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Social Network Education: a Physics Laboratory on Web

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Abstract

The prevalence of Internet and the repid progress of World Wide Wed technologies have successfully turned the dream of distance learning into reality. Using virtual reality techniques on the WWW, we have developed a web-based distance learning system for experiment, a traditional Physics Laboratory whose training requires many equipment. In our system, all equipment is consisted of many fundamental elements. To build a new experiment that requires a new equipment, we can combine many existent elements into the new equipment. The experiment can be done by a single people or many people via networks.

1. Introduction

In recent years, rising development of information technology makes that multi-medium applications on the computer increase widespread. The multi-medium computer deals with data not only text but also graphics, image, voice, video, and animation, etc. Therefore it becomes a new teaching tool. The 80% information accepted by the human have come from the sense of vision [7]. There are also researches supporting that experience of vision serves as an important role during the study [4]. The researches of psychological education focus on the design method to devise the effective visual information. In other words, it becomes the focus of teaching design to devise an effective representation, by whom the interaction and perception are improved, to show graphical and textual information for learners [10]. There are a great number of researches on the study of combining with textual data and visual information. Almost of these researches have the similar results to support the theory of dual coding [8]. That is, visual information has the major advantage to improve the effectiveness of a learner to understand the textual data. In the contrast, the complicated design can not exactly reflect needs of the design.

From the view of information organization, the dynamic image (animation) is an extendsion of images. Knowledge or phenomenon can generate the comparison and connections among images by the dynamic display. It usually produces a wonderful assistance for a learner. The human brains can be roughly subdivided into two parts according to their functions. The left part controls the function of logical or linear considerations. It emphasizes the capacity of processing sorted or sequential data. However the right brain manages the senses of intuition and vision. It emphasizes the capacity to process data in distributed or parallel mode. Therefore, in a CAI (Computer Aided Instruction) system, it is inappropriate to use a great number of visual images and information. It is necessary to consider the bias and limitation of vision sense and data processing for the human.

In general, the multi-medium information learning system have the teaching characters such as topic orientation, interaction, and regarding users (learners) as the center of learning. [3]. It can provide an ideal study environment. During study, users can freely choose study contents as well as progress of the study to satisfy the needs of each user. In the system, users can review the previous study contents at any time to strengthen the effect of study. Users may want to express or to plan some affairs such as programming an experiment and discussion. If they have a learning environment which can provide constructive animadversion, then the environment not only stir the learners' imagination but also improve the learners' expression abilities.

It can reduce 64% study cost and shorten 36% study time to use an interactive multi-medium system as the training tool [7]. For this reason, the applications of multi-medium in the education have been accepted and have been developed quickly. Computer aided learning is a kinds of cooperative learning activities. Learners in the learning environment provided by computers can aid each other and effectively instruct other learners [6]. The multi-medium computer system can be used to train students for writing their reports. During the process of seeking and designing report styles, students can not only review the learned knowledge but also organize as well as resemble learned concepts [9]. Some little students will sit at front of computers to discuss, observe, and aid each other if multi-medium computer systems are put in a classroom [11]. Such a learning style is useful for building the capacities such as social behavior, problem solving, companion learning, and communication skill.

In recent years, the characters and functions of the hypertext and hypermedia attract the teaching researchers [2]. The hypermedia system coincides with the model of perception theory in the knowledge represenations and processes. Thus it can promote the growth of effective learning [5]. The World Wide Web (WWW) is a shared network system by hypertext or hypermedia scheme to exchange documents or information. For this reason, it has the above advantages of multi-medium and interactive learning systems. Therefore it is a potential environment to develop a new teaching place.

In this paper, we use the world wide web as a teaching environment. On this open environment (system), users (learners) learn and discuss each other conveniently. It stirs companion competition to improve teaching effects and learning interests. For studying methods to make up teaching materials, we concentrate on the physics laboratory and design some experimental models. In this paper, we regard the free falling objects as an example to study teaching material building methods such as models, control factors, and experimental components.

2. Experimental Models

There are researches subdividing learning technologies from traditional computer-based training system to cooperative learning system into the following four types [1]:

(1) CBT (Computer-Based Training) : Teachers and students all use computers to ameliorate conventional training methods.

(2) ITS (Intelligent Tutoring Systems) : The ITS is formed by embedding the human characters into the CBT system. It contains knowledge in a field as well as learning models.

(3) ILS (Interactive Learning Systems) : In this model, students operate the system directly. The learning effects is enhanced by interaction between students and the system.

(4) CLS (Cooperative Learning Systems) : The system provides learners with the capacity to obtain other learners' viewpoints and concepts.

In our system, a learn discusses with remote learners by the computer network. Learners obtain other learners' opinions on-line. Therefore our system is an instance of the CLS learning model.

Lifelike diagrams stir actively feeling reactions of the human. The low resolution text or images prevent the human from understanding or perception.From the measure of vision receipt, it must be improved to fill a full display screen with the textual information in the CAI materials. The interactive communication is a prompt method to display a screen page with text and images. For the effects of interactive communication, we build models for each experiment. Learners proceed freely each experiment and ask their questions. The system gives an explanation as rational as possible according to its model. Learners in such a system can ask questions without any pressure and obtain the exact or near-exact explanations or answers.

For the activity of our system, we adopt completely solid objects and three-dimensional space in the system. It increases the realism of our system and stirs up the learner's study situation. Our system can operate not only in the simulated environment or vitual reality but also in laboratories, i.e. combining our function with real equipment. Therefore our system can operate individually as well as communicate the remote users by network to accomplish an actual physics experiment.

It is very tedious to establish the system models. The complexity of models in our system can be reduced because that we restrict our system to experiments for the physics. Each physics experiment has explicit principles and theorems. The control factors for each experiment are clear. Its reactions can also be derived. Therefore it becomes easily to eatablish models of experiments in our system. The model for a physics experiment in our system is established as follows.

1. Principles and theorems: For each experiment, find suitable principles and theorems. These principles and theorems becomes the guidelines of our system to react users' operations. Each response generated by our system must obey these guidelines. Otherwise, such a response will be erased and will not be sent to learners. Our simulated system will also ignore such a response.
2. Scope: According to the principles and theorem of the experiment, we make sure scope of the experiment. In other words, the complexity of content of the experiment is defined or the degree of learners in our system is determined.
3. Control factors: It is possible that there are many control factors for an experiment. For these control factors, the difficulty must be determined for our system users. Users first learn to control these factors with low difficulty and then learn to control these factors with higher difficulty gradually. In such a way, the learning effects increase.
4. Experimental equipment: An experiment must be proceeded by operating suitable equipment. Some equipment has relation to control factors. These equipment allows users to tune dynamically. Other equipment is fixed and then users concentrate on these control factors. The user concentrates on the experiment study without any interference.
5. Operation model: It is a critical point that an user manipulate these control factors in our system. If an user is easy to manipulate these control factors, then the user can concentrate on the meanings of these control factors. There are two ways to manipulate control factors in our system. First, an user handles a control factor by the mouse operations

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directly. This is a convenient way in the graphical user interface system. Another way allows that an user enters a value by the keyboard to tune exactly the control factor. It is a conventional control method.

6. Responses: After each control factor is set up, the experiment can be launched. Our system must generate the suitable result and send appropriate feedback to users. There are two ways to display our feedback. First, a consecutive images of the experiment are given. It provides learners the immersive experience. The learner can look at a minor change. The second method only provides an image describing the result of the experiment. This is the fastest way to display the result for users.

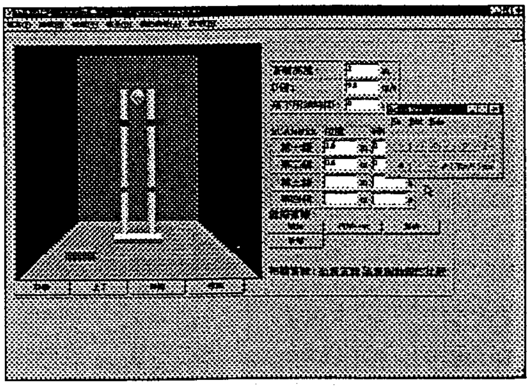

Figure 1: The operational interface of the free falling objects experiment

The free falling object (See Figure 1) is used as an example to build its experiment model by the above steps. These steps are illustrated as follows.

1. Principles and theorems: The free falling objects means that objects move toward the ground with no initial speed. This phenomenon is affected by the universal gravitation. It obeys the following rules:

   $v = gt$, and

   $$s = \frac{1}{2} g t^2$$

   where v denotes the speed, t is the time, s denotes the distance, and g is the gravity acceleration.
2. Scope: We can determine the following experiments from the above principles and theorems.
   a. Relations between distance and time: First, the distance between the object and the ground is changed. Then, time required by the object fallen to the ground is measured. Moreover, relations between the distance and time can be derived.
   b. Relations between time and gravity acceleration: First, the gravity acceleration is changed. Then, time required by the object fallen to the ground is measured. Moreover, relations between the time and gravity acceleration can be derived.
   c. Relations between weight and time: First, the weight of the object is changed. Then, time required by the object fallen to the ground is measured. Moreover, relations between the weight and time can be derived.
   d. Relations between volume and time: First, the volume of the object is changed. Then, time required by the object fallen to the ground is measured. Moreover, relations between the volume and time can be derived.
3. Control factors: According to the purpose of each above experiment, control factors of the free falling object can be determined as follows.
   a. Relations between distance and time: There is a single control factor: distance.
   b. Relations between time and gravity acceleration: Only one control factor exists in the experiment. It is the gravity acceleration.
   c. Relations between weight and time: The weight of the object is a single control factor for this experiment.
   d. Relations between volume and time: The density of the object (or volume) is the control factor for this experiment.

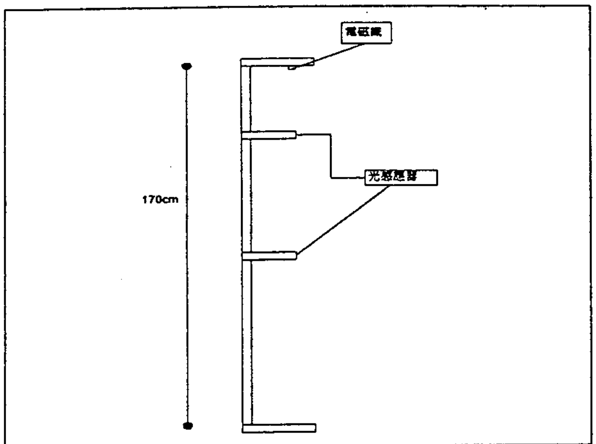

Figure 2: The platform of the free falling objects experiment

4. Equipment: The platform of the free falling object is very simple (see Figure 2). It consists of a terrace and a ball on the terrace. Only one attribute of the terrace can be tuned. That is its height. There are two changable attributes for the ball. These concepts is easy to implement by the object oriented technology.
5. Operation model: Each experiment has its single specified control factor. The control factor is easy to identify. The experiment can be launched only if users set up the control factor. The system starts to simulate the experiment when it is launched.
6. Responses: In the free falling object experiment, our system simulates each state of the experiment. The number of simulated states is determined by users. In each state, our system must display the position of the object and the time that has been taken.

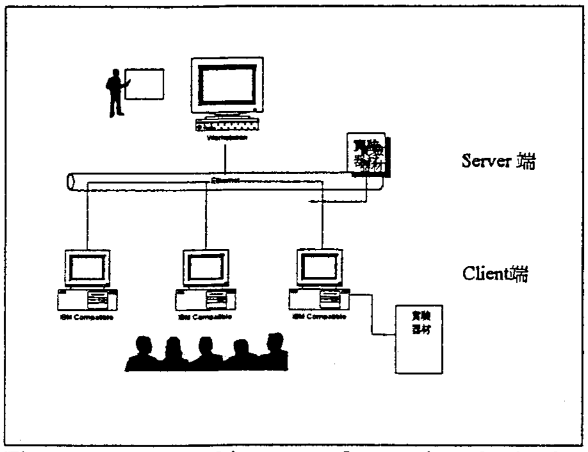

Figure 3: The architecture of our virtual physics laboratory

3. System architecture

In our system, we have developed experiment equipment for a simulating physics laboratory and a complete computer-based experiment assistant system (see Figure 3). Such an assistant system allows users to collect outside information by sensors or computer interface cards. The purpose of our system is to provide a free and interactive environment for students proceeding their physics experiments. Our network simulating laboratory has applied virtual reality technology for implementing some mechanics experiments. In these experiments, our system will be extended to input outside data from the real experiment equipments. The specification of our simulating experiment equipment coincides with principles of the open system. Users can build their experiment environment by composing of our simulating experiment equipment. In such an experiment, users can proceed the experiment as their designated steps to obtain the experimental results. The experiment can be also simulated by our system to obtain its prediction which is derived by properties of our simulating experiment equipment. These two modes make users to predict, operate, observe, explain, and verify during experiment learning. It is a suitable learning model. For the purpose of network teaching, we also study to develop a mechanism. Such a mechanism allows multi-users and multi-computers to share the learning environment by the computer network.

There are some characters on our system architecture as follows.

1. Our system platform is based on the internet.
2. The interface of our courseware is based on the hypermedia.

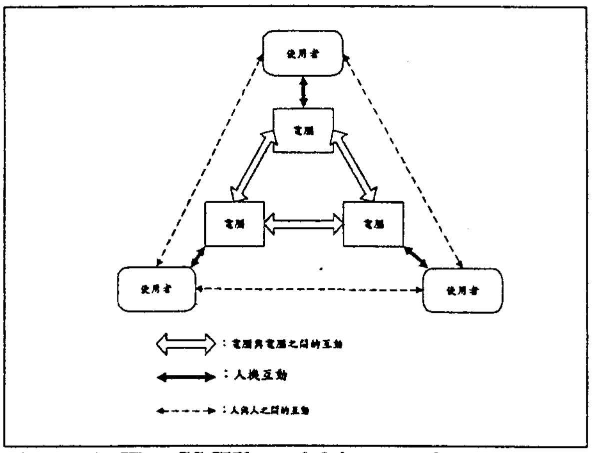

Figure 4: The CSCW model in our virtual physics laboratory

3. The computer supported cooperative work (short for CSCW; see Figure 4) mechanism of distributed systems is embedded in our system.
4. The simulating mechanics laboratory has been build.
5. All developed simulating experiment equipment can be combined into a new experiment equipment.

In our system, we adopt three-dimensional mode displaying network physics laboratory to improve display quality. The OpenGL library is used to handle three-dimensional graphical objects. It cooperates with Superscape VRT which is a powerful tool for virtual reality. Two active X control objects opengl.ocx and vrt.ocx are required in such a combination. The active X control objects can not be executed individually. The container is necessary for control objects to spread their functions. The browser is a well-known container.

Learners must use Internet Explorer 3.0 or higher version browser to enter our system due to that we adopt the active X technology in our system. To improve the interaction of our system, CGI, Java Applet, and JavaScript are also added into our system. Each language handles objects and processes which is optimal for the language. VBScript acts as an important role in the homepage which adopts much active X technology. It is useful particularly in the communication and connection of the active X and the Java Applet.

Under considerations of interactions and humanization, we integrate design opinions and experiment modules. The system architecture of our physics laboratory can be subdivided into following components:

1. Identification: Each user must pass the identification and then enter our system to proceed his physics experiment learning. The information about identifications can be used to record users' learning states and trace users' learning processes.
2. Text: The text component is used to display experiment-related material for daily life and facts. Before performing this experiment, some leading problems are displayed in the component to stir up users' interest. After experiment is performed, some explanations are also given in the component to emphasize experiment result.
3. Experiment: This windows allows users to manipulate their experiments. It consists of many experiment equipment and modules. The major technology used in this windows is control objects of active X such as opengl and vrt. The inputs of this windows can be entered by the mouse or keyboard. Its output directly writes down the data windows.
4. Data: The data windows is used to record and display data generated by the experiment. Its display modes can be textual tables or graphic diagrams. Users can derive relations between control factors by comparing, matching, drawing, and analyzing.
5. Message: The message windows displays status of the proceeding experiment and instant message such as warning and errors. The information displaying in the windows is used to remind users correcting their experiment steps.
6. Help: The help windows displays the related and implied information. This windows is a pop-up windows. It appears only if a user invokes assistance to conquer his obstacle.
7. Discussion: The discussion windows is a place in whom two users interactively discuss and exchange opinion. Its architecture is similar to the chat room on the BBS.
8. Calculator: There are complicated calculations on the physics. This windows provides users a convenient tool to compute numerical results.

4. Learning Models

Our system is build on the internet to provide a new and convenient physics experiment learning environment. All experiment equipment is made in our system by objects. An object obeies its rules in the physics. Objects can be combined into a new object with powerful functions. Each part of a combined object keeps its original properties. A builder applies well-defined objects to compose a necessary object without considering their detail. The build is easy to compose an object matching needs. The load of building physics experiment models is dramatically reduced by this method.

Our system is based on problem orientation. For a class of problems, students can design their experiments and objects by composing the mechanics kit embedded in the system. All mechanics experiment equipment are studied in order to design the mechanics kit. Components of the mechanics kit are classified into templates and objects. Each template is a combination of experiment equipment. Although users can build freely a template himself, each template contains its constraints. Constraints of a template prevent users from building a unpractical experiment. Components of a template are all general objects. Users compose a new template by combining existent objects.

A simulating physics experiment environment with no pressures is provided by our system. In such an environment, users choose interesting experiment for studying. The control factors of each experiment is very clear and then users drive their experiments easily. Almost each user completes his experiment by himself. Consequently, our system allows that multi-users work together to perform a experiment. These users exchange their opinion by the discussion windows. Each of these users can start the experiment by pressing the start button. Other users will be informed that the system is started by one user. If there are no users to cancel the start signal in a specified period, then the experiment is performed actually. Each user will receive responses of the experiment.

The major teaching idea of our system is learning by doing. Users learn a specified knowledge by performing a series of related experiments. The specified knowledge can be obtained by users from analyzing these experiment results. All experiment results will be kept in our system unless the user erases them. Experiment results can be displayed in the data windows with textual table or gtraphic diagram. Control factors of each experiment is clear, relations between control factors and measured values is easy to derive.

The help windows of our system is a facility similar to an assistant master. If a user encounters a difficulty for manipulating the system, then he can ask help windows for explanation and an example to demonstrate its proper operations. Although the help windows provides useful information, a user may be difficult to operate. In such a case, the user can send an email to the teacher or expert for asking help.

5. Conclusion

In this paper, we proposed a method to build a physics laboratory on the internet. In such a simulating laboratory, all experiment equipments are build by objects. Each experiment is studied by subdividing into many objects. These objects are combined by the model of the experiment. Therefore a user can build his new experiment by composing existent objects. For a learner, our system provides a convenient way to study the physics experiment. Multi-users can operate the same experiment in our system by the computer network. In such a case, the effect of learning can be enhanced by discussion.

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Reference:

1. G. Boy, Learning evolution and software agents emergence, Intelligent Tutoring System: Third International Conference, ITS'96, Montreal, Canada.
2. D. H. Jonassen, Hypertext as instructional design, Educational Technology Research and Development, 39(1), pp. 83-92, 1991.
3. M. Jon, Multimedia why and why not, The Computing Teacher, pp 16-18, 1995.
4. A. Large, Computer animation in an instructional eniivironment, Library & Information Science Research, 18(1), pp 2-23, 1996.
5. A. Lanza, Some guidelines for the design of effective hypercourses, Educational Technology, 31(10), pp. 18-22, 1991.
6. K. Linda, Computers in the early childhood classroom, The Computing Teacher, pp.54-55, 1989.
7. P. F. Merrill, K. Hammons, et. al., Computer in education, 3rd edition, Simon & Schuster Company, 1996.
8. A. Paivio, Mental representation: a dual coding approach, New York: Oxford University Press, 1990.
9. S. Peter, Thinkingland-helping students construct knowledge with multimedia, The Computing Teacher, pp.12-15, 1995.
10. L. P. Rieber, A historical review of visualization in human cognition, ETR&D, 43(1), pp 45-56, 1995.
11. M. Vaughn and T. Kimberly, Using technology in early learning classrooms, Learning and Leadind With Technology, pp.8-10, 1995.