Competency-Based Training Virtual Classroom for Vocational Training on WWW

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Abstract

In this paper, a distributed distance education system is built on WWW (World-Wide Web), called CBTVC (Competency-Based Training Virtual Classroom). This system extends CBT self-learning materials for vocational training into asynchronous distance education net and offers a "Registration → Self-learning → Qualification" learning cycle.

This research investigates the characteristics of distance education and the media in learning materials. Built on FreeBSD, CBTVC environment provides not only network learning materials but also different self-assessment methods. CBTVC and its network learning materials can be represented as a hypermedia organization chart, which is a learning model for analyzing the learning portfolio from web log files. An experimental learning unit "waveform measurement by oscilloscope" is used to demonstrate these results.

Key words: Distributed distance education, Learning materials, Learning model, Virtual classroom, Vocational training

1. Introduction

Distance education means that teachers and students separate in different time and at different locations. [9] Long time ago, people taught and learned through message exchanges of mails and books. When radio and television were invented at the beginning of this century, one-way broadcast brought different mass communication. [1] Succeedingly, the development of computers and multimedia in this decade adds more interactions in learning media, like video compact disc. Up to now, it can be observed that as Internet prospers recently, the application of distance education has entered a WWW era. [4]

Since 1993, Employment and Vocational Training Administration in the Republic of China has promoted Competency-Based Training (CBT) for vocational training and completed numerous units of training materials. Competency-based education is an education system which clearly defines the goals and the abilities in learning process for students to achieve. (J.M. Copper and W.A. Weber, 1973) Such education system satisfies three assumptions: (1) Education has practical value, whether it is for the present or for the future; (2) It is possible to clearly describe necessary abilities in career, including techniques, cognition and emotion; (3) Teachers can perceive the changes of students' behaviors. [8]

Continuing the previous researches [6][11], this paper presents an asynchronous distance education system built on WWW, called CBTVC (Competency-Based Training Virtual Classroom). "Virtual" means it has the same effect as the real. "Classroom" is a place that teachers and students can study and discuss together. "Virtual classroom" means teachers and students can teach and learn by using multimedia courseware though networking. (Tiffin and Rajasingham, 1995) Virtual classroom provides not only the guidance in network learning materials, but also the learning environment for discussion groups. Such environment can help learners reach learning goals by cooperation. [6]

Section 2 focuses on the analysis of distance education in vocational training. In Section 3, several kinds of learning materials are analyzed in details. Section 4 uses several learning models to analyze the distance education in CBTVC. One experiment system is implemented for CBTVC in Section 5. Section 6 is a conclusion.

2. Distance Education in Vocational Training

There are three characteristics in distance education. [9] First of all, remote learners will learn independently and autonomously. (Wedemeyer, 1970s) Secondly, about learning environment, the teaching materials and learning methods in distance learning have to be industralized, then learners can proceed step by step. (Peters, 1960s) The last and the most important in network learning, there are many interactions between techers and students. (Moore, 1993) Generally speaking, group learning will bring learners better learning effect than single learning does; therefore, we adopt group-learning model in our distance education system design. [2]

The design of learning environment tries to satisfy different requirements of different learners. For distance education in network systems, there are four kinds of application levels: (1) Self-learning learner: That is, learning through personal computer and modem. (2) Small group: Group members from different families or schools learn together through a group distance education service center. Such groups are smaller than traditional classes. (3) Course networks: Some courses can utilize network connections in several synchronous distance conference centers to process different levels synchronous group interactive learning. (4) Virtual learning institutions: Such institutions work for distance administration, distance services, distance library and some academic department asynchronous operations. (Tiffin and Rajasingham, 1995)

According to recent researches, new communication technology makes distance learning two kinds of models: synchronous models and asynchronous models. (Tiffin and Rajasingham, 1995) Some immediate distance conferencing systems, such as video conferencing, audio conferencing and audio-graphic conferencing, belong to synchronous models. Synchronous distance learning has very high immediacy but needs wide bandwidth, then the hardware is more expansive and the dissemination is limited. On the other hand, synchronous models, such as electronic mail, BBS (Bulletin Board System) and WWW, need less bandwidth, hence they are less expansive and can be more popular. [10]

Distance education aims at accomplishing teaching or leaning through network, then is a CSCW system. The so-called CSCW (Computer Support Cooperative Work) means that a group of persons work together on network. A CSCW system is a groupware with a multi-user and multi-machine interface. On WWW learning environment, learning materials are placed on server as the form of homepages. And can be accessed by self-learning learners as asynchronous model. Such WWW learning materials has satisfied the former two characteristics of distance education – the independence and autonomy of learners and the industrialization of learning materials. About the third characteristic of distance education, the interactions in distance education, researches depict that there are three kinds of interaction behaviors in CSCW systems: (1) man-machine interactions, (2) multi-machine interaction and (3) multi-human interaction. [5] It is notable that human interactions are completed by man-machine interactions and multi-machine interactions in a CSCW environment. [7]

By researches, from the viewpoint of learners, the interactions in distance education can be divided into three categories: interactions between learners and learning materials, interactions between learners and teachers, and interactions between the learner and other learners. [4] The last two are classified to multi-human interactions, which should be accomplished through man-machine interactions and multi-machine interactions designed in distance education environment. In the asynchronous model of distance education, the interaction between teachers and students, or between students and students, can be accomplished through the discussion groups in BBS. Moreover, the mail forwarding function in discussion make possible cross-net discussion, which is impossible by just a pure WWW server (no discussion group) or by just a local discussion group. In addition to the above two interactions, that is, the interactions between teachers and students and between students and students, discussion groups can include the interactions between the authors of learning materials and the readers (teachers or students) to provide more abundant multi-human interactions.

In recent years, vocational training follows *CBT* (Competency-Based Training) to develop training materials in plenty of occupations. Such CBT training materials are designed in modular

forms for guiding self-learning, hence are very suitable for asynchronous distance education. The learning step of learning materials in CBT (Competency-Based Training) learning model is shown in Figure 1. [12] The features in CBT learning, such as goal-oriented course design, autonomous learning and "student-guide with trainer support" training mode, can greatly fit the needs of enterprises. For distance education, CBT training satisfies its second characteristic, industrialization, in which education looks as an industry, schools as factories, courses as production lines, and students as the raw materials and products. (Bobbitt, 1918) In such circumstance, media and learning materials have to be designed and learned in some specific orders. (McNeil, 1977) This corresponds to the independent and autonomous learning in distance education. Therefore, the idea of CBT training is very suitable to be built as asynchronous distance education.

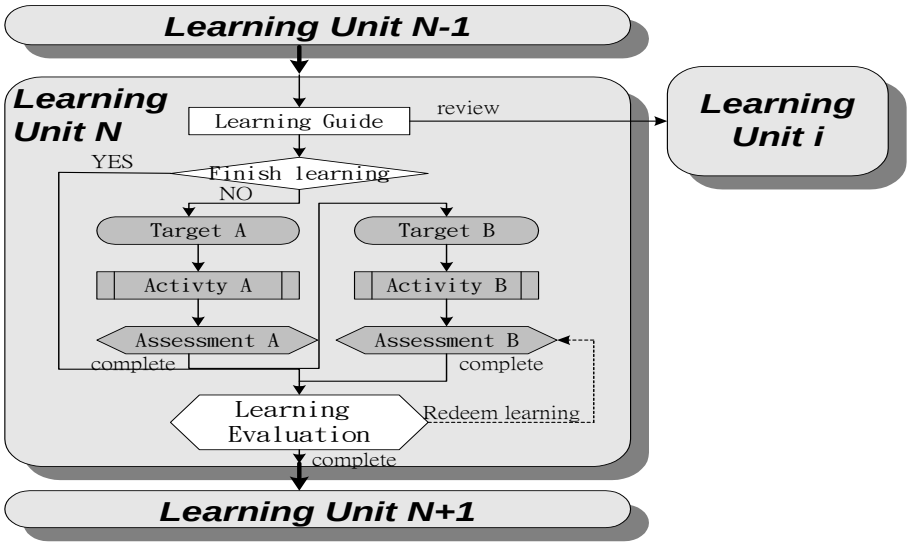

Figure 1. Learning steps in a Competency-Based Training

WWW-based learning is one kind of asynchronous distance education and can be used in self-learning mode. In such learning, a web site is often built up for the placement of learning materials and for the access of learners. As the number of learners increases, the loading of the system becomes heavy and the needed bandwidth becomes large. This causes the limitation of students in a single web site and distributed architecture is then proposed. In a *distributed learning* environment, each site has limited users but all sites are connected through networking, hence there will be no limitation of learners in the whole learning net, as the CBT vocational training net shown in Figure 2.

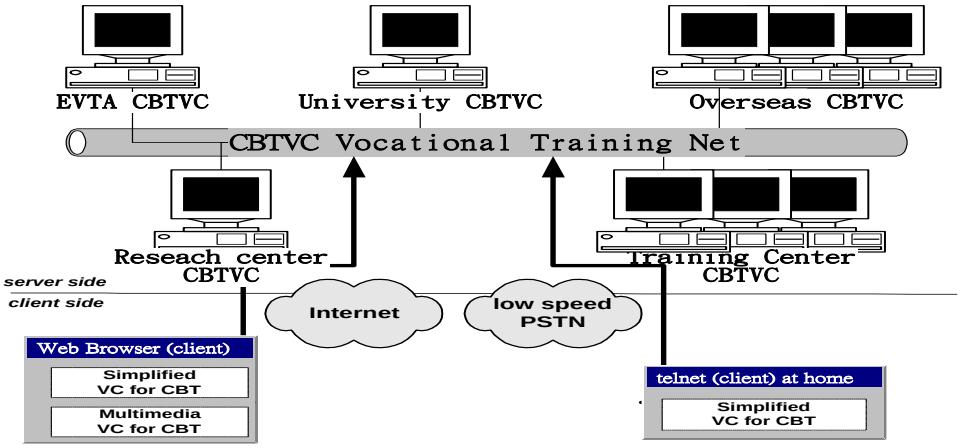

Figure 2. CBT vocational training net

In the above asynchronous distance education environment, all sites are connected through networking, so learners can access any site to learn at any time and at any place. According to the learning material model of CBT training shown in Figure 1, students have to learn under some learning flow control. Therfore, the learners should register at first to get the identification of students. After a student finished some learning unit, he or she must pass some qualification procedure then get the license. Such qualification corresponds the present ability certification in vocational training system. Of course, this qualification cannot be completed through network, and only hands-on examination gives credit. So an asynchronous distance education is a *"Registration → Self-learning → Qualification" cycle* and matches the current vocational training license system, as shown in Figure 3.

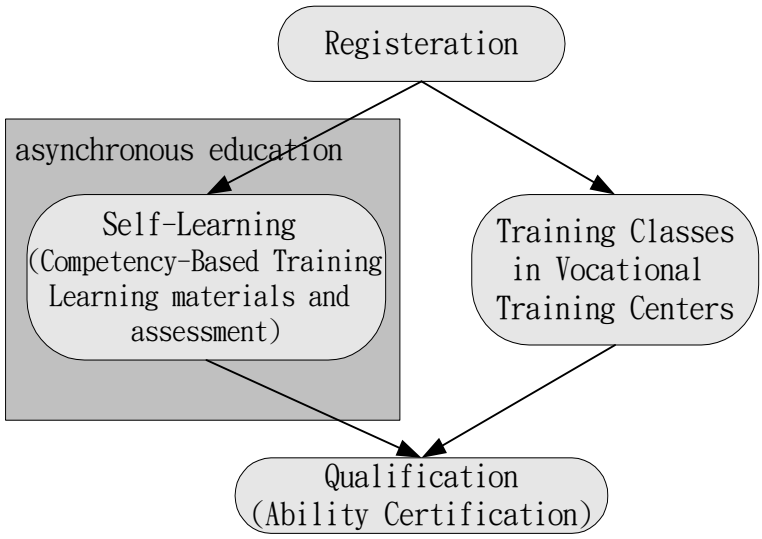

Figure 3. "Registration→Self-learning→Qualification" cycle and vocational training

3. Analysis of Learning Materials

In asynchronous distance education, self-learning comes from the learning materials of web storage and the learning support of user interface. Briefly speaking, the interactions between students and learning materials in asynchronous education depend on whether learning materials give learners enough supports to form an efficient learning. Besides the design problem of learning materials, a distance education system also has to provide other supports, such as interactive interface and learning flow control.

The learning materials for asynchronous distance education have to meet the characteristic of independent and autonomous self-learning. These learning media must contain enough sensual excitements. About self-assessment, such designs have to consider not only enough hints, but also different interactions, learning efficiency, learning period, learners' emotion and so on. Learning models embedded in learning media can be analyzed as Table 1.

Learning models	Implementation and Interactions	Learning media
Teaching	Independent learning Learning flow control	Multimedia learning materials
Discussion	Author/teacher/student discussion group Real-time discussion	Text and audio
Test	Self-assessment (check for learning efficiency)	Learning profiles
Homework	File transfer (also check for self-learning or pier review)	Multimedia files

Table 1. Learning models and materials in asynchronous distance education

To accomplish self-learning, it is necessary to divide learning materials into several units so that learners can follow the learning flows to study autonomously and independently. [12] Each unit has its own learning goal, multimedia contents and self-test. With the outcome in self-assessment, a learner can check his or her learning outcomes in this unit. The contents of each learning unit are analyzed as linear or branchy course organization. This kind of learning process is organized in some order with serial or parallel links. On WWW these links can be implemented by hyperlinks, which make an organization chart of these hypermedia learning materials, as Figure 4 shown. Learning flow offers learners different guided and flexible learning processes. Each learner has his or her own personal learning flow, which is just a traversal path in hypermedia organization chart theoretically.

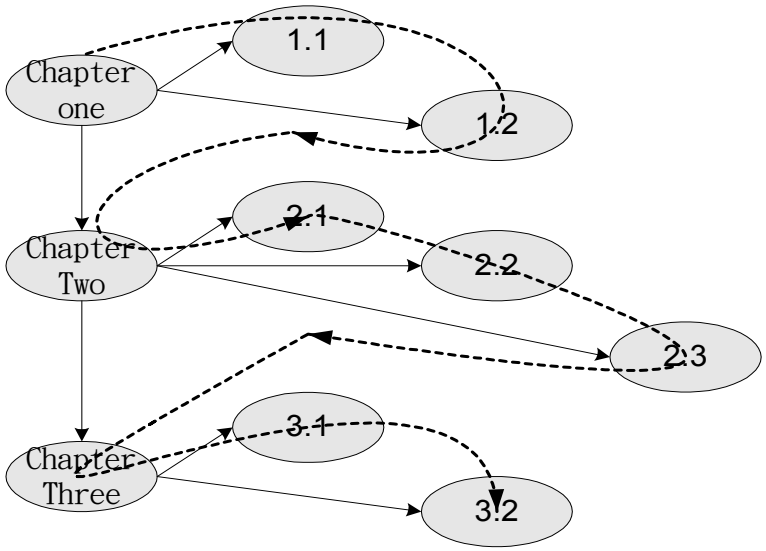

Figure 4. Hypermedia organization chart and one learning path

In the above hypermedia organization chart, some assessment software can be used to judge whether the arrangement of learning materials is suitable, whether the development of learning units or learning paths is good, and so on. Moreover, the learning behaviors of learners can be analyzed accordingly, such as a learner spends too much time in some learning paths or a learning path is too long or too complex (has too many branches). On the other side, learning media almost contain all media of present like test, graphic, audio, video, animation, VR (Virtual Reality) and interactive programs, shown as Table 2.

Learning media	Application forms	Storage forms	Size
Text	Contents, organization, homework, discussion	HTML homepage	Several KBs
Graphic	Graphics or video	Vector or compressed forms	Several KBs to hundred KBs
Audio	Voice, audio, real-time audio discussion	(Real-time) voice/music compression	Decades to hundreds of KBs
Video	(Real-time) video, display	(Real-time) video compression	Hundreds of KBs to decades of MBs
Animation	(Real-time) animation	Vector graphic	Several to decades of KBs
3D animation, Virtual Reality	(Real-time) 3D animation	3D animation format	Decades of KBs to several MBs
Network Programs	Simulation, Interaction	Java, ActiveX components	Decades of KBs to several MBs

Table 2. Media in learning material

As described, assessment criteria are very important for self-learning materials. With the present technology in networking, learning achievement assessment methods can be divided into several modes: test, practice, homework, discussion and portfolio analysis, as Table 3 listed.

Assessment modes	Implementation and Interactions	Learning media
Test	Test-bank, test, analysis, self-test, collective-test, computer-test.	True-false, choice problem database
Practice	Self-practice, cooperative and competitive learning	Procedural problem solving process
Homework	Homework hand-in, management, print-out, automatic assessment	Multimedia file
Discussion	(Real-time) Author/teachers/student discussion group	(Multimedia) articles or audio messages
Portfolio analysis	Learner login and usage records	Learning models and portfolio analysis

Table 3. Self-assessment in asynchronous distance education

4. CBTVC: A Distance Vocational Training Education System

As a result, we can conclude that asynchronous distance education contains the following important issues, which could also be the requirements and limitations of distance education:

1. Learning materials should be modular and organized to provide enough learning activities and self-assessments in each unit.
2. Learners can study autonomously and independently, not only with the modular learning materials but also in a sophisticated interactive learning environment.
3. There already exist many synchronous distance education environments, such as audio and video conferencing. These environments usually do not have enough learning materials but provide good multimedia interfaces. Therefore, they can cooperate well with our asynchronous distance education environment.
4. Finally, not all education objectives are suitable in distance education. Only cognitive education objectives can be implemented in distance education. Those learning activities involving in complex skills are very difficult to be accomplished remotely.

Based on the above key issues and recent development of networking technology, we can obtain several basic requirements of distance education systems: (1) cooperation with synchronous systems, (2) distributed architecture, (3) openness of data formats, (4) compatibility with the present networking protocols, and (5) applying "Registration → Self-learning → Qualification" learning cycle.

Since learning materials, homework, test (database), practices and experiments are all hypermedia; it is natural to use WWW server to build up our vocational distance education system. For homework and discussion group, FTP (File Transfer Protocol) and BBS discussion group can be used as compatible protocols. Nowadays, BBS with mail forwarding function has formed large discussion groups on Internet. To get in touch with the current BBS discussion groups, all learning processes with questioning or discussion are implemented as BBS discussion forums. And using plug-in CGI (Common Gateway Interface) or ASP (ActiveX Server Page) services to WWW server, a complete asynchronous education system for vocational training can be accomplished as a CBTVC (Competency-Based Training Virtual Classroom) shown in Figure 5. In the designed system, all the problems and answers (whether correct or wrong) in tests, discussion data in discussion groups, problem solving processes in practices and multimedia files in homework will be recorded as the learning profiles of learners. Also, all the learning process history will be traced in such learning portfolio. To analyze learning states of the learning process, a learning model can be established accordingly, as Figure 6 shown.

There are two notable points. Firstly, Figure 6 only shows the self-learning part in "Registration → Self-learning → Qualification" in asynchronous distance education and the login action after registration. Formal registrations and qualifications need other software or face-to-face learning systems. Moreover, the learning model in Figure 6 can also be treated as the data model of our learning process analysis. From such data model, we can analyze the learning states of learners, which can be as a linkage between qualification and the self-learning of asynchronous distance education. For example, the results of qualification have to match the learning states in self-learning process, or there might exist cheats in self-learning.

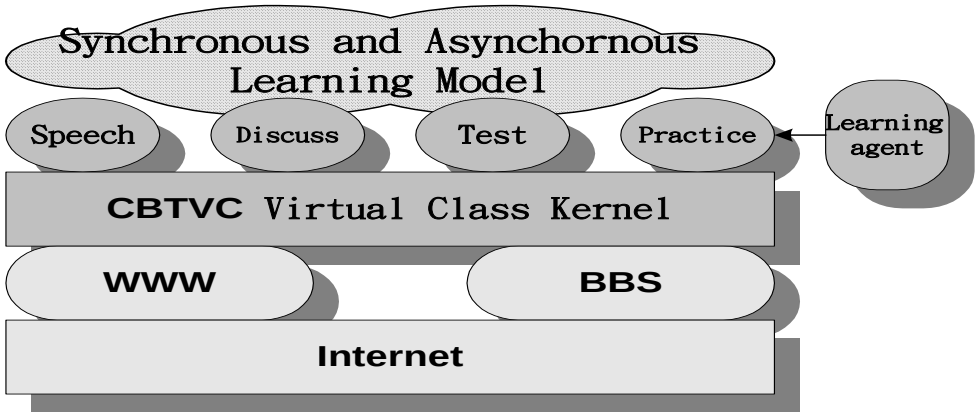

Figure 5. CBTVC (Competency-based training virtual classroom) system architecure

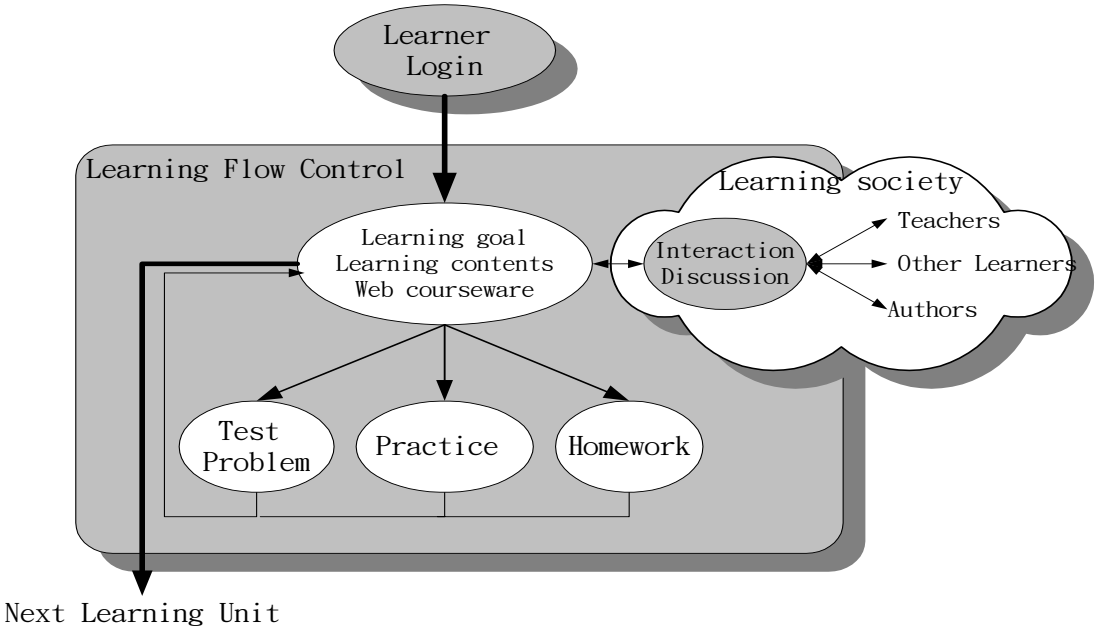

Figure 6. Learning model in CBTVC

5. System Architecture of CBTVC

Based on Web-BBB on Internet, CBTVC uses plug-in CGI/ASP services to establish a complete asynchronous distance education system. The operating system is FreeBSD, a free UNIX system on personal computer. And the Web-BBS system is composed of Firebird BBS system and Apache httpd server. All the above software is free. Besides, WebBBS, chatroom, test development, homework and learning data query are constructed by plug-in CGI. These CGI programs are all located on cgi-bin directory of WWW system. The learning flow model of CBTVC system is shown in Figure 7. The login snapshot of CBTVC system is shown in Figure 8. Also, CBTVC constructs several discussion groups, shown in Table 4, all of which possess interactive discussion and mail forwarding.

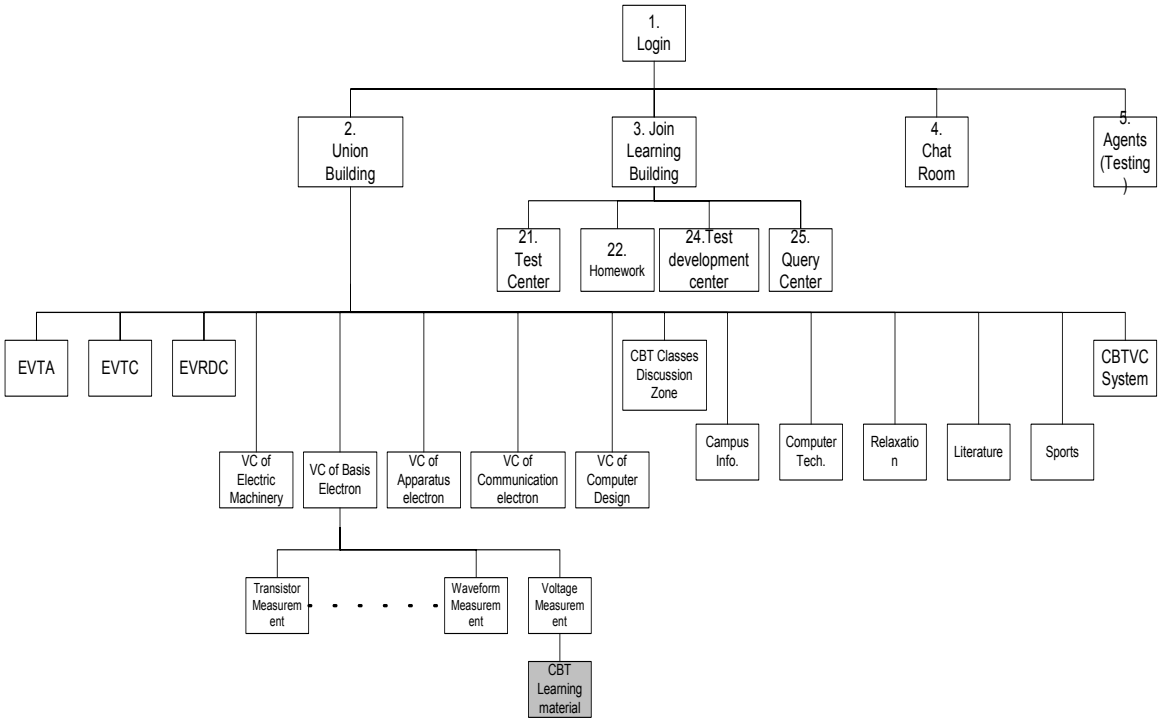

Figure 7. The learning flow model of CBTVC system

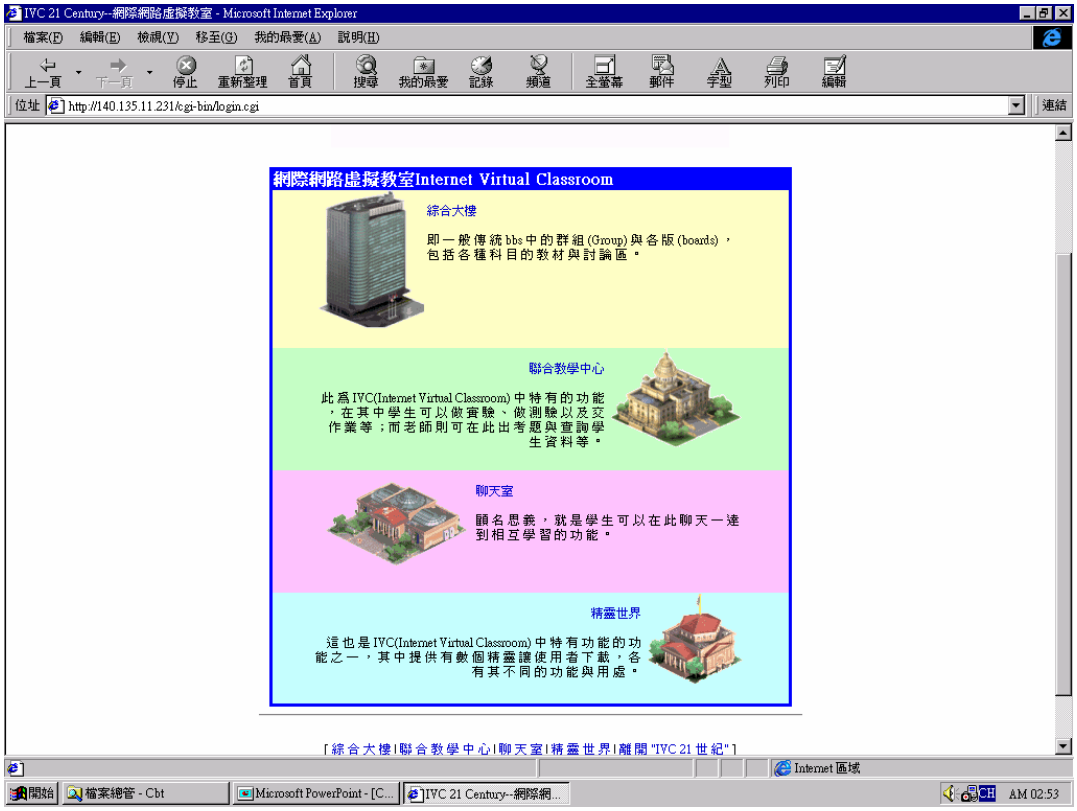

Figure 8. CBTVC login snapshot

The learning materials of CBTVC are developed from the ready-made CBT training materials. The learning unit "Waveform measurement by oscilloscope" in "Basic electronics" virtual classroom is selected as the demonstrative learning material in CBTVC. Since the Vocational Training Research and Development Center had produced this training material in videotape form, the corresponding WWW learning material is created from the videotape. The hypermedia organization chart of this WWW learning material is shown in Figure 9, and one homepage of this unit is shown in Figure 10.

Discussion Groups	Characteristics	Discussion Group	Application Level
Virtual administration	Related to real administration institutions	Vocation training bureau / centers	Virtual learning institution
Virtual classroom	Learn society to cooperatively study several learning units	Waveform measurement by oscilloscope, Basic electronics	Small group network
Virtual class	Learning society of learners of the same class (the same learning stage)	CBT class, Tai-Sun teacher training	Course network
BBS	Traditional BBS discussion group	Relaxation, Recreational, Literature, Sports	Individual learner
System maintenance	System maintenance and opinion collection	CBTVC	System management

Table 4. CBTVC discussion groups

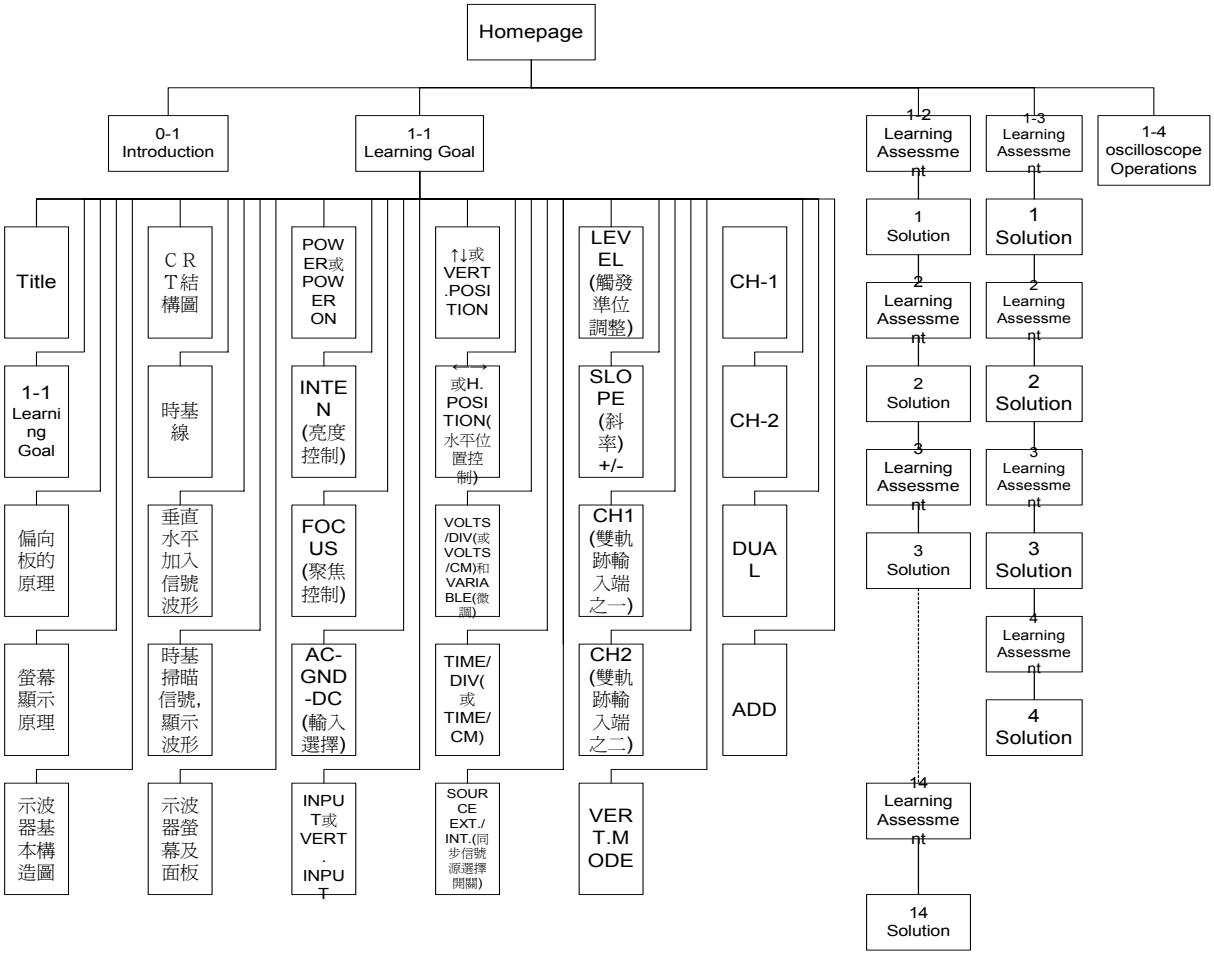

Figure 9. Chart of "Waveform measurement by oscilloscope" in CBTVC

In the CBTVC system architecture, CGI/ASP plug-in programs are used to implement all modules, including test, homework, practice and experiment. From the viewpoint of program design, these modules are collected in a Joint learning building. The corresponding snapshot is shown in Figure 11. In test module, teachers can edit test sheets in Test development center. These test sheets can be true-false or choice tests. Problems may be composed of pictures, audio, and other multimedia, as shown in Figure 12. Learners can take part in computer examinations in Test center. In Query center, test results can be consulted with teachers and students. However, students can only query their own test results but teachers can consult all students' scores through some test analyses.

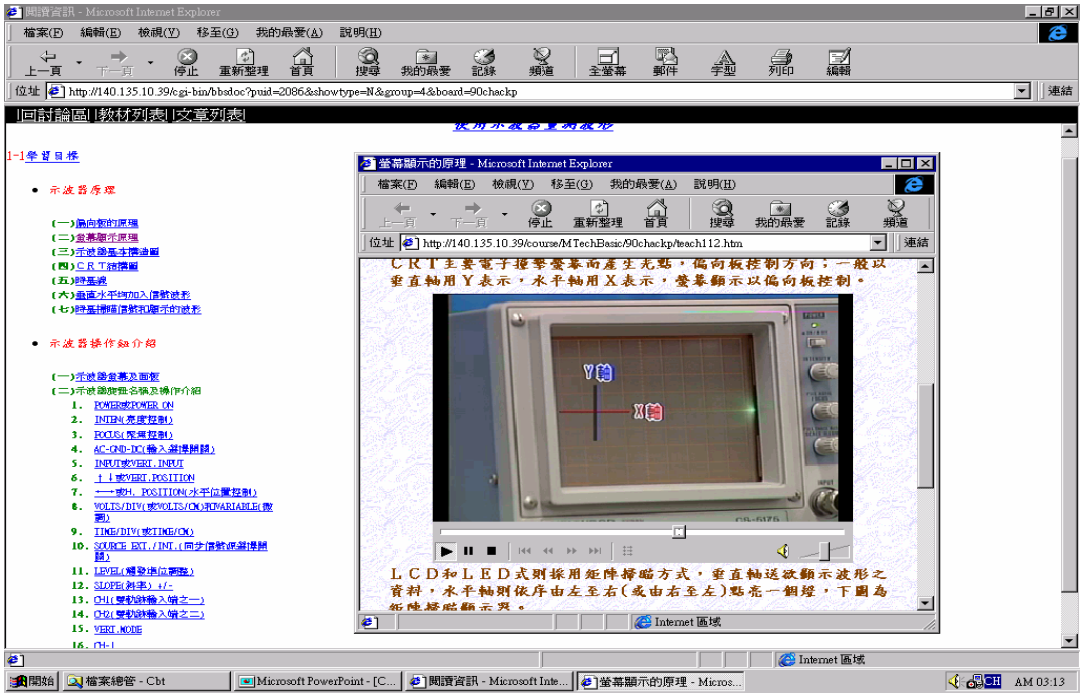

Figure 10. Demo homepage in learning material of CBTVC

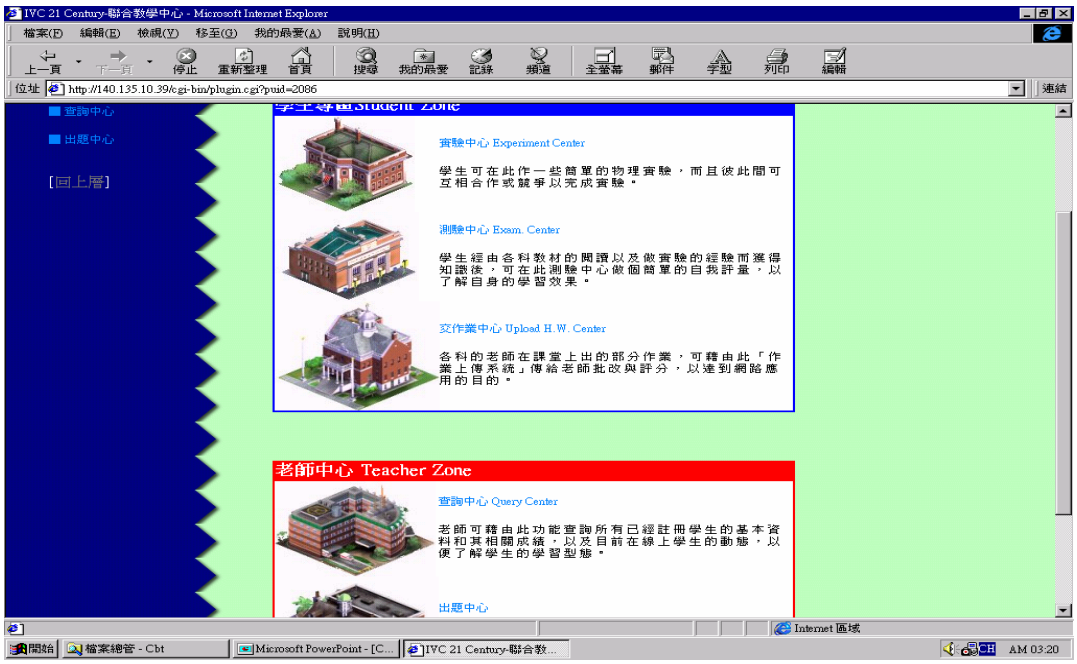

Figure 11. Joint learning building

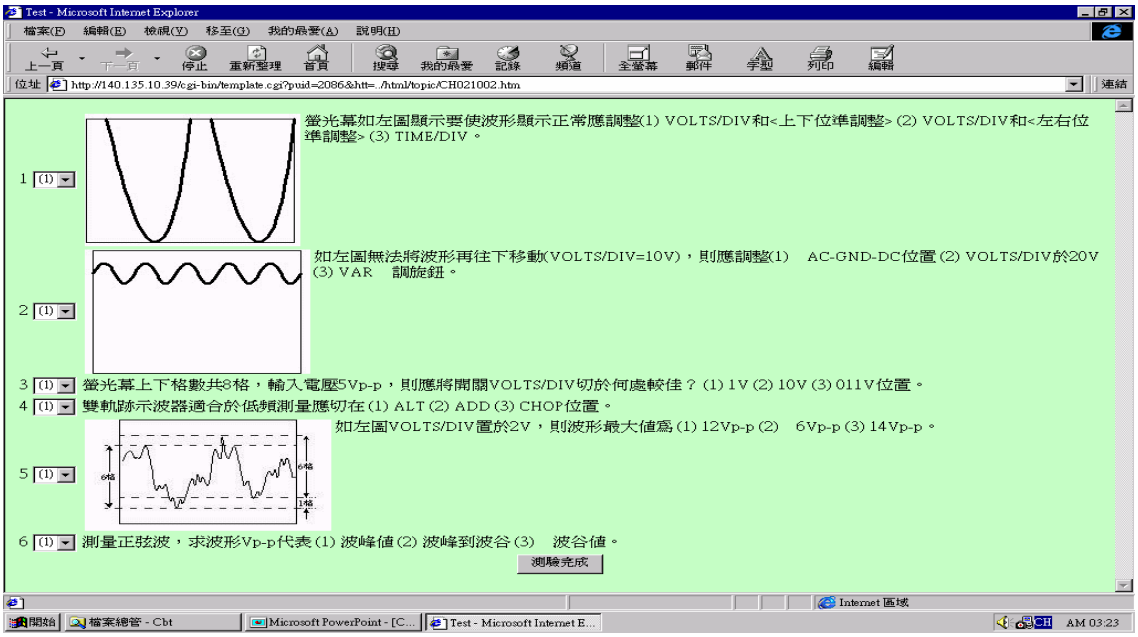

Figure 12. Multi-media problems in CBTVC test module

All the above modules try to simulate the assessments and discussion in the present classrooms and laboratories by network software. In such way, distance education only provides supports for traditional learning and will never surpass traditional learning. Therefore, the learning effect in distance education can never be better than those in classroom learning. On network, the only chance for distance education overwhelming traditional teaching is the analysis of learning model. When a learner is engaged in computer learning, computers will record all his or her interface actions. Theoretically, these learning actions can be modeled and analyzed in computers.

Following the learning flow model in Figure 7, CBTVC merges the log files of Web server with students' registration information. The resultant learning messages are shown as Table 5. Besides learners' identification numbers of login actions and log data, such messages also contain dates and times. Mapping these learning messages into the learning model in Figure 7, we can obtain a visualized learning path, shown as Figure 13. In Figure 13, we can observe not only the learning path of the learner (GS60770) but also his or her stay time in each homepage of CBTVC learning model. From Figure 13, we can know that the learner entered one learning group (which can be found from original data), chose one learning material he wanted to read. Afterwards, he or she maybe found out that this unit was not very interesting, so he or she browsed back and chose another one.

14/May/1999/14:44:31##GS60770##01#puid=721007068
14/May/1999:14:44:52##GS60770##02#
14/May/1999:14:45:02##GS60770##07#
14/May/1999:14:45:08##GS60770##08#
14/May/1999:14:45:10##GS60770##09#
14/May/1999:14:45:10##GS60770##12#
14/May/1999:14:45:11##GS60770##08#
14/May/1999:14:46:34##GS60770##08#
14/May/1999:14:46:41##GS60770##19#

Table 5. Learning messages recorded in CBTVC

The analysis in Figure 13 only applies the learning model of CBTVC to the learning messages. If such analysis is applied to hypermedia organization chart, we can obtain more information about learner in CBTVC network learning material. On the other hand, the learning path in Figure 13 only depicts the learning messages in the learning model. More in-depth result can be found out with more complete analysis tool. By and large, such portfolio analysis can offer distance education a more automatic, convenient, objective and practical way for assessment.

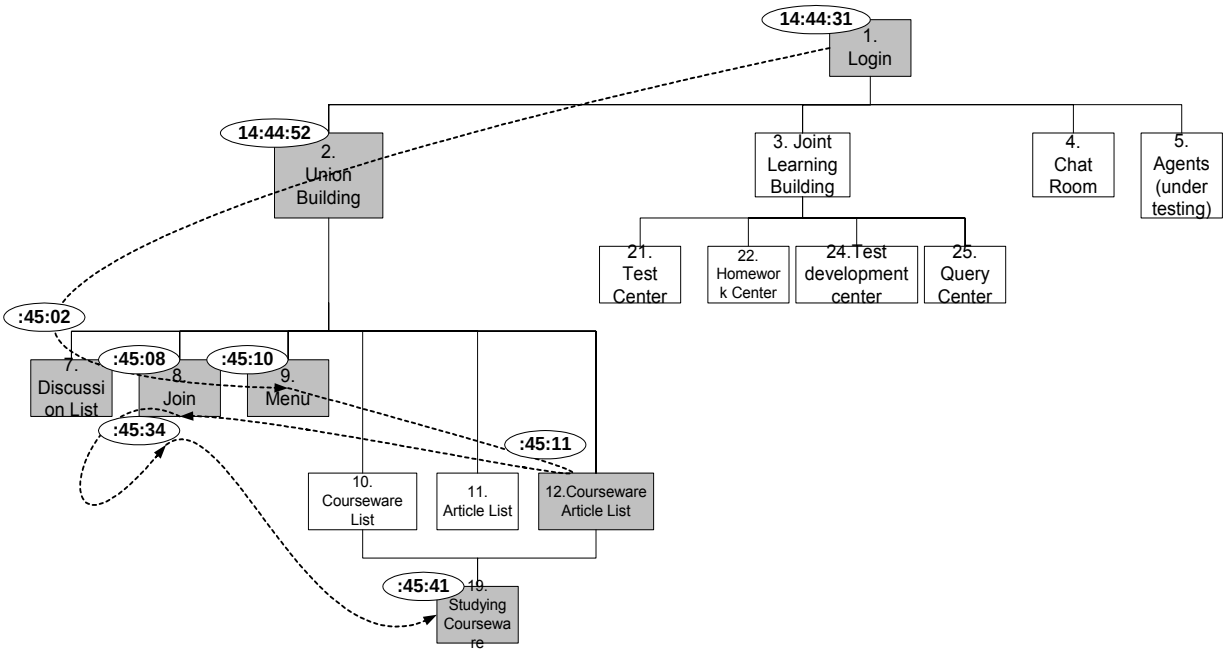

Figure 13. Visualize learning path of learning messages in CBTVC learning model

6. Conclusion

This paper builds up a WWW-based asynchronous distance education system, called Competency-Based Training Virtual Classroom (CBTVC), for vocational training. The investigation starts with the discussion of the characteristics of distance education and the model of asynchronous distance education, then the "Registration → Self-learning → Qualification" cycle combining with CBT (Competency-Based Training) self-learning training materials is proposed as an asynchronous learning model for distance education vocational training. Accordingly, we point out the problems of network learning material, and then discuss the learning processing in hypermedia organization chart and the self-assessment in network learning materials. The learning unit "Waveform measurement by oscilloscope" in "Basic electronics" virtual classroom is selected as the demonstrative learning material in CBTVC. Finally, there is a preliminary study for the learning portfolio in CBTVC learning model.

After finishing the above CBTVC system, we discover that there are many follow-up researches, including: (1) The development of a whole distance education CBT learning materials for a specific occupation. (2) The construction of several CBTVCs to set up a cross-platform vocational training net. (3) The standardization of distance education CBT learning materials. (4) The establishment of the assessment system of distance education CBT learning materials. (5) The assessment of learner in a distance education system. (6) The construction of learning processing analysis system combined with qualification system. Only these works are completed, a distance education vocational training system can be set up as a complete vocational training net.

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