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Research and development of web-based virtual online classroom

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Abstract

To build a web-based virtual learning environment depends on information technologies, concerns technology supporting learning methods and theories. A web-based virtual online classroom is designed and developed based on learning theories and streaming media technologies. And it is composed of two parts: instructional communicating environment (ICE) and collaborative learning environment (CLE). ICE provides learners with learning materials, lecture videos, and interactive environment etc. CLE supports active learning by providing the environment with learning tools, learning materials and contextual discussion for learners. The environments are designed with event-based synchronous strategies and e-learning technologies standards.

Different users have different ideas about the use of learning tools in the virtual classroom. According to the questionnaire, teachers are accustomed to communicating and teaching face to face. They hope they could be able to control the teaching and learning process and observe learners behaviors like in the traditional classroom. Learners love to use such tools as chat-room, BBS, etc., to control their learning pace.

Keywords: Virtual online classroom; Instructional communication environment; Collaborative learning environment; Streaming media; Synchronous strategies

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1. Introduction

The web-based learning environment has some advantages such as stretching the spatial and temporal barriers, flexibility, interactivity and interoperability (Curran, 2002; Huang & Hu, 2000; Khalifa & Lam, 2002; Kinshuk & Yang, 2003; Wheeler, 2000). Some organizations have developed their web-based learning environments to have lessons. The learning environments which have imitated the traditional learning environment are comprised of some kinds of web-based learning tools. At the same time, learning theories and technologies for designing web-based learning environment are widely studied.

Mohamed Khalifa (Khalifa & Lam, 2002) compared the efficiency of the learning process and results of distributed passive learning environment (DPL) and distributed interactive learning environment (DIL). The results show that the DIL is obviously superior to DPL. Web-based learning systems such as WebCT, TopClass and BlackBoard (Wheeler, 2000) are widely used in daily on-campus courses. The systems provide learners with lots of learning tools and materials. Stephen designed a virtual classroom by the integration of windows streaming media technologies (Huang & Hu, 2000). The classroom was used for teaching by live broadcasting lecture information. In our opinions, a virtual classroom not only delivers course materials to the learners, but also provides live, contextual and interactive environment for the learners. In addition, teachers can control the learning and teaching process as if they do in the traditional classroom.

Although web-based learning systems have a lot of advantages over traditional face-to-face learning, they have certain limitations that hinder the learning process. These limitations are as follows (Chou, 1999; Leidner & Jarvenpaa, 1995; Lim & Benbasat, 1997; Sloane, 1997; Weeler, 1998; Wulf, 2000):

(1) No human teacher expression and explanation. Most of existed learning materials are the combinations of text and graphic. The learners do not get human teacher expressions and oral explanations. Therefore, they could miss out the impact of teacher's gestures in their learning process.
(2) No synchronization and match between course materials and their explanations. Since there is no integration of course explanation with other learning resources, there is possibility of mismatch between the explanations provided in the web-based learning system and any other learning materials that learners might use.
(3) Lack of contextual understanding, just-in-time feedback and interactions. The greatest advantage of traditional face-to-face education is the personal interaction with learners, and the opportunity for both learners and teachers to take advantage of relative cues to make points and to verify that a point or a question has been understood. But the learners in online learning do not have contextual discussion or explanation for certain concept. This leads to the lack of contextual understanding.
(4) Lack of platform-independent standardized materials. Some web-based learning systems are built according to their requirements, they lack of standards' descriptions and reusability.

The web-based virtual online classroom (WVOC) are be developed against the above the problems by providing effective interactive tools and contextual learning scene. The WVOC includes

two parts: instructional communicating environment (ICE) and collaborative learning environment (CLE). ICE is used for teachers to control the learning and teaching process, and determine what knowledge should be presented and/or delivered to the learners. And CLE is developed for learners to actively learn.

The remainder of the paper is organized as follows. Section 2 addresses the key features of streaming media, learning technologies standards and learning theories for developing a virtual classroom. Section 3 outlines the architecture of a web-based virtual classroom, probes into the event-based synchronous strategies and the reusable and sharable ways of learning materials. Section 6 concentrates on the applications of a virtual classroom and effective analysis of learning tools. Finally, some results and future works are discussed.

2. Relative technologies and learning theories

What is the main principle of designing web-based virtual online classroom? It depends on learning theories and information technologies (IT). Some learning theories like objectivism, constructivism, etc., provide some good methods for constructing virtual learning environment. These theories show that interactivities and learning motivation play an important role in the teaching and learning process. Information technologies can promote educational innovation. Especially, streaming media technology, as one of the information technologies, is able to promote the delivery of learning materials, improve quality of service of learning contents. In addition, learning technology standards are very important for the learning resources reused and shared. Learning tools, learning content and contextual learning activities are the points to design virtual classroom.

2.1. Learning theories

Learning environment's efficiency is determined by learning methods supported. What makes the difference is not the technology itself, but rather, the learning methods enabled and supported by the technology (Khalifa & Lam, 2002). The main learning theories are objectivism and constructivism. Objectivism is a teacher-centered learning method whose goal is to represent and transfer objective realities from the teachers to the learners. An objectivist environment supports the passive learning methods, in which the learners are passive recipients of instruction, acquiring common understanding from teachers, rather creating their own knowledge. In contrast with objectivism, constructivism is learner-centered. In a constructivist environment, learners can control their learning paces. The role of teacher is to assist the learners in constructing their own knowledge.

Web-based virtual online classroom is designed to promote learners to explore information freely, allow learners to communicate with each other. ICE is mainly used to transfer learning materials and promote teachers and learners to interact instantly. To improve interactivity, ICE also provides some efficient tools like BBS, chat-room and so on. CLE encourages learners to explore and communicate freely. This environment provides for learners some other learning tools such as lecture video, chat-room, contextual discussing forums, frequently asked questions (FAQ), and so on.

Because learning materials include lots of videos and audios in web based virtual online classroom, the service quality of learning content is hard to be guaranteed. To play these files needs wide bandwidth, this is hard to be given by network. So, we use Windows Media Technologies.

2.2. Streaming media technologies

Streaming media technology uses "streaming" to deliver media content. Streaming means the client can render content while that content is being received over network without being downloaded first, which greatly reduces the waiting time and storage requirements of the client computer.

Windows Media Technologies consist of following three components: Windows Media Tools, Windows Media Services and Windows Media Player. The key features of Windows Media Technologies can be summarized as follows (Microsoft Corporation, 1999): (1) wide bandwidth range, (2) intelligent streaming, (3) multiple bitrate encoding, (4) built-in multicast service, (5) wide availability for end user, (6) script command embedding, and (7) on-demand or live presentation.

In WVOC, ICE provides some tools for authoring and transferring learning materials, the learning and teaching contextual information and lecture videos. The learning materials include some existed documents or files. The learning and teaching contextual information include learning status information, communicating information and feedbacks. Learning materials and lecture videos can be used as two ways: (1) live broadcast, (2) on-demand archival retrieval. In live broadcast, learners can view the lecture simultaneously. It is also possible to save the live broadcast content as courseware for content-on-demand. By using streaming media technologies, a live stream or a file can contain multiple audiences. Streaming media server can monitor and automatically adjust the bitrate of each client stream according to current bandwidth so that end users acquire the highest quality of learning content.

2.3. Learning technology standards

In order to facilitate the widespread adoption and deployment of learning materials, some organizations (e.g., ADL, IEEE LTSC, ARIADNE and IMS) have been developing technical standards to support the broad deployment of learning objects. Learning resources are integrated into reusable and sharable learning objects based on learning object metadata (LOM) standard and content packaging (CP) specification, described and bund by eXtensible Markup Language (XML).

Now, one of the most promising metadata schemas is the Learning Object Metadata schema developed by IEEE working group p1484.12. The LOM standard specifies a conceptual data schema that defines the structure of a metadata instance, which can adequately describe learning materials and make them available in searching, managing and reusing (Abruf, 2001). Content packaging information model describes data structures that are used to provide interoperability of internet based content with content creation tools, learning management systems, and run time environments. Its purpose is to collect and package learning contents in some electronic forms to enable them efficient aggregation, distribution, management, and deployment (IMS, 2001).

In WVOC, LOM and CP specifications are used to describe learning resources, learning and teaching scene. The teaching and learning process in ICE is synchronically recorded and

integrated into the courseware. These resources and contextual scene can be searched, managed, reused and shared. In addition, the recorded courseware can be used by learners to learn or review in the CLE. The courseware can be re-edited according to different requirements.

3. Design of WVOC

3.1. Characteristics of WVOC

With the development of computer and communication technologies, pedagogic strategies in the traditional classroom are stretched to the virtual learning environment. Some care needs to be given to the aspects of the virtual classroom that have led to its success as the most prolific learning environment. There are some basic features involved as follows:

(1) Encourage self-paced learning. Web-based learning is independent. On this ground, learning environment should provide customized, self-paced learning materials for the learners. Self-paced learning could overcome some learning obstacles, such as anxiety, low esteem, dependence, etc.
(2) Promote the interaction between teachers and learners, learners and learners, and maximize participation of the online learners in virtual classroom. Interaction can make the learners share their experience and construct their own knowledge.
(3) Help the contextual learning and discussion. In the learning activities, different learners with different cultural backgrounds have different understanding to the same knowledge. So, contextual discussions are very important.
(4) Provide live, spontaneous learning resources for learners.

3.2. Components of WVOC

As Fig. 1 shows, the physical architecture of the WVOC is composed of broadcast center, virtual classrooms and servers.

The broadcast center includes teaching information processing unit, environment information sampling unit and virtual classroom control unit. Teaching information processing unit broadcasts live lecture with media streaming technologies. Lecture programs sampled in classroom and other learning materials are synchronously recorded as standardized courseware. The courseware is stored in courseware-on-demand server. Environment information sampling unit is used to deliver teaching and learning scene. The synchronous courseware can provide remote learners with some learning resources and learning situation. Virtual classroom control unit is the controlling center. Teachers in the centre can control the learners learning processes.

A virtual classroom is made up of teaching information receiving unit and environment information sampling unit. Teaching information receiving unit can receive lecture videos and learning materials from the broadcast center. environment information sampling unit can sample, encode and deliver the learning situation in the virtual classroom to the broadcast center.

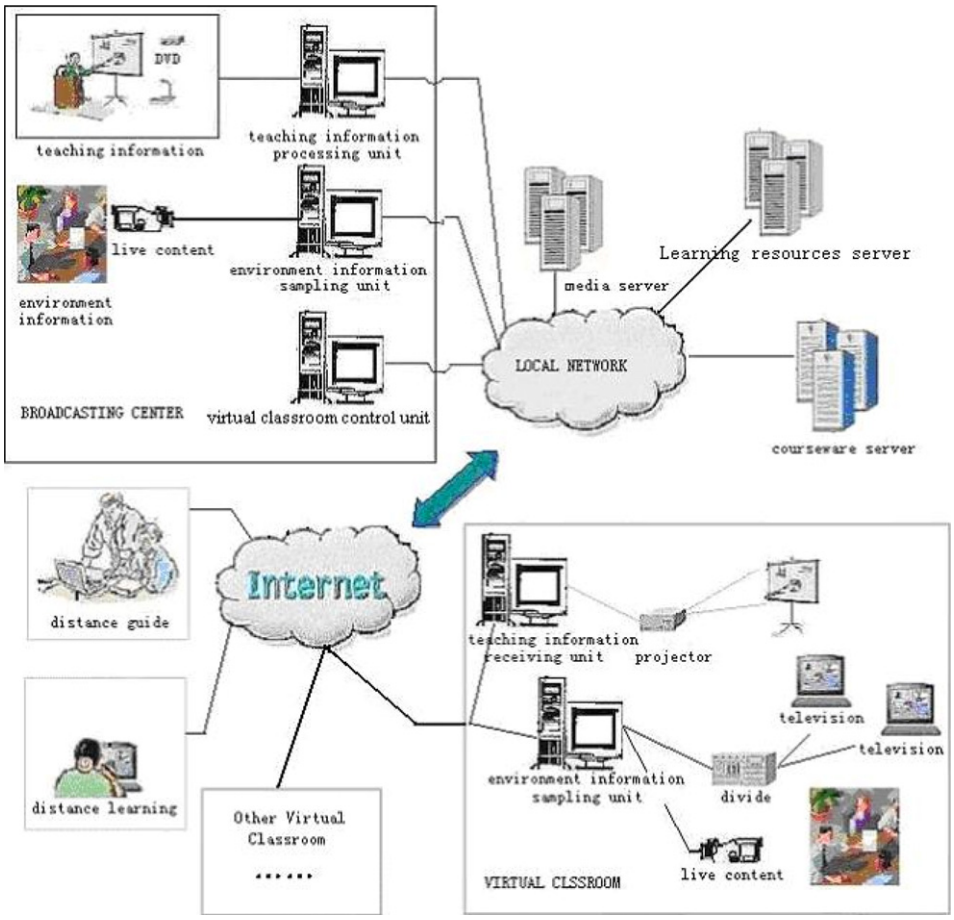

Fig. 1. WVOC is composed of broadcast center, virtual classrooms, and servers.

3.3. Architecture of WVOC

As Fig. 2 shows, web-based virtual online classroom involves broadcast workstation, courseware-on-demand server, streaming media server, learning resource server and clients. The framework of live broadcast center is client/server. Broadcast workstation is the core of live broadcast center. In the workstation, teachers can collect learning materials, sample lecture information and control learning and teaching process. Besides, the workstation has the following features:

- Choosing, setting, switching video sources.
- Inputting, previewing, delivering learning materials.
- Managing users rights.
- Controlling synchronous delivery and editing synchronous message.

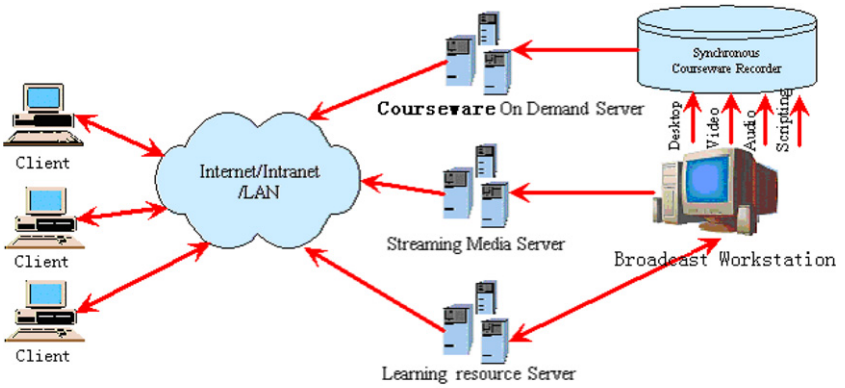

Fig. 2. Web-based virtual online classroom involves broadcast workstation, courseware-on-demand server, streaming media server, learning resource server and clients.

Live lecture programs can be broadcasted by media streaming server or stored in media streaming server. The synchronous learning materials are uploaded into learning resources server.

Client browsing tool is the interface for learners to join in virtual classroom. The web browsers that are making sophisticated virtual classrooms possible today, such as Netscape Navigator and Microsoft Internet Explorer, have also encouraged the development of literally dozens of third-party software plug-ins that provide additional multimedia capabilities to the browser. The browsing tool of WVOC is designed by using ActiveX components and event-driven strategies.

3.4. Synchronous strategies between lecture video and learning materials

Synchronization between video–audio and learning materials can effectively promote learners to understand the instructional information. A script command is an order pair of a unicode string associated with a designed time in audio/video streaming. When Windows Media Player catches a URL script command, the specified URL will be launched in the web browser. Script command event can be bund with data streaming with editing tools. Fig. 3 shows an example of event-based synchronization. ''Mainvideo'' substitutes for video file ID, ''time duration'' is the begin time and the duration time, ''href'' stands for the link source, and so on. Script commands are embedded in the lecture video. When a lecture video is played, a specified web page or an electronic whiteboard data will be automatically downloaded and displayed.

3.5. Standardized description of courseware

In order to reuse and share the video-driven courseware, LOM and CP specifications are used for describing and packaging learning resources. Fig. 4 shows XML binding of a courseware. The tag ''time'' is the trigger point of a driven learning material, ''videourl'' is the driving lecture video, ''timeblockid'' is the knowledge point ID, and so on.

```
<?xml version="1.0" encoding="gb2312" ?>
- <events>
 + <mainvideo ID="632187510298593750">
 - <mainvideo ID="632187510298593750">
   - <windows windowsID="V1H0">
     - <event>
         <time Duration="00:00:09.6">00:00:08.2</time>
       - <content type="Page/Ppt" resourceID="6321875106864062505"
           href="200442812117609\ppt.files\slide0066.htm">
           <title>Java的特点</title>
         </content>
       </event>
     </windows>
       ......
   </mainvideo>
 + <extraresource>
 </events>
```

Fig. 3. Example of script command for event-based synchronization.

```
<?xml version="1.0" encoding="gb2312" ?>
- <manifest>
  - <metadata>
      <schema>CELTS Content Package</schema>
      <schemaversion>1.6</schemaversion>
    + <lom>
    </metadata>
  - <organizations>
    - <organization identifier="TOC1">
        <title>default</title>
      - <item identifier="item0" identifierref="">
          <title>newcourse</title>
        + <item identifier="6321875106859375003" isvisible="1" identifierref="200442812117609
            \ppt.files\slide0064.htm" time="00:00:13.3" timeblockid="2"
            videourl="632187510298593750_out_1.asf">
            ......
        </item>
      </organization>
    </organizations>
  + <resources>
  </manifest>
```

Fig. 4. Courseware involves lecture videos and learning materials described by CP and LOM specifications.

4. Applications of WVOC

4.1. Instructional communication environment

Web-based virtual online classroom has been applied in school of network education in central china normal university. It provides a good learning platform for remote learners and learners in campus. As Fig. 5 shows, figure (A) is live broadcast center, (B) is the client. In live broadcast centre, there are two sets of video sampling equipments. One is for capturing teaching information; the other is for sampling learning scene. Teaching and learning process is scheduled as follows:

Firstly, a teacher uploads learning materials to the learning resources server, sets up the system parameters. Then, the teacher looks through learning materials and arranges their sequence. In

(A) A teacher has a lecture in live broadcast center.

(B) A remote learner looks through the learning content

Fig. 5. Web-based virtual online classroom has been applied in Central China Normal University. (A) A teacher has a lecture in live broadcast center. (B) A remote learner looks through the learning content.

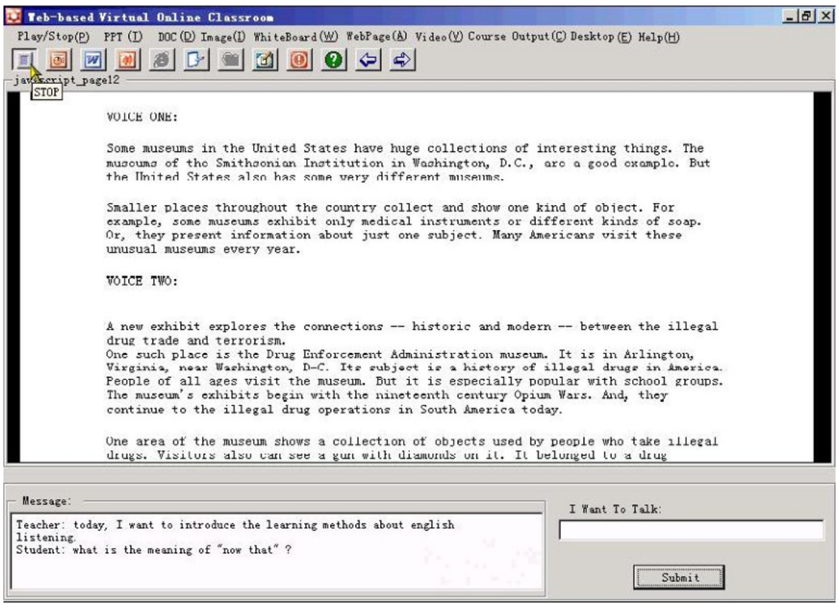

Fig. 6. The teacher shows and explains learning materials in broadcast workstation.

Fig. 6, the teacher shows and explains learning materials in the teaching process. At the same time, he receives feedbacks from learners and answers some questions.

A learner looks through and studies learning materials from live broadcast center. He can also apply for the right to ask questions by the electronic hand. As Fig. 7 shows, while the teacher agrees to discuss, he switches the video source to broadcast the interactive scene.

In order to overcome the limitations of bandwidth, we set up multiple bitrate encoding format such as 56, 100, 300, etc., for transferring video according to such networks equipments as modem, asymmetric digital subscriber line (ADSL) or network card. The video files or streaming

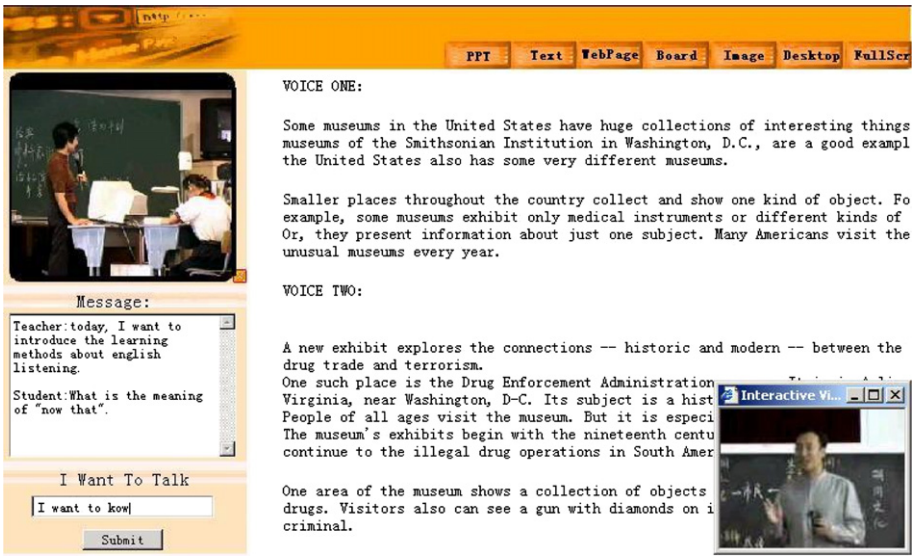

Fig. 7. Remote learners discuss the questions with the teacher and interactive scene is broadcasted.

are compressed with MPEG 4. The other learning resources are stored in learning resources server. The information in electronic whiteboard are recorded as text and transferred. The clients receive the recorded information and redisplay the drawing. By these means, quality of services of learning content is guaranteed. These methods make content-based interactive learning become possible.

4.2. Collaborative learning environment

(1) *Content-based interactive learning.* As the Fig. 8 shows, the upper left is displaying video area, the below left is knowledge-based navigated bar, the upper right is displaying content area, and the bellow right displays relative interactive information. When the video documents are played, learning materials are synchronously showed in displaying content area. When the navigator bar is chosen, the video is controlled to go forward and backward. At the same time, the relative synchronous learning materials are displayed.

(2) *Combination of courseware and learning environment.* As Fig. 9 shows, we design a collaborative learning environment about "Advancing Learning Course" by using the recorded courseware and learning tools such as email, discussing forum, and frequently asked questions. In this environment, remote learners can benefit from the class at a later time by accessing stored courseware. The remote learners are also able to go over all materials or randomly select interesting topics from a given list of topics covered in the class. The learner looks through teaching and learning videos at first. Then he answers questions. If he needs help, he can click the link of courseware to display the relative content. In addition, he can discuss some questions with teachers or other learners by chat-room.

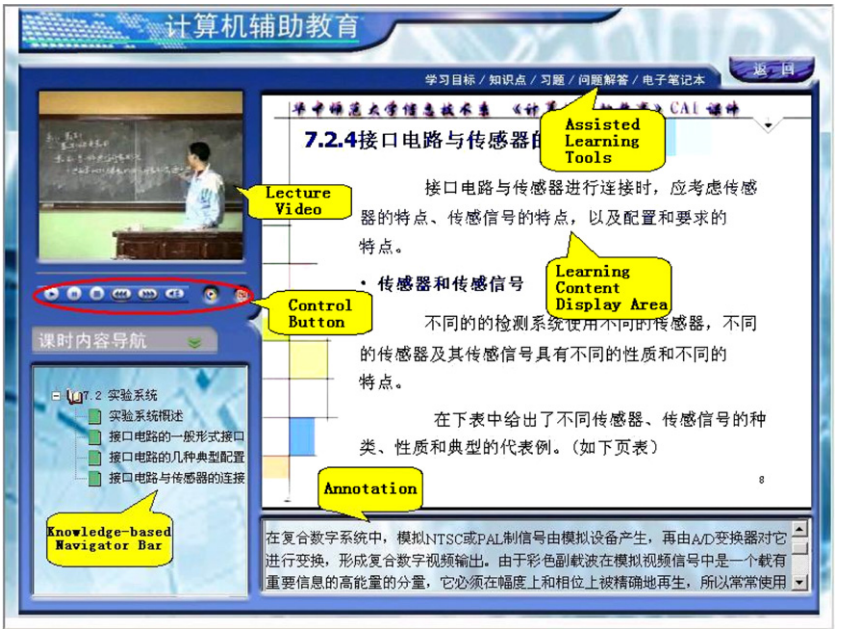

Fig. 8. Content-based interactive learning courseware includes four parts: lecture video, content display area, navigator bar and relative information area.

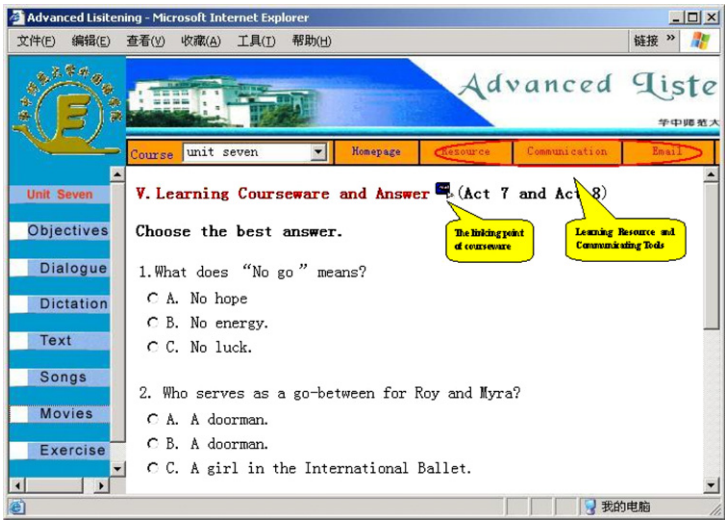

Fig. 9. A collaborating environment is designed with the live stored courseware in WVOC and relative learning tools.

He also can watch the discussed information or discuss with teacher or other learners in person by email or review relative information in learning resources server with searching tools.

5. Evaluation of WVOC

WVOC is designed according to learning methods and strategies. It is used in teaching the common course or facilitating active learning. To verify the efficiency of the system, a formative evaluation of the system was conducted. Fifty learners and five teachers had investigated in the questionnaire. The questionnaire includes six aspects by comparing ICE to CLE as follows: (1) frequency of use, (2) provided appropriate level of interactivity, (3) efficiency of supporting learning methods, (4) convenience in use, (5) usefulness for active learning, (6) helpfulness to teach.

As Table 1 shows, most of learners think that content-on-demand is very useful tool in CLE. They also admit that FAQ, chat-room and contextual discussing forum are essential and effective tools, which can help them to learn well. However, learners are not accustomed to discuss questions by email. They hope they could acquire just-in-time feedback. They do not think that live broadcast center is able to promote appropriate level of interactivity in ICE. They need more flexible, audio–visual communication tools.

According to Table 2, most of teachers agree that live broadcast center is one of the most available tools in the virtual classroom. Through live broadcast center, they can effectively control the

Table 1
Learners evaluation results

	ICE			CLE			
	Broadcasting center	Chat room	Electronic whiteboard	Email group	Content on-demand	FAQ	Discussion forums
Using frequency	1.43	4.23	3.22	2.12	3.67	3.32	3.12
Interactivity	1.01	4.12	3.11	1.50	1.42	1.65	2.13
Effectiveness	3.42	3.21	2.76	2.12	4.11	4.21	3.87
Enjoyable to use	2.22	4.54	3.21	1.89	4.05	3.95	3.42
Active learning	1.54	3.66	3.22	1.98	4.23	3.76	3.82
Helpful to teach	3.78	2.13	2.22	1.87	4.32	3.56	3.75
Average value	2.23	3.65	2.96	1.91	3.63	3.41	3.35
Scale:	strongly disagree 1 2 3 4 5 strongly agree						

Table 2
Teacher evaluation results

	ICE			CE			
	Broadcasting center	Chat room	Electronic whiteboard	Email group	Content on-demand	FAQ	Discussion forum
Using frequency	4.32	2.1	2.52	4.23	2.23	3.67	3.54
Interactivity	2.31	3.12	3.42	2.57	2.11	2.94	2.79
Effectiveness	4.56	2.31	3.21	3.42	4.12	4.21	4.52
Enjoyable to use	4.76	2.12	2.98	4.22	3.13	4.28	4.34
Active learning	2.43	2.65	3.22	3.20	4.23	3.78	3.91
Helpful to teach	4.53	1.99	3.13	3.65	4.23	4.06	3.85
Average value	3.82	2.38	3.08	3.55	3.34	3.82	3.82
Scale:	strongly disagree 1 2 3 4 5 strongly agree						

teaching and learning process in the virtual classroom just as in the traditional classroom. They do not like the complex operating ways of live broadcast center, because it is difficult for them to operate the system. However, they think content-on-demand, FAQ and contextual discussing forums are helpful to learners.

Most of learners and teachers also think FAQ and discussing forum can help learners relax themselves, reduce their anxieties and increase their self-confidence. The questionnaire shows that most of learners and teachers do not feel adaptable when they use the virtual classroom as their mainly educational tool. Because they do not think this kind of learning methods can substitute completely for the face to face communication and discussion.

Learners and teachers think that they have mastered some new learning skills through using in the WVOC. The skills include how to discuss in chat room, how to operate the whiteboard and how to discuss questions in discussing forum, and so on.

According to the questionnaire, most of learners and teachers believe that ICE can effectively support learners to learn, that CLE can effectively promote learners to learn actively.

6. Conclusion and future works

WVOC is designed as the objectivist and constructivist learning platform with event-based synchronous mechanism, standardized describing technologies and some interactive ways. ICE is mainly designed for live broadcast of lecture and CLE is designed for active learning.

Different users have different ideas about the learning environment in a virtual learning space. According to the investigations, teachers are accustomed to control the learning and teaching process and implement face-to-face activities, remote learners hope they could get more widely learning space and hold their learning pace. In addition, they admit the contextual learning and discussion are very important for active learning.

The design and applications of WVOC has achieved the anticipated objectives, and WVOC has some additional advantages over the face to face education, but a number of functions need to be improved. Firstly, the system is built based on windows streaming media technologies, which makes the system less platform independent. Secondly, the system supports the limited formats for learning materials, and learning materials must be created in advance. In addition, the system should support more learning modes, such as ''whiteboard plus e-note'', ''learning topic plus discussing forum'' and so on. Lastly, in the contextual discussion and learning environment, ''search'', ''index'' and ''publish'' functions can be added, which may let learners acquire related learning resources and information from other learning forums.

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