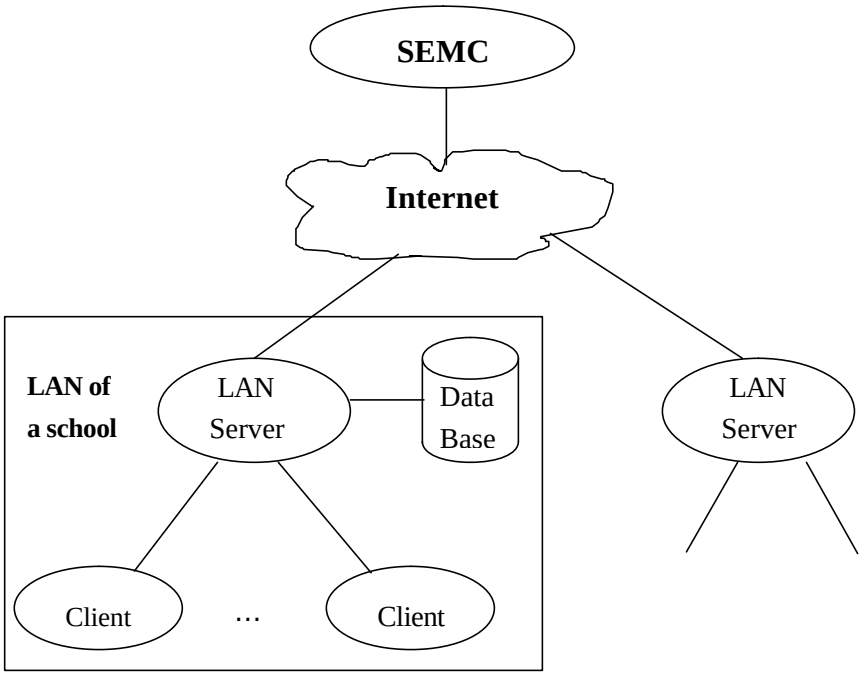

Figure 1 Structure of SIM_EDI.

The roles in SIM-EDI within a LAN include automatic roles, students-performed roles and a System Manager. Automatic roles consist of Simulated Bank, Consumer, Customs and Mailer. Student-performed roles consist of Collection Agent, Manufacturers, Wholesaler, Retailer and Transport Agent. In addition, there is an automatic role on the Web server named SIM-EDI Management Center (SEMC). Figure 2 shows the relationship of the roles in this system.

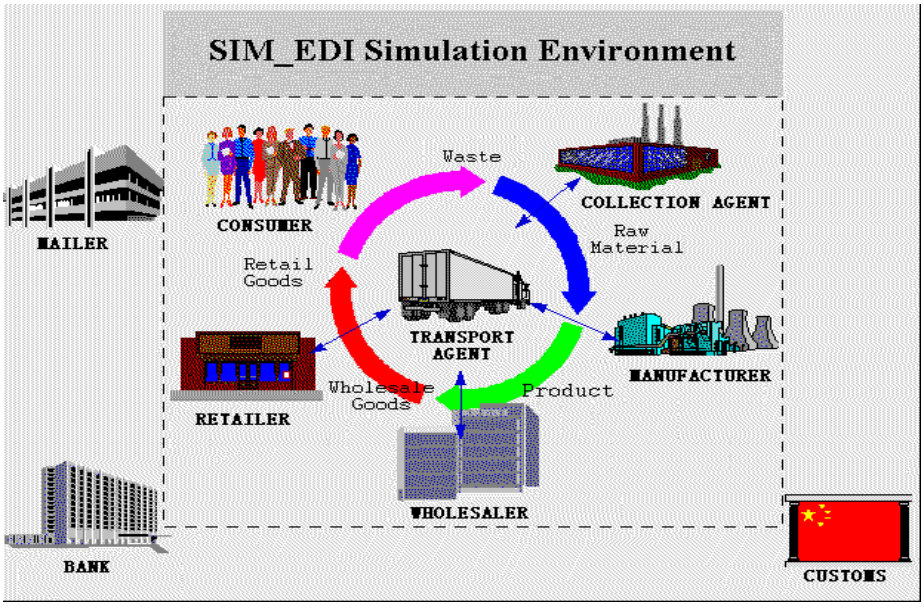

Figure 2 SIM_EDI Simulation Environment.

2.1 Simulation Bank

The Simulation Bank is an automatic role in SIM-EDI, and forms a key link of currency flow in the EDI simulation system. It is in charge of the income and expenditure account for each enterprise, settling accounts for them, and transferring accounts to remote banks. The Simulation Bank interacts with every kind of user; its key functions include collecting the production and operating costs of users, dealing with a user's import and export customs duty, also handling current funds between two users (including international and domestic) and registering a running log. Figure 3 is a work flow diagram of the Simulation Bank. In addition, in the course of checking documents, the Bank appends data of every deal into a statistics database and uploads it to the SEMC regularly, which can be queried by the student roles.

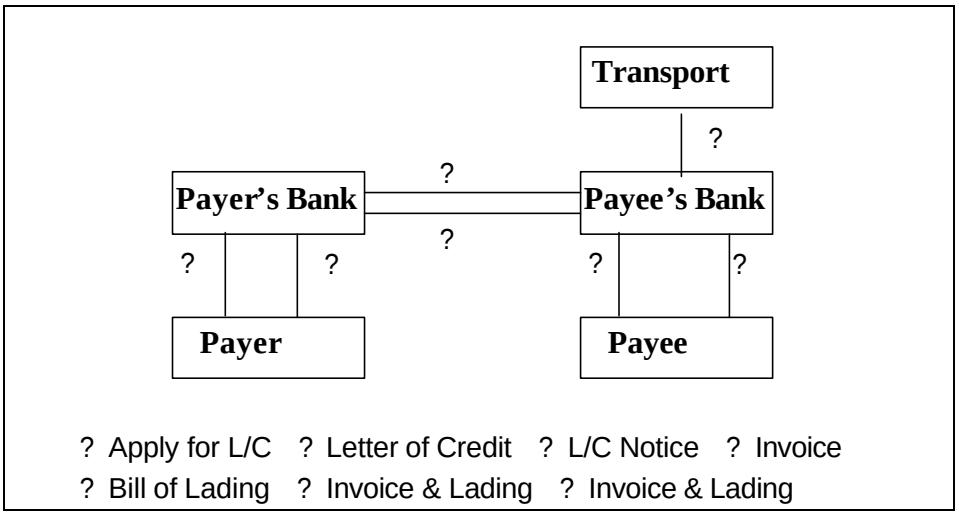

Figure 3 Simulation Bank.

2.2 Consumer

The Consumer, in the SIM-EDI system, is also an automatic role, which is the source and destination of currency flow and flow of merchandise. The Consumer sells waste to a Collection Agent and buys products from Retailers automatically, and then registersthe transaction in the log. Depending on current market conditions and the quoted price of Collection Agents and Retailers, the Consumer makes the selection. From a macroeconomics view point, the consumer's buying activity can be regarded as

consumption, and the selling activity as supplying labor for money. Each Consumer maintains a supply curve for each of the goods it sells and a demand curve for each product it consumes. The instructor can adjust some parameters to control the currency flow and goods flow of the whole system.

2.3 Customs

Just as we look on the Bank as the key link of currency flow, the Customs is a pivotal agent in the flow of merchandise. All imports and exports must pass through the Customs. Its key function is inspecting the goods and collecting customs duties when goods enter or leave the country. The instructor can adjust the Customs tariff according to the concrete conditions. Figure 4 is a classic goods flow of international trade.

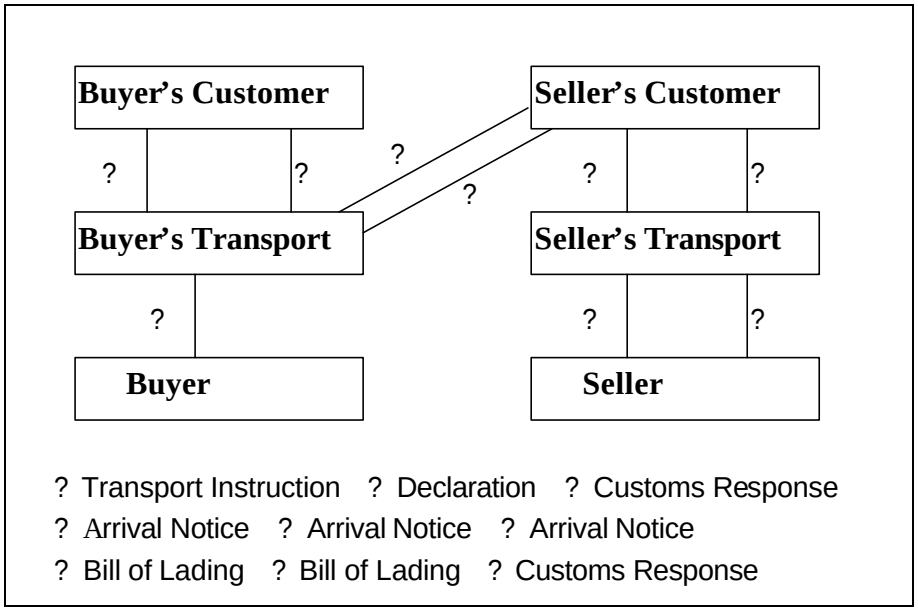

Figure 4 Customs

2.4 Mailer

The Mailer, the key link of information flow in SIM-EDI, is in charge of the interchange of EDI documents and email. The Mailer interacts with every kind of user role, the Simulation Bank and the Customs; it is also in charge of recording postage and backup. The interval between two mail action cycles is determined by the manager, who should establish suitable parameters according to current running conditions, taking account of the efficiency of both the system and the users. (See figure 5)

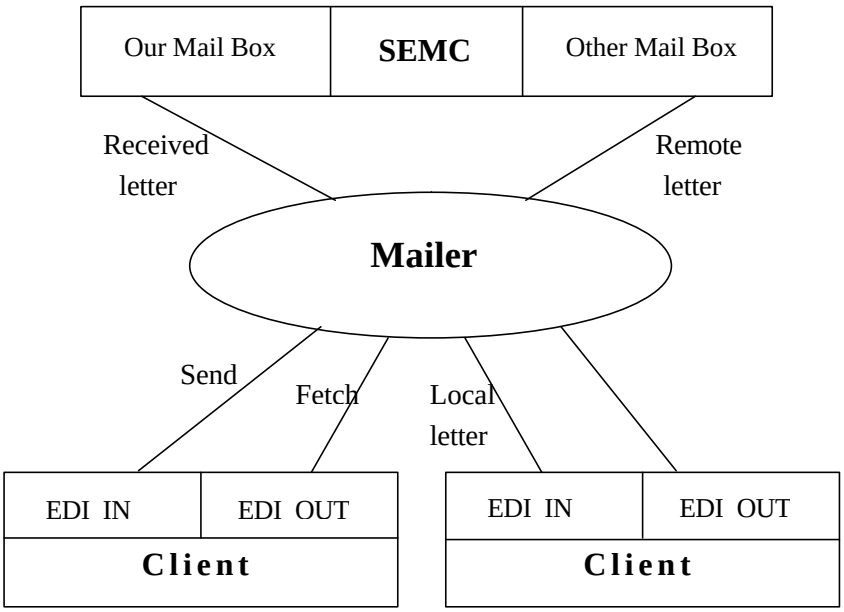

Figure 5 Mailer

2.5 Instructor

It is not appropriate to say that the influence of the instructor becomes weak in a collaborative learning system. In SIM-EDI the instructor plays three distinct roles:

- the computer system administrator, DBA etc. for the distributed computer system;
- the referee/controller of the game that takes place within the simulation world;
- the instructor/guide/assessor in the real world.

The instructor should:

(1) Insert, delete and modify user accounts, and report details to the SEMC on WWW. Once the users have been created, the instructor should initialize all users; if the system is down, the instructor should recover the system;
(2) Settle any trade dispute between users, punish any student who breaks a contract and force a transfer between accounts;
(3) Grade students according to their rate of attendance, the number of valid documents that they draw up, the number of international trades struck and their profit rate;
(4) Adjust the running parameters of each automatic role to simulate different macroeconomics environments, thus functioning like the government;
(5) Help students to use the SIM-EDI software and answer their questions;

In addition, the instructor is in charge of routine maintenance operations for the system, such as managing the log, querying the database, and so on.

So, as you can see, in this system, the instructors do not stand high above the students as they do traditionally, but behave rather as an agent of the system in order to keep things running smoothly. The students can learn trade and management through their own practice and by exchanging experiences with their "trading partner".

That is the biggest advantage of this software. A collaborative learning environment is more suitable for fostering professional skills. But we cannot neglect the influence of the instructor altogether; no matter what the situation is, the instructor is the most intelligent and active factor in the system, which cannot be totally replaced by a computer.

2.6 SIM-EDI Management Center (SEMC)

The SEMC is an intermediary, which works on a Unix host at Renmin University in China. Its functions consist of the temporary storage of "international" documents as well as their registration, the management of statistical data and supplying an information service for each of its clients in the schools. Its information services include market quotation, information about its clients and advertisement.

The original reason why we set up the SEMC is because the LAN Server in a school may not have a static IP address, hence schools cannot send messages to one another directly. Now, by using the SEMC, they can upload the documents being sent to the SEMC, and download the documents to be received from the SEMC. The SEMC implements information transmission through the Internet. (See figure 5)

SIM-EDI encourages students to study collaboratively, and different students will have different backgrounds. So, it is essential to set up a site in the SEMC to discuss the learning experience. All users can log in to the site to share their experiences, knowledge and questions.

The SEMC also supplies patch programs to upgrade the software, which can be downloaded by every user.

3 SIM-EDI WORKING PROCESS

The work process of student-performed roles is as Figure 2. Recycling agents buy waste from the Consumer, produce raw materials, then sell them to the Manufacturers. The Manufacturers transform raw material into finished products, which they sell to the Wholesalers. The Wholesalers sell goods to the Retailers. The Retailers post the price and wait for the Consumer to buy them.

In figure 6, the Transport Agent (TA) can undertake the transportation of any deal. The arrangement for transportation is similar to that of any other business; if the business interacts with a role of SIM-EDI in some other school, the TA must apply to customs to have the goods examined, and pay for the customs duty.

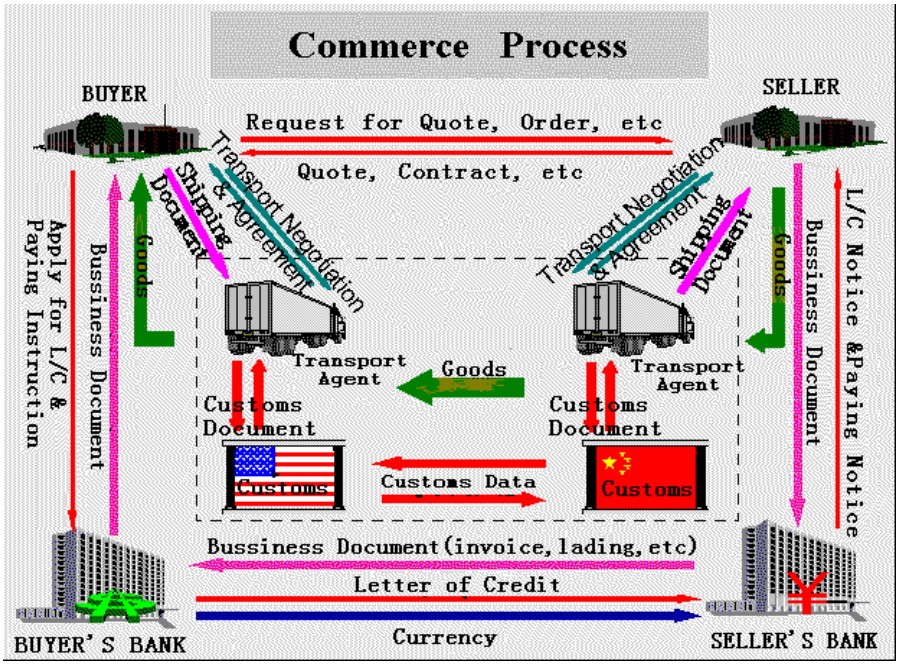

Figure 6 Commerce Process

3.1 Commercial Documents

In this system, there are many commercial documents. These were designed after consulting real commercial documents which conform to the EDIFACT standard. The documents can be divided into the following series: *Negotiation Period(*Request For Quotation etc.), *Transportation period(*Provisional Booking etc.), *Payment period(*Invoice etc.), *Applying for customs in time of export period(*Customs Declaration etc.)

In this system students negotiate through the documents (including all negotiations of business to business and business to transport agent). After a student has sent a document, he can see a display of the information flow which takes place between the different systems. In fact, it is exactly this kind of information flow which is actually used in a standard EDI system. This function can give students an explicit and perceptual understanding of commercial methods and the standardization of EDI.

To ensure the truthfulness of the simulation and avoid ceaseless negotiation or meaningless argument, some documents in SIM-EDI have a legal effect, this legal effect comes into force immediately upon issue of those documents. Therefore, documents must be signed once the two sides have reached an agreement. If one side sends a document of this kind at will before agreement has been reached, the other side has the right not only to refuse, but alternatively to require the former to carry out the contract according to the clauses listed in the document. This is similar to the commercial process in the real world.

3.2 Business Management Function

There is a mini MIS (Management Information System) in every user's system. This MIS can manage the daily routine such as manufacture, finance etc. More importantly, it can integrate the enterprise with the market, account costs, control the proportion of investment and output automatically, and bring broad benefits to the enterprise. Of course, an enterprise must pay for timely and effective market information as the relationship between supply and demand in the Market changes. In addition, the mini MIS can also provide an enterprise with accounting of profits, so that users can know their own business performance in a certain period clearly.

This simulating MIS can give students an explicit understanding of the essence of EDI, i.e. the close combination of enterprise and market. This makes them realize that today, with the rapid development of IT, business management is gradually evolving from the relatively closed processing of internal data into the global commercial tide. Its aim is to become an organic component of the worldwide information base, which is different from pure internal management and an isolated system, since the data that is processed includes much external information. An enterprise is no longer an isolated agent. Being an organic part of global commerce, it can only achieve efficient management through exchanging information with the outside world.

3.3 System of Rewards and Penalties

In an educational system, the instructor should mark every student in the light of their participation, and this is taken as an important marking criterion in SIM-EDI. The main related elements include: the quantity and quality of the documents that the student has sent, the deals that he/she has participated in, etc. That reflects the importance of the participation principle in teaching and learning practice. In addition, being the direct reflection of the effect of studying -- the profit of the enterprise is certainly another important criterion. It is the proof of the effect of students' study and of their practical ability. Rewards should not be offered in pure money, credit or score, but regarded as a method which can stimulate students to remain diligent; so in SIM-EDI, besides a bonus, the students who meet the criterion for a reward can obtain a reduction of tariffs, free mailing of documents and priority from consumers during sale or purchase.

Certainly, in addition to rewards there must be penalties in an educational system. In SIM-EDI students can be punished when they break a contract or the rules of this game, such as not delivering goods or paying on time etc. Penalties are enforced by increasing or decreasing the payment for goods according to contract. At the same time, the instructor should give a warning to students who have broken rules, and make a record. This penalty method is similar to that in real trade -- mainly in the form of a fine. This makes the system much more real, and also make students realize the importance of commercial credit, which is another main purpose of the teaching content.

In addition, we encourage students to exchange their experiences with one another, and not to learn in isolation. EMAIL in this system can be used not only for negotiation but also to exchange what has been learnt about the commercial process and business management. In this way, students can propose their own questions for discussion among themselves, or pass on their own experience to their partners. This is similar to oral discussions in an ordinary classroom. But the scope of participation has been enlarged to all students who have the same SIM-EDI in their school. This can help students to acquire more knowledge through collective effort, and foster their collaborative ability. Instructors can also reward the students who take an active part in the discussion.

From the introduction above, we can learn that SIM-EDI is a collaborative learning software system which simulates a real commercial environment. In this system, starting from the basic idea of a deal, through business cooperation and competition with their partners on the network, students can teach themselves the whole commercial process and business management. Simultaneously it can also foster in them the ability to teach themselves. This method of abstracting theory from concrete examples is entirely in accordance with the cognitive process of human beings. The instructors play a relatively minor role in this system. Their main functions are to organize, to arbitrate and to maintain the system balance. The function of *guidance*, which was originally the Instructors' exclusively, has now shifted to the students themselves. This is the best method to bring the students' initiative into full play, and so divert their goal in studying from obtaining the diploma to acquiring knowledge and ability. In this way people will change their idea of receiving education from *I have to learn* to *I wish to learn*. This is also a main aim in the spread of computer aided education, especially on the WWW.

Certainly, if this system is restricted to a LAN, it is very difficult to ensure that the students will negotiate by documents. In fact, we have found that students in the same classroom often bypass the documents and negotiate orally with their partners in order to find a short cut to gain higher profits in a shorter time. This method of negotiation bypasses the main teaching content of SIM-EDI, that is to make business arrangements with a remote partner by sending and receiving documents. Unless they use documents students cannot obtain a good mastery of enough knowledge, nor will they develop a sense of the difficulty of business. So a really effective SIM-EDI system must be founded on the WWW.

3.4 Superiority of SIM-EDI on WWW

The WWW can simulate a much more real environment. If SIM-EDI is restricted to a LAN, oral negotiation is inevitable, and that breaks regular commercial practice. But using the WWW, the students in different LANs can only communicate through the network. Being a rational broker, each participant will firmly comply with the regular economic and commercial process.

(1) Use of the WWW distinguishes domestic trade and foreign trade to some extent. We can regard a LAN as a country. The trade within a LAN is domestic trade, and trade with a remote site is similar to foreign trade. Correspondingly, the function of the bank and customs is also divided into two different parts.
(2) When the system becomes larger and more complicated, some regularity may emerge from the mass of facts. With a small sample, the disorder of individuals can lead to the chaos of the whole. When the system becomes larger, although individuals may remain disordered, the ensemble will present an orderly state. Running SIM-EDI on the WWW enlarges the number of participants, and leads to a more real simulation. This brings benefits for research into macroeconomics models.
(3) One can conveniently obtain knowledge in relevant fields through the INTERNET or by exchange between partners, and not just through a simple online help.
(4) A larger system leads to more variety and so more amusement, in particular through the increase of changeable factors and the choice of partners.
(5) When more users participate there is a wider exchange of experience.

4 CONCLUSIONS AND SUGGESTIONS

After analyzing the system, we list some of our conclusions and suggestions when exploiting a collaborative learning system on WWW as follows:

(1) Support multiple platforms, such as NETWARE, WINDOWS NT, UNIX etc. This is important to ensure the portability of the system.
(2) Simulate the real environment at the user interface, but make the internal implementation simple and easy to manage; the minimal platform requirement of the system should be reduced as far as is possible.
(3) The game rules in the simulated environment should be independent from the simulation program, e.g. in SIM-EDI the business rules are independent of the program. When new rules are introduced, the instructors are only required to download the new business rule library from SEMC and overwrite the previous ones. There is no need to modify any program.
(4) Simulation should be flexible. The Instructor can adjust many types of parameter in order to change system behaviour, so simulating different kinds of environment.

(5) Taking consideration of the network load, especially the transfer rate on the INTERNET, all data transfers should use short files to guarantee high speed.
(6) Even in an educational system, security should be considered. In order to avoid cheating, we can use authority management and log file.
(7) There is no centralized management. Every part of the system can execute freely. The balance of the system depends on a set of game rules.

Through the above analysis, we can learn that collaborative learning system based on constructivist theory will broaden the development of CAE. But because of the recent development of this kind of system, it has not so far been widely used in education. Further research and practice are required in this field. As IT develops in the future, we think that work on collaborative educational environments can focus on the following areas:

- Timely application of new technology.
- Integration of diverse resources and technologies.
- Universality and modularity of the collaborative educational environment.
- Making collaborative educational software flexible (easy to expand, modify and port).
- Developing interest among those responsible for education.

We believe that, in the future, more and more collaborative learning systems will arise, which can entirely change our idea of education: receiving education will become an equal collaboration between instructors and students, and the latter will be the center of education. The system that we have developed has been used not only to teach and to demonstrate, but also to support students' initiative in study and collaborative exploitation. The *classroom* is no longer dull and dry to students, but has become a charter where students can carry out free exploration and study, utilizing every kind of tool and information resource. Traditional teaching means control and dominance, but collaborative learning system is based on the WWW, which combines students from all over the world. In this way everyone can share in the collective wisdom.

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