Virtual Mentor and The LBA System  
— Towards Building An Interactive, Personalized, and Intelligent E-Learning Environment

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ABSTRACT

Internet has been universally recognized as a medium for network-enabled transfer of information and knowledge in various areas. E-Learning technology, which delivers educational material electronically via the Internet, has been widely used in both academic education and corporative training. However, existing e-Learning systems have various limitations, such as presenting multimedia instructional content in static, passive, and unstructured manners and giving learners insufficient control over learning content and process. As a result, higher effectiveness and greater societal potential of e-Learning are hindered. In this paper, based on the constructivist learning theory, we propose a new concept called Virtual Mentor (VM) that refers to a multimedia-integrated e-Learning environment that emphasizes interactivity, personalization, and intelligence. A prototype VM system that integrates state-of-the-art information technologies will be introduced. Results from preliminary studies have demonstrated that learning through a Virtual Mentor environment can be as effective as, or even more effective than, traditional classroom learning. Our research gears towards developing more appealing and effective e-Learning technology.

KEYWORDS:

Virtual Mentor, E-Learning, Multimedia-Integrated, Interaction, Personalization
1. INTRODUCTION

The current knowledge-based economy requires new methods of delivering education and training, partly to enhance traditional methods of knowledge acquisition and to convey new skills and tools [1]. The traditional context of learning is experiencing a radical change. There are many situations in which people want to learn exactly what they are interested without time and location constraints. These kinds of needs require learning to be personalized, flexible, and available on-demand. The concept of traditional classroom education does not always fit comfortably into the new world of lifelong learning where the roles of instructors, students, and curriculum are changing.

With the increasing use of networked computers and remarkable advances in telecommunication technologies, the Internet has been widely recognized as a valuable and inexpensive medium for network-enabled transfer of skills, information, and knowledge. There are many different definitions of e-Learning. In this paper, the term “e-Learning” refers to learning in a Web-based virtual learning environment [36], where electronic instructional material is delivered to remote learners over the Internet. It provides a configurable infrastructure that integrates learning material, tools, and services into a single solution in order to quickly, effectively, and economically create and deliver training or educational content [2].

Although a considerably large number of e-Learning systems have been developed in the past few years, many of them have various limitations that may hinder the improvement of e-Learning effectiveness. For example, some systems present text-based instructional material only, which may seem boring to online learners, or lack adequate instructional content. Although recent e-Learning systems have adopted multimedia technology, research issues about how to effectively present multimedia learning content and how to increase learner engagement have not
been fully investigated. Some e-Learning systems do not provide sufficient interactivity. Learners have little flexibility to adapt learning content and process to meet their individual needs. Consequently, it is difficult to get learners focused and increase their engagement.

In this paper, we propose a new concept called Virtual Mentor (VM), which is defined as an interactive and intelligent e-Learning environment that presents well structured and integrated multimedia instructions while emphasizing relevance, interactivity, and personalization. We have developed a prototype VM system called LBA (Learning By Asking). The rest of the paper is organized as follows. Section 2 briefly reviews e-Learning research and existing systems. Then, the Virtual Mentor concept will be proposed in Section 3. Section 4 introduces the LBA system. Section 5 describes preliminary system evaluation. Section 6 discusses the findings and other important issues. Finally, we conclude in Section 7.

2. E-LEARNING RESEARCH AND SYSTEMS

E-Learning can be either synchronous or asynchronous. Synchronous e-Learning requires simultaneous participation of all learners and instructors at distributed locations. It refers to any learning event delivered to remote learners in real-time and includes immediate, two-way communication between participants. Therefore, synchronous e-Learning is scheduled delivery of learning. Asynchronous e-Learning does not require simultaneous participation of learners and instructors. It refers to any learning event that does not take place in real-time [28]. Therefore, asynchronous e-Learning is “on-demand” delivery of learning, which gives learners more control over learning time, process, and content. The majority of current e-Learning systems provide asynchronous learning environments, since they are simpler to develop and are less expensive
than synchronous e-Learning systems. In addition, synchronous e-Learning loses time flexibility.

Extensive research has shown that in contrast to traditional classroom learning, e-Learning has several advantages for learners [12, 24, 36]: first, e-Learning provides time and location flexibility. People can learn via the Internet at any time, any place. Second, in the long run, e-Learning results in cost and time savings for companies and educational institutions. Third, it fosters self-directed and self-paced learning by enabling learner-centered activities. Fourth, e-Learning offers a collaborative learning environment by linking each learner with physically dispersed experts and peers. Fifth, it allows unlimited access to electronic learning material. In addition, electronic learning material is not susceptible to environmental damage from dirt, heat, magnetism, etc, and can be updated in a timely and efficient fashion.

Many studies have reported that e-Learning is at least as effective as traditional classroom learning, measured by exam grades and learner satisfaction [5, 12, 19-21, 41]. While most literature emphasizes the benefits of e-Learning, some researchers have also pointed out its drawbacks such as frustration, confusion, and reduced interest in subject matters [23, 32].

Early e-Learning systems used text-based instructions only, which could make learners bored and disengaged during online learning [41]. With latest advances of multimedia technology, a number of multimedia-integrated learning systems have been developed [34]. Simply defined, the term “multimedia” refers to a computer-based presentation that delivers information by integrating two or more media. Multimedia content, transmitted over ever-increasing network bandwidth, has a dramatic impact on both processes and products of learning. It provides a multi-sensory learning environment that can help maximize learners’ ability to
retain information [40], and entice learners to pay more attention to a task through vivid and rich presentations that are more intriguing and fascinating [3].

There are a few limitations of current multimedia-based e-Learning systems. First, some are not sufficiently interactive. For example, it is difficult and time-consuming for a learner to locate a piece of information in a 3-hour instructional video or to skip a portion that is already known. Consequently, e-Learning is less likely to hold learners and get them effectively engaged in learning [22]. In CISCO E-Learning (www.cisco.com/warp/public/10/wwtraining/elearning), for example, a video of a lecturer is synchronized with his/her PowerPoint slides. It gives people a perception of listening to an online lecture in real-time. The major limitation of this system, however, is that it provides limited interactivity and flexibility. Learners take a passive role during an online lecture. If they want to re-listen to any previous section, they have to stop the video and re-start it from the very beginning of that lecture. In addition, it is difficult to skip a portion of a presentation, inevitably resulting in a linear learning process.

Second, under many circumstances, a learner may prefer to ask an e-Learning system a question directly and get an answer right away instead of having to either navigate knowledge repositories or sequentially go through multimedia content in order to find the answer. So far, most e-Learning systems do not provide this capability. Third, some systems simply post learning material on the Internet without any processing. Postings are usually static and unstructured, without any indication of close associations among relevant material in different media. For example, instructional videos and PowerPoint slides of same lectures are presented separately. E-learners may even have to go to different Web sites to view them individually.

In order to address those problems, we propose a new concept called “Virtual Mentor (VM)”. We have developed a prototype VM system called LBA (Learning By Asking), aiming
to engineer an effective method to integrate and present multimedia instructions in an interactive online learning environment.

3. THE CONCEPT OF VIRTUAL MENTOR

The concept of Virtual Mentor (VM) is influenced by our belief in the notion of constructivist learning theory that describes how learning takes place. Constructivists view learning as a formation of abstract concepts to represent reality. They believe that learning occurs when learners construct their own unique versions of knowledge based on their own background, experiences, aptitudes brought to bear on the learning task [29]. Constructivism satisfies the needs of addressing motivational problems through interactive activities in which a learner must play an active role rather than a passive one. Individuals are assumed to learn better when they are forced to discover things themselves and when they control the pace of learning. Learning is an active process and should be conducted in a self-directed fashion. Many educators have adopted constructivist learning theory in developing technology-aided learning environments. E-Learning provides many opportunities for constructivist learning by providing and supporting resource-rich, student-centered settings and by enabling interactive learning to be related to context. If learners are empowered to determine what to construct or create, they are more likely to be engaged in learning activities [39]. In addition, a high level of interactivity of an e-Learning system can enhance learner engagement.

We define the concept of “Virtual Mentor” as a multimedia-based e-Learning environment that presents well-structured and synchronized multimedia instructions in an interactive and personalized manner. This environment, as a whole, serves as an online virtual instructor. The concept of VM consists of following principles: A VM is multimedia-integrated. It captures
experts’ knowledge/wisdom in videos or lectures, and presents them to learners together with other associated material in different media; A VM enables real-time knowledge acquisition. It enables learners to access knowledge at any time via the Internet. A VM is interactive. Learning is a knowledge acquisition process through continuous interaction between online learners and a VM. Learners are able to ask a VM questions directly and get answers from it in real-time. A VM is self-directed. Self-directivity in a VM describes a learner-centered process in which a learner takes initiative and responsibility to determine his/her learning needs and choose personal learning strategies. A VM is flexible. It provides learners with flexible control over learning process, style, and content. Learners can randomly access multimedia learning material, or skip a portion of content they already know or are not interested in. In other words, they are capable of accessing knowledge in a non-linear and flexible fashion. A VM has intelligence. It is able to keep track of individuals’ learning progress and provide personalized tutoring.

There are two primary capabilities in a Virtual Mentor environment. One is learning by asking questions. People can learn from asking questions and getting answers. Imagine there is a substantial Web knowledge repository containing instructional videos and other multimedia material on many topics. It would be a daunting task for a learner to navigate all material in the repository in order to locate a piece of knowledge. A VM allows learners to ask questions directly and get relevant instructions immediately. The other capability is learning through a multimedia interactive e-Classroom. The e-Classroom in a VM attempts to create a rich online learning environment that presents well structured and synchronized multimedia content in an interactive way. Learners can watch an online lecture at their own pace and with individual emphasis.
4. LBA — A PROTOTYPE VM SYSTEM

4.1 What is LBA?

We have developed the LBA (Learning By Asking) system, a prototype VM environment based on the above principles. It is an asynchronous e-Learning system. The basic idea of the overall LBA system is described as follows.

First of all, we videotape domain experts during their lectures or interviews that may take a couple of hours. The content of a video is likely to consist of a number of sub-topics in the domain of interest. We logically segment those digital videos into individual clips based on their content so that each clip only focuses on a specific topic. Although there has been extensive research effort on video segmentation in the past decade, content-based video segmentation still requires human assistance. A variety of segmentation schemes have been developed, including rule-based methods, machine learning techniques, or topic detection and tracking (TDT) methods [8, 17, 27]. Most existing algorithms focus on segmenting TV broadcast news and movies, which usually have frequent scene changes and interruptions for commercials that are commonly used as important clues for automatic segmentation. However, those algorithms cannot be applied to segmenting most instructional videos that normally have only one speaker and few scene changes. Since video segmentation is not the focus of this project, in this research, we performed manual logical segmentation by simply identifying time boundaries of each clip in a video. All video clips are compressed and stored on a video-streaming server and are accessible via the Internet. Automatic segmentation of instructional videos is a real research challenge. One possible approach is to utilize text-clustering techniques on transcriptions derived from audio information of a video, then to synchronize segmented texts with the video content.
In addition, we have created a knowledge repository on a Web server. It contains metadata of video clips, including titles, file sizes, names of speakers, keywords, starting/ending time, and content templates, as well as other associated multimedia material such as PowerPoint slides and lecture notes. Content templates, including keywords and their weights, and sentence frames of each clip, are automatically generated using information retrieval and information extraction techniques [44]. Once the Web server and video streaming server are installed, remote learners are able to access learning material from local computers to acquire knowledge at any time.

As a prototype VM environment, the LBA system consists of two major sub-systems: Asking a Question & Interactive E-Classroom. The ‘Asking A Question’ sub-system allows learners to ask questions of their interests in natural language. The system then retrieves relevant video clips and associated material, and returns them to learners immediately. It creates a real-time, virtual question-answering conversation between learners and LBA. An embedded intelligent learning assistant provides personalized learning guidance. The “Interactive E-Classroom” is an online classroom in which learners can see the image of an instructor, listen to what s/he says, and read presentation slides and lecture notes simultaneously. Multimedia instructions are structured and synchronized based on content. The “Interactive E-Classroom” aims to provide learners with flexible learning control via rich learner-content interactivity. To facilitate interaction and collaboration among learners themselves or between learners and instructors, an online discussion forum is incorporated into the LBA system.

4.2 Two Sub-systems in LBA

4.2.1 “Asking a Question”
How many of us, when we buy a new television, ever read the instruction brochure? How many of us ever bother to read the instruction manual for our computers? In fact, most of us skim the documentations and get started right away. While encountering a specific problem, we hope we can obtain appropriate instructions immediately without having to browse the documentation for answers. This is the motivation behind the “Asking A Question” sub-system.

In this sub-system, the learner is able to ask LBA a question of interest. There are two ways to express a question — using either a Boolean keyword query or a question in conversational English. The question is sent to the Web server, where the primary information processing and content retrieval will take place. After question analysis, the system searches the video metadata library for the best match. In other words, video clips whose content is likely to answer the question will be identified and ranked based on their relevance.

Since we are dealing with interview or lecture videos without frequent scene changes, traditional video indexing and retrieval schemes based on visual or audio features are not suitable to those instructional videos. In the “Asking A Question” sub-system, the content retrieval is performed utilizing relevant texts such as lecture notes or transcriptions of sound track of videos. Users can also choose to ask questions in natural language, which have two primary advantages over keyword queries: 1) natural language queries are more expressive than keywords, so users find it easier to specify their information needs, and 2) they provide more context for terms than keyword queries, which reduces vagueness of users’ interest. A number of information retrieval systems as AskJeeves (http://askjeeves.com/), Synthetic Interviews [33], FAQ Finder [13], and the START system (http://www.ai.mit.edu/projects/infolab/) are able to accept and analyze natural language queries. In LBA, we have developed a novel two-phase natural language approach to content-based video retrieval for natural language queries. It integrates natural
language processing (NLP) technology, named entity (NE) extraction, frame-based video indexing scheme, and information retrieval (IR) techniques [37]. The general procedure of this new approach involves 1) Natural language question parsing and formalization: after a learner submits a question in conversational English through the Web interface, LBA analyzes it and automatically generates a question template containing both syntactic and semantic information extracted from the question; 2) Content-based video indexing: in LBA, the textual description of video content is obtained either from a transcription of the soundtrack of a video or from lecturers’ scripts or lecture notes made during course preparation. A keyword indexing table and a sentence template table are then created automatically as video indexes; 3) A two-phase matching and ranking approach to retrieving relevant clip(s) whose content(s) may answer the question. The details of this approach are available in [44]. It is different from other question-answering based information retrieval systems like Ask Jeeves, since those systems typically use a pre-defined question template to identify user’s question type, then ask the user to further confirm his interest from a list of possible questions provided by systems.

Finally, the links to selected candidate clips, as well as other related material such as presentation slides and lecture notes, will be delivered to the learner’s computer, where s/he can play any of those returned clips immediately by clicking the corresponding link. In the meanwhile, some follow-up suggestions dynamically generated based on his/her learning history will also be provided (see the ‘Learning Assistant Module’ section). At any time, the learner can choose either to replay a clip as many times as they want or to ask new questions and repeat the above process. The procedure of this sub-system is shown in Figures 1.
4.2.2 Interactive E-Classroom

Lectures can convey core course material in a more easily digestible form than textbooks. They offer a framework that outlines the scope of material and lubricates the learning process. Students overwhelmingly demand the retention of live lectures [7].
In a traditional classroom lecture, students can simultaneously see an instructor, watch PowerPoint slides or transparencies, and hear what the instructor explains. There is a need for an online classroom to have a similar level of synchronization of various online content [31]. Therefore, we intend to create an “Interactive e-Classroom” in LBA that simulates the traditional classroom environment to which people have got used. It enables learners to watch an online lecture presented via synchronized video and audio of instructors, PowerPoint slides, and instructors’ lecture notes on a single Web interface (Figure 2). While playing an instructional video, the “Interactive e-Classroom” is always able to automatically display corresponding slides and lecture notes about the topic that the instructor is introducing in the video. Although currently content synchronization is implemented at a slide level, it can be created at different granularity levels.

Figure 2. The Interface of the “Interactive E-Classroom” in LBA
If a learner does not intervene during an online lecture, the whole lecture will automatically “flow” from the beginning to the end, slide by slide. However, various operations to control learning pace and content can be performed at any time by pressing control buttons located at the top of that interface. For example, a learner can click the ‘Next’ button to skip the current video clip/slide/note if it is already understood, or press the ‘Prev’ button to go back to review the previous clip. When a learner moves the mouse over the ‘Content’ button, a pull-down menu will display a content index of the current lecture. S/he can directly jump to a particular clip/slide/note portion by clicking any sub-topic in the index. These buttons are designed to provide rich interactivity and flexibility to learners. The LBA system obtains appropriate time boundaries of clips from the database and dynamically generates a .smil (synchronized multimedia integration language) file that is used by the video streaming server to gain access to the clip. Furthermore, at any time, learners can enlarge any of those three content windows to a full-screen display based on their personal needs.

4.3 Learning Assistant Module (LAM)

Web-based distance education gives remote students the same chance of learning as local students. Students who take part in distance education differ greatly in their goals, professional background, interests and knowledge of subject matters. It has been well recognized, therefore, that one of the primary disadvantages of traditional distance learning via the Internet is the lack of capability of tailoring learning material to meet individual needs [10]. Some artificial intelligence technologies, such as Intelligent Tutoring Systems (ITS) and Adaptive Hypermedia Systems (AHS), provide useful methods for adaptive education without real instructors [10, 11, 14, 26].
Enlightened by intelligent tutoring research, in the “Asking A Question” sub-system, we have developed an intelligent learning assistant module (LAM) that can automatically generate dynamic and personalized learning guidance in the form of follow-up suggestions to learners after answering each natural language question [15]. Suggestions are produced based on learning history (including the questions that have been asked and videos that have been watched) of individual learners. For example, if a learner asks a question ‘What is skin cancer?’, the LAM may prompt a follow-up suggestion such as ‘Do you also want to know how to prevent skin cancer?’. The LAM works with the question understanding component in the LBA system to analyze questions in natural language. It includes a knowledge base that consists of three sub-components, namely an instructional case base, an instructional rule base representing the teacher module, and a user profile representing the student module.

The objective of the instructional case base is to store domain knowledge. In LBA, each video clip focuses on a specific subject and is viewed as a knowledge node in a domain knowledge network. Each clip can answer certain questions, so the association between two different questions or between a question and a clip can be viewed as a link in the knowledge network. Knowledge contained in video clips can be either declarative or descriptive, or both, which is sometimes difficult to express in explicit rules in rule-based reasoning [42]. Therefore, we applied a case base reasoning (CBR) technique to generate follow-up suggestions. Each record in the case base consists of a question template that learners are likely to ask and related suggestions from domain experts. The suggestions comprise a list of follow-up questions that might be interesting to learners after the current question has been answered. When a learner asks a particular question, the LAM searches its case base and retrieves the most similar cases. It
then reuses the identified cases to give individualized suggestions, which are adjusted according to previous learning history.

Rules in the instructional rule base represent teaching strategies. Suggestions retrieved from the instructional case base are generic to learners and may need to be revised based on their learning history. We used instructional rules to manipulate cases and user profiles. They are represented by production rules.

The user profile is a centralized, dynamic Web database that contains background and learning history of all individual learners. Basic personal information such as demographic data and individual interest is stored in this database when learners register for the LBA system. Records of previous learning history, including questions that have been asked, video clips that have been seen, and other relevant information, are automatically captured on the fly and stored in the database.

4.4 The Discussion Forum in LBA

Collaborative learning serves as a way to create the feeling of an actual class or a community among a group of learners. It encourages knowledge construction in an environment where learners can share understanding or opinions, which makes learning an immediate, challenging, and engaging activity [9, 25]. Substantial research has shown that groupware-supported collaborative learning leads to more student involvement, superior performance, and greater participation and productivity than individual learning [4, 35]. Furthermore, learners’ exposure to other people’s viewpoints can challenge their initial understanding and thus motivate learning.
Collaboration tools in e-Learning systems are geared toward knowledge sharing and group discussion. A variety of collaboration tools have been used on the Internet such as electronic bulletin boards, online chat rooms, newsgroups, NetMeeting, and Web-based GroupSystems. Currently, text-based online collaboration tools are in widespread use for supporting online learning, although it is fully recognized that new tools supporting multimedia material are in great demand by e-Learning systems [38].

A text-based online discussion forum has been integrated into LBA to enable learners to exchange ideas or post comments/questions that can be answered by either peer learners or instructors. Messages are grouped by subject matters. When learners watch a video clip and its associated content, they can always click a ‘Forum’ button on the interface to view all available comments regarding that clip, displayed in an order based on when comments were made, starting from the most recent one.

4.5 The System Platform

As an easy-to-use system, LBA only requires a thin-client — remotely located learners only need a Web browser (such as Internet Explorer), a RealPlayer from RealNetworks (http://www.realnetworks.com) that is available on the Internet for free download, and a sound card installed on their computers.

Primary information processing, including question understanding, content retrieval, and generation of packaged material, is conducted on the Web Server. The current LBA system uses Apache on a Gateway dual Pentium III 800MHZ server as its Web server. The operating system is Red Hat Linux 7.1. Since the LBA system accepts natural language queries, we also have installed a commercial natural language processing software called iSkim on this server to parse
questions and analyze video-associated texts. Java Servlet programs are developed to deliver learning content to learners. Multimedia content, such as metadata of videos, PowerPoint slides, and keywords in the lectures, is stored in a MYSQL relational database, which is accessed by Java Servlet programs via JDBC (Java Database Connectivity). The relevant instructions, such as associated video, slides, and notes of a lecture, are logically linked with each other in the database. The video processing, editing, and compression are conducted on Apple G4 computers using software packages called Final Cut Pro and Media Cleaner to generate video files in RealPlayer format (.rm). Normally, the size of a one-hour video in this format is about 80MB after compression.

There are two ways to watch a video on the Internet. The first method is to download an entire video file to a local computer before playing it. The second is to use video streaming technology. It reduces video transmission delay by playing a video while it is downloading. In the LBA system, we adopt video streaming technology. The RealSystem Server from RealNetworks is selected as the video streaming server in the LBA system. There are two other commonly used commercial video streaming servers available: QuickTime Streaming Server from Apple Computer, Inc. and Windows Media Streaming Server from Microsoft. Media streaming content of an online lecture can be created at three different levels: audio only, audio and graphics, and audio and video. Along this continuum, complexity and requirements for system and network bandwidth increase exponentially. As mentioned before, we logically segment a video by identifying starting and ending time of each clip instead of physically segmenting them into many small video files. By this means we can maintain and locate video files in a more efficient manner. RealSystem Server 7.0 is chosen because it provides a very easy way to enable random access to any particular point in a video, and it is platform-independent.
and free for download. Although it allows only 25 simultaneous users, it is adequate for the current needs of this research project.

4.6 Potential Applications

A Virtual Mentor system like LBA can be applied to a large variety of applications, especially to real-time knowledge acquisition or lifelong learning where both visual and auditory information are desired, such as distance education, remote software technical support, online workforce training, and healthcare consultation. A typical example is on-the-job workforce training. Traditionally, employees in a company have to leave their duty, travel to a designated place, and stay there for a few days to receive training. From a financial point of view, in addition to high traveling costs, this type of centralized training may result in losing business because employees are away from their offices during training. From a knowledge management perspective, such a pattern does not manage and reuse a company’s knowledge (e.g. training material) in an efficient way. Training offered via a VM can enable individual training at any place whenever it is needed, and can be more cost-effective. Healthcare consultation is another potential application of Virtual Mentor. When people confronting a health problem need information about their conditions, a Virtual Mentor can help them obtain information through real-time interaction with virtual professionals.

5. PRELIMINARY EVALUATION OF LBA

One of the primary objectives of this research is to identify what potential factors may have influence on e-Learning effectiveness. For example, we are particularly interested in assessing 1) whether the presence of instructional videos improve students’ learning performance
significantly; 2) whether learner-content interactivity influence students’ performance; and 3) whether the learning performance of LBA users is equivalent to that of traditional classroom students. In order to address those questions, we have conducted two experimental studies using the LBA system with different set-ups of interactive e-Classroom. The learning contexts used in studies were data normalization (database) and Internet Search Engine. There were a total of 336 undergraduate students (55.4% were male, either freshmen or sophomores) from more than 10 majors participated in the studies. Each student could get up to 5 extra credits for participating in the studies, depending on how well s/he learned from either a traditional classroom lecture or an online lecture through the e-Classroom. Students were randomly assigned into either one of the following LBA e-Learning groups or a traditional classroom group:

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<th>Table 1. LBA Experimental Groups</th>
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<tr>
<td>With Video</td>
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<td>Richer Interactivity</td>
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<td>Less Interactivity</td>
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In the experiments, different LBA online groups had different system setups. For example, students in the group A used the LBA system with the exactly same interface shown in Figure 2. (with all the multimedia content plus content index and control buttons), while for group C, although all multimedia content was available, there was no content index and control buttons provided on the interface. Group B (or D) worked with an interface similar to the one used by group A (or C), except that there was no instructional video available. During lectures, students in online groups were not permitted to talk with each other, while those in classroom groups were allowed to ask instructors questions like they normally do in traditional classroom lectures. We did not allow online students in the experiment to use the discussion forum in order to avoid
collaborative learning effect. Same instructors who taught the classroom group also prepared the course material for online groups to ensure that the content in each lecture was consistent.

All online groups conducted experiments in a research lab, while traditional classroom groups took lectures in a regular classroom. Every group had the same amount of time for lectures and went through a similar experimental procedure. Each subject was given a pre-lecture test and a post-lecture exam (closed-book, closed-notes) about the content covered by lectures. The students’ learning performance was measured based on the difference between their pre-test and post-test scores. The learner satisfaction was evaluated based on questions (using 7-point Likert scale) in a questionnaire filled out by subjects after the experiments.

Although we used different learning contexts and subjects in two experiments, the results from ANOVA analysis were consistent. First of all, students that took the lectures through an e-Classroom environment with richer interactivity (Groups A and B) significantly outperformed those with less interactivity (at 0.01 significance level). Second, the presence of instructional videos had a significant positive impact on learning performance (at 0.05 significance level). Third, in both studies, the learning performance and learner satisfaction of the group A were the highest among all groups, significantly higher than traditional classroom group (at 0.05 significance level) [43].

In the post-study questionnaires, most online students reported that they liked multimedia presentation in the e-Classroom and they were satisfactory with self-controlled learning process. They commented that this is a very effective and easy-to-use learning system, and sufficient interactivity and flexibility would be most important to an e-Learning environment, which is similar to findings in other research [6].
6. DISCUSSION

Although we used different learning contexts in experiments, we obtained consistent results in our study that students learning through a Virtual Mentor (LBA) environment achieved better learning performance and higher satisfaction than those in traditional classrooms. One plausible reason for this phenomenon is that in a conventional classroom, learning is instructor-centered and sequential. For various reasons, most students do not question or ask for repetition in the class even when they have trouble comprehending what instructors are saying. As student enrollments increase, class size keeps growing, resulting in less personal interaction in traditional classrooms. It significantly reduces the advantage of immediate feedback in classrooms. A Virtual Mentor environment like LBA emphasizes learner-centered activity and interactivity. They can repeat selected content over and over again until they fully understand it. Another possible reason is that the “Interactive E-Classroom” provides a rich set of instructions, and content synchronization reduces students’ cognitive load.

However, that does not necessarily mean that a Virtual Mentor can replace traditional classroom learning. First, learning is mostly a socio-cognitive activity. A Virtual Mentor cannot provide the same social life that students can have on a real campus [24]. Second, positive learner attitude and user acceptance have been considered critical factors that contribute to the successful application and implementation of online learning technology [16]. Not every student likes learning through a computer, and not every instructor likes to teach on the Internet. Past research has shown that Web courses do not seem to attract many students that have limited computer skills [18] and there are higher dropout rates in online courses than in traditional courses [30]. Many students are not willing to enroll in virtual education degree programs. In our study, a number of students reported that although LBA is very effective and user-friendly, they
would still prefer to classroom learning if they had a choice. Third, initiative preparation time for an online lecture via a Virtual Mentor is dramatically increased compared to the preparation time for a traditional classroom lecture. Finally, not every type of learning material is suitable and effective to be taught online.

This research provides several implications to Web-based education. Since instructors and learners are physically separated from each other in an e-Learning environment, how to improve learner engagement and get them more focused is a critical factor for the success of e-Learning. Therefore, from a content perspective, providing multimedia instructions, especially instructional videos, can make online learning more attractive. More importantly, multimedia instructions should be structured and organized in a meaningful way based on their content to enable random access. From an interaction perspective, an e-Learning system should enhance not only learner-learner and learner-instructor interaction by providing online communication tools, but also interaction between learners and e-Learning systems to enable self-directed learning.

There are some other important issues in a Virtual Mentor environment. For example, copyright and license agreements of online material must be considered in order to avoid illegal use. Encryption techniques and digital signature methods can be used to protect knowledge transferred over the Internet. A Virtual Mentor should also be able to receive online payment to compensate intellectual property.

7. CONCLUSION

With advancement of multimedia technology, a substantial number of multimedia-based e-Learning systems have been developed in recent years. However, limitations of some existing
systems such as inefficient ways to present learning content may hinder the greater societal impact of e-Learning and improvement of its effectiveness.

In this research, we propose the concept of Virtual Mentor and describe the implementation of a prototype VM system, aiming to develop more effective and appealing e-Learning environments using state-of-the-art information technologies. A Virtual Mentor is a multimedia-integrated e-Learning environment that emphasizes interactivity, personalization, and intelligence. It allows students to ask it questions directly and then responds with relevant instructional content in real-time. The multimedia instructions are well structured and organized according to their content, which are presented in a synchronized manner. Preliminary evaluation results have demonstrated that students in a Virtual Mentor environment like LBA can potentially learn as well as, or even better than, those in traditional classrooms. Multimedia-based e-Learning will play a more and more important role in lifelong learning or on-demand knowledge acquisition.

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