Frederick Li   Jianmin Zhao
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Advances in Web Based Learning – ICWL 2008

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Jinhua, China, August 2008
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Preface

This year, we received about 170 submissions to ICWL 2008. There were a total of 52 full papers, representing an acceptance rate of about 30%, plus one invited paper accepted for inclusion in this LNCS proceedings. The authors of these accepted papers came from many different countries. We would like to thank all the reviewers for spending their precious time reviewing the papers and for providing valuable comments that aided significantly in the paper selection process. Authors of the best papers presented in this conference will be invited to submit extended versions of their papers for possible publication in a special issue of *IEEE Internet Computing*.

This was the second time that the ICWL conference was organized in China. It was particularly special this year to hold ICWL 2008 in China, as the Beijing 2008 Olympic Games were co-located in the same country during the conference period. We would like to especially thank our Organization Co-chair, Lanfang Miao, for spending an enormous amount of effort in coordinating the local arrangements. In fact, we would like to thank the entire conference Organizing Committee for their hard work in putting together the conference. In particular, we would like to express our appreciation to our Registration Chairs, Jiying (Jean) Wang and Lanfang Miao, and Treasurer Howard Leung for their tremendous efforts in communicating with the authors regarding registration matters and maintaining the registration lists up-to-date. Our Workshop Co-chairs, Elvis Leung and Philips Wang, organized a Workshop on Blended Learning (WBL 2008), which was co-located with ICWL 2008. At this workshop, participants could share their ideas on and experiences in supplementing e-learning with classroom learning.

We would also like to thank Won Kim for delivering an invited speech and sharing his insightful views on Web-based learning research issues. Finally, we would like to thank all the authors of the submitted papers, whether accepted or not, for their contribution to the high quality of this conference. We will continue to count on your support of the Web-based learning community in the future.

Frederick Li
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On Properly Using Technologies to Make E-Learning Effective

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Abstract. E-learning is learning without the presence of a human instructor in class. Advances in technologies have made e-learning possible. E-learning can complement the traditional in-class learning. However, e-learning contents are often boring, or unclear, or detract from learning. If e-learning can be much more effective than today, technologies must be used properly in creating the learning contents, without losing the focus on learning. In this paper, we examine the different types of technologies available, and how they may be used to make e-learning effective.

Keywords: e-learning, social networking, effective learning.

1 Introduction

E-learning is self-paced learning made possible by the use of technologies, including the PC, Office software, graphics software, the Internet and the Web, the DVD/CD player, and such handheld devices as MP3 player, PDA, e-reader, etc. However, e-learning is first and foremost about learning, not about technology. This simple fact has often been lost to the designers and creators of e-learning contents. As the learner has to learn effectively without the human instructor who will guide him and answer questions, designing and creating contents for e-learning require careful thought and considerable investment of time, and continued improvement [1]. Unfortunately, often the contents are unclear, inconsistent, confusing plain wrong, and/or boring. They often detract the e-learners because of careless use of technologies. Sometimes the contents are not even accessible to the e-learners, due to software or hardware mismatch, or inadequate Internet access speed. In order to make e-learning effective, we should take one step back, and re-examine how technologies may be used to help the e-learners learn, not to just dazzle them or detract them.

There are at least four types of technologies that can be used to create and view e-learning contents. These include those that deal with textual contents, those that deal with non-textual contents, those that can help engage the e-learners, and those for social networking. In this paper, we examine how each of these technologies can be properly used to make e-learning effective, and also how not to use it.

2 Textual Contents

Text technologies are those that can be used to create, store, and modify textual contents. They include the PC and smaller computers, and software such as WORD and

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PowerPoint that run on them. They also include the Internet and the Web. Many of these have already become every working tools for knowledge workers. Text is the primary medium for delivering the bulk of e-learning contents today, although some e-learning can be done exclusively with the use of videos or audios. As such, the designers and creators of e-learning contents should focus first on making the textual parts of the e-learning contents for effective e-learning.

Making textual contents effective for e-learning requires the same discipline and techniques that it takes for technical writing. We summarize them below, since often the designers and creators of e-learning contents seem to lose sight of them.

1. There should be a good structure or organization for the contents, and different parts of the contents should be connected through a good flow, or logical progression. If the structure consists of a fair number of sections, there should be a table of contents.
2. Each key term should be clearly defined and, if deemed necessary, illustrated with one or more simple and intuitive examples. Each uncommon acronym should be spelled out where it is first used.
3. Each key concept should be clearly explained, and, if deemed necessary, illustrated with one or more simple examples. Whenever possible, all of the illustrations should be based on one, or a few at most, realistic and intuitively acceptable running examples that are relevant to the subjects of the contents.
4. Complex concepts and results should be built up progressively from small, easy and simple to large, difficult and complex.
5. Key complex concepts and result summaries should be shown using standard visualization means (figure, table, chart,…). Visualization means should be used in a disciplined way; that is, visual aids should not be created when they are not needed, or if simple textual explanations would suffice.
6. All the terms, acronyms, concepts, icons, etc. that appear in the visual aids should be defined in the visual aids, or should be explained in the textual parts of the contents that refer to the visual aids. In other words, when the visual aids are used to help explain certain concepts and results, they should not add to confusion or give rise to needless questions that will go unanswered.
7. A good presentation style should be selected, and used consistently from start to end. The presentation style includes layout, spacing, the mix of font styles, font sizes, colors, background colors; the use of acronyms; the position of the figure and table captions; the use of the upper case letters; etc.

3 Non-textual Contents

There are three types of technologies that can be used to create, store, transmit, and view non-textual contents. They are visualization technologies, audio technologies, and simulation technologies. Each of these can potentially make e-learning more effective by conveying concepts that are difficult to convey using only the textual contents. Each of these can also make the e-learning experience more enjoyable by stimulating the senses of the e-learners and by breaking the monotony of e-learning. We discuss each of these below.

The visualization technologies can be used to add 2-dimensional and 3-dimensional graphics, motion graphics (animation), images (including screen capture, and digitized photographs), videos, etc. to the learning contents. They include content creation technologies, such as screen capture programs, graphics software, motion graphics software, video cameras, digital cameras, Web cameras, etc. The visualization technologies also include a wide variety of devices and technologies that can play the visual contents, such as the Web browser with plug-ins, PC and smaller computers, digital televisions, DVD players, smart phones, PDAs, e-readers, beam projectors, etc.

The visual contents can serve as a new medium for helping to convey concepts to the e-learners. Screen captures, images, graphics, motion graphics, and videos can convey complex concepts or details much more clearly than are possible using text alone [2]. Although such contents can be very effective for a variety of learning topics, their use must be carefully planned. They tend to come in very large files, and so can require high-speed Internet connection, a computer with a large amount of memory and high-speed CPU, and can take a long time, and visual quality may suffer.

The visualization technologies can add interactivity to the otherwise lifeless textual contents. We will discuss this in Section 4.

The audio technologies can be used to add music, sound effects, podcasts [3], etc. to the learning contents. The audio technologies include devices and technologies that can record audio, and those that can play the audio contents, such as the PC and smaller computers, smart phones, Web phones, etc.

Audio contents are of course essential for learning languages. [4] makes an interesting proposal for the use of music as background to the textual contents in e-learning. For example, musical theme, called leitmotif, may be defined for each of a few key situations or characters in the text contents, and may be played in the background. For example, For example, in a customer service training course, a different leitmotif can be associated with a different type of customer: a playful theme for the inquisitive customer, an ominous theme for the angry customer, a rushed theme for the demanding customer, a happy theme for the satisfied customer. This is akin to the use of leitmotif in movies or even video games.

Simulation technologies can be used to create simulations or demos of products and situations [5]. The popular Excel spreadsheet may be used as a simulation tool. Learners can use it to learn how changing one parameter can affect the overall results. There are various elaborate simulation tools that e-learners can use to learn to operate products and experiment with various hypothetical situations without causing any undesirable side effects. They include complex and expensive systems, that duplicate every key, button, and function of the actual products, such as Global Knowledge On Demand (kp.globalknowledge.com), X.HLP Designer (www.xhlp-usa.com), XStream Software RapidBuilder (www.xstreamsoftware.com). They also include less expensive tools, such as CamtasiaStudio (www.camtasia.com), ViewletBuilder (www.qarbon.com), and RoboDemo (www.ehelp.com), etc. These offer limited interactivity, and some only allow the e-learners to see demos.

Although the use of technologies opens up great possibilities for helping e-learners learn, bad use of technologies can actually confuse and frustrate e-learners instead. Unfortunately, e-learning content designers and creators too often end up making bad use of technologies. The bad use of non-text technologies comes in several different flavors.

1. inaccessible or difficult-to-access visual or audio aids. The creators of the learning contents should not create visual aids or audio aids that the e-learners cannot see or hear, or take too long to load or play, or take up too much memory space in the e-learners' computer. Motion graphics may use animated GIF format, or Macromedia Flash and Shockwave. Motion graphics, 3-dimensional graphics, images, and videos come in large files that tax the Internet access speed and the e-learners' computer capacity [6]. The creators of the visual aids and audio aids should address such issues as incompatible data formats, software or software versions or hardware; or hardware capacity, network capacity, or Internet access speed.
2. form factor (device size) mismatch. Mobile phones (with the possible exception of Apple's i-phone) today have small screens that cannot really display normal Web pages for comfortable viewing. This is due to mismatch in form factors between the Web pages designed for display on the monitor of a PC or a laptop computer, and the small screen of the mobile phone. The creators of the visual aids or audio aids should take into consideration, the form factor of the devices on which the contents are to be played.
3. unnecessary or gratuitous use of non-textual aids. Other than to help the learner at a disadvantage, a non-textual aid for explaining a concept should not be created, when it is simple enough to clearly convey the concept, for example, using a short list of bulleted items using PowerPoint.
4. embedding terms, acronyms, and even concepts, that are not explained either in the visual or audio aids, or in the main body of the textual contents that refer to them. Non-textual contents should be included to make it easier for the e-learners to understand things, and they should certainly not add to confusion or cause additional questions to arise that will go unanswered.

4 Engaging the Learners

Using technologies, the creators of e-learning contents can engage the e-learners. As we discussed in Section 3, non-textual contents, in the form of visual/audio contents or visual/audio aids, can stimulate and engage the e-learners. Beyond this, there are several ways to engage the e-learners, and thus help them learn and retain what they learn. Some require the use of technologies and some do not.

1. A theme or imagery may be used from start to end in explaining or illustrating key concepts in the e-learning contents [7]. Common themes include sports, movies, food, vehicles, people, geography, history, etc. For example, in binary search trees in data structures, all keys smaller than the current root key go to the left subtree, while all keys larger go to the right subtree. To drive home this essential characteristic of binary search trees, a "small to the left, and the large to the right" theme or image (e.g., short persons on the left of the center, and tall.persons on the right) may be shown.
2. The challenges that force people to think at various steps in computer games may be injected at various points in learning a sequence of concepts [8]. This may take the form of exercises to force the learners to think deeper into one or more of the concepts learned.

3. Of course, e-learners are no different from conventional learners in that they learn by first understanding the basics of a concept, reinforce this understanding by relating the concept to similar concepts they already know about, then applying the concept to some problems, and then combining more than one concept and applying them to some problems. As such, it is important that the textual parts of the e-learning contents include well-designed exercises and exams.
4. The e-learning contents should in general include interactive elements [9, 10]. There are various ways to have the e-learners manipulate selected parts of the contents, such as rollover (rolling the mouse over designated text or media element to get pop-up text), hot text and click zones (clicking on designated text or media element for further information), drag and drops (clicking on a graphical element to move it to another location), etc. Another type of interaction is exercises or questions at various points in the e-learning contents. They may be simple true/false questions, or multiple-choice questions, or fill-in-the-blanks questions. It is important that feedback to the answers be given immediately, so as to help the e-learners advance to the next part of the contents. It is best to make the questions and answers stimulating by borrowing from the game paradigms, such as the board game. However, interactivity must not detract the e-learners from learning. In other words, simple questions and answers should not be made tedious or gratuitous, or require the use of expensive multimedia files that take a long time to load or play, or lead to technical difficulties. Further, interactivity has to be added in a highly usable and intuitive way [10].
5. The e-learners can be better engaged or more comfortable with customized learning contents. There are three types of customization: learning media, learning environment, and content [10]. The customization of the learning media refers to the choice of textual, audio, and visual contents. Even if all media are available, some learners may prefer one over another, depending on personal preferences and/or the nature of the contents. The customization of the learning environment refers to the look and feel of the learning contents, such as the layout, background colors, national languages, themes, etc. The customization of the learning content refers to the ability for the e-learners to select certain parts of the learning contents. In general, it is difficult and resource-intensive to create multiple versions of the same learning contents for customization.

5 Online Social Networking

During the past decade, many social networking sites have emerged to help members form online communities and exchange various types of information of common interest, and opinions on the information. These sites, including MySpace, FaceBook, Bebo, Meebo, Twitter, Friendster, LinkedIn, Cyworld, etc. have signed up, collectively, about 200 million members around the world, who join online communities and share their personal profiles and information about events in their lives. There are also information sharing sites, such as YouTube, Flickr, Pandora, Yelp, etc. that have also signed up tens of millions of members who share videos, photographs, reviews on many things (such as local restaurants, bars, stores, hotels and motels), etc., and form communities to exchange additional information and opinions. Many other Web sites allow visitors to post comments, email contents to others, and even rate them.

E-learners may make join some of the social networking sites and information sharing sites for the express purpose of receiving and giving help to other e-learners by joining communities, or special interest groups, and interacting with members of the communities. Further, several of the facilities provided by the social networking sites, information sharing sites, and others, may be adapted to e-learning sites to help e-learners learn more and better. These include the following:

1. a forum for posting and viewing comments on the learning contents, and learning experiences.
2. voting on (i.e., rating) the learning contents. This can help establish confidence in such aspects of the learning contents as authority, popularity, controversy, etc.
3. saving and organizing lists of learning contents (for future viewing and sharing with "friends")
4. forming and joining special interest groups. Members of the same interest group can post questions, answers, comments, special announcements, etc. that may help other members learn.
5. sharing learning contents or a saved list of learning contents with other members designated as "friends" or members of common special interest groups.
6. personal files of members, which can help establish the members' credentials with respect to the contents and comments that they may have posted.

Beyond these, such sites as Yahoo Scholar allow visitors to contact human experts for answers to particular questions, and Naver have amassed a large collection of answers (provided by paid staffers or unpaid visitors) to particular questions by the visitors. Connecting e-learners with human experts online who are willing to answer questions on specific subjects can similarly be helpful to the e-learners.

6 Concluding Remarks

Self-paced e-learning offers some major advantages over the traditional in-class learning, and its importance is certain to grow. However, the designers and creators of e-learning contents must never forget that e-learning is first and foremost about learning, not about technology. There are four types of technologies that can help make e-learning more effective and more enjoyable than it is today. These include technologies that can be used to create and view textual contents, those that can be used to create visual and audio contents, those that can help engage the e-learners, and those that can help the e-learners to form learning communities. In this paper, we examined how each of these technologies can be used to help e-learners learn more effectively, and also examined some of the problems that bad uses of technologies may create. It takes considerable thought, investment of time, and investment in technologies to make e-learn realize its full potential. We hope our work will serve as useful guidelines for the designers and creators of e-learning contents.

Acknowledgments

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Richness Versus Parsimony Antecedents of Technology Adoption Model for E-Learning Websites

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Abstract. E-learning can be viewed as an innovation in information technology (IT) and learning. The Technology Acceptance Model (TAM) has previously received significant attention in the IS research field. The Perceived Characteristics of Innovating (PCI) antecedents of technology adoption decisions have not been widely researched empirically. This study explores students' perceptions of utilizing the e-learning website in their decision processes. This work also identifies which model supports a more explanation of variance in the e-learning context. Both TAM and PCI antecedents are investigated in the same context of an e-learning website. Experimental results demonstrate that the PCI constructs explain slightly more variance in users' intentions of continued use than TAM antecedents. The PCI adoption model provides increasingly rich information concerning the continued use of e-learning website.

Keywords: Technology Acceptance Model (TAM), Perceived Characteristics of Innovating (PCI) beliefs, E-learning, Intentions

1 Introduction

The Internet allows the receipt, updating and processing of information immediately worldwide, and e-learning has received significant attention in recent years. E-learning is defined as education delivered, or learning conducted, by Web techniques [1] and lets a person learn at a distance over the Internet using technology. This process enables a learner to learn at any time at any place, and is often called online learning [31]. This novel learning method provides an alternative to conventional face-to-face, instructor-led education [11]. E-learning can be highly personal and interactive, enabling students to attain an intimate out-of-classroom learning style.

International Data Corporation (IDC) estimates that the value of the e-learning market worth will be between \$21 billion and \$28 billion by 2008 [4]. IDC states that the revenue from synchronous e-learning exceeded \$5 billion by 2006 [30]. Business spending on e-learning is expected to reach approximately \$19.6 billion by 2010, according to IDC [26]. However, the continuous growth of the e-learning market has led to a lack of discussion of individuals' behavior in the adoption and continued use of e-learning.

The Technology Acceptance Model (TAM) has previously received significant attention in the IS research field. TAM has become one of the most widely employed

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individual-level technology adoption modes [9]. Perceived ease-of-use and perceived usefulness have played (important roles in affecting technology adoption decisions. The parsimony antecedents of the model are often successfully applied to explain significant variance. Although parsimony the model is very important, individual responses to innovation technologies often depend on the context [9]. For instance, e-learning users are likely to consider whether an innovation can be employed on a trial basis before confirming its adoption.

Tornatzky and Fleischer [31] defined innovation as “the situationally new development and introduction of knowledge-derived tools, artifacts, and devices by which people extend and interact with their environment” (p. 10). E-learning can be treated an information technology (IT) innovation and learning approach innovation for many learners, according to this definition. Based on Rogers’ Innovation Diffusion Theory [28], Moore and Benbasat expended a set of eight Perceived Characteristics of Innovating (PCI) antecedents to technology adoption decisions. Little empirical research has tested the constructs of perceived innovation characteristics [3], [9]. Moreover, few previous studies have directly compared the performance of the two models.

This investigation explores students’ perceptions of using an e-learning website in their learning processes. As an innovative learning method, the adoption of e-learning involves the adoption of information technology, and changing learning approaches. Therefore, this work also aims to identify the model that most effectively explains variance in the e-learning context. The TAM and PCI antecedents are studied in the same context of the e-learning website.

2 Literature Review

2.1 The Technology Acceptance Model (TAM)

The technology acceptance model attempts to explain and predict the determinants of individual behaviour toward a system. The model presents two key beliefs concerning use of technology, namely perceived (usefulness (PU) and perceived ease of use (PEU). Perceived usefulness captures the degree to which a potential adopter regards the target technology as providing value over alternative ways of performing the same task. Ease of use encapsulates the level to which a potential adopter views usage of the target technology as involving little effort [14]. Perceived ease of use is hypothesised to be a predictor of perceived usefulness. Additionally, perceived usefulness is postulated to have a direct influence on behavioural intentions to use the technology. The beliefs about using the target system affect usage intentions and behaviour via their impact on a potential adopter’s attitude [5], [14].

Davis, Bagozzi and Warshaw [14] concluded that the internal psychological variables (i.e. the beliefs) that are central to TAM completely mediate the influences of all other variables in the external environment on an individual’s use of an innovation. They observed that ‘external variables…provide the bridge between the internal beliefs, attitudes and intentions represented in TAM and the various individual differences, situational constraints and managerially controllable interventions impinging on behaviour’ [14]. External variables only indirectly affect usage intentions or usage behaviour [2], [14], [17]. Perceived usefulness and perceived ease of use directly influence on intention to use [22], [29], [35], [36] and technology use [38] across varied organisational contexts and technologies [19]. However, results from TAM-based research in online learning [21] and online shopping [20] revealed that perceived ease of use was not a good predictor of intention to use. Further research on the application of TAM in different environments is necessary.

2.2 The Perceived Characteristics of Innovating (PCI) Constructs

Rogers [27] identified attributes of innovation that are fundamental to acceptance behavior including relative advantage, complexity, compatibility, trialability and observability. Based on the work of Rogers and others, Moore and Benbasat [23] expanded the innovation characteristics into seven constructs, and developed an instrument to measure the perceptions. These constructs are relative advantage, ease of use, compatibility, image, result demonstrability, visibility and trialability.

The first PCI construct, namely relative advantage, presents the degree to which a potential adopter considers the innovation as providing an advantage over previous ways of performing the same task. The second construct, ease of use, is similar to Rogers' concept of complexity [27], and captures the extent to which a potential adopter considers the use of the target system to be free of effort [13]. Moore and Benbasat's construct of compatibility is consistent with that of Rogers: "the level to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters."[23].

Moore and Benbasat [23] indicated that the image construct, which is a part of relative advantage in Rogers' framework, can independently predict innovation use. The image construct denotes the perception when using an innovation in terms of improving the social status of the potential adopter. Furthermore, Rogers' attribute of observability is divided into two constructs of result demonstrability and visibility, defined respectively as "the tangibility of the results of using an innovation" and "the extent to which potential adopters see the innovation as being visible in the adoption context". Finally, trialability denotes the perception of potential adopters of an opportunity to try the innovation before committing to its use.

Research in PCI reveals that individuals' perceptions about the characteristics of an innovation significantly influence their acceptance behavior. Such discussion on perceptions has been persistent in research literature in system use [13], [23] and use intentions [3], [16], [33], [34], [37]. Based on the constructs proposed Moore and Benbasat [23], Slyke et al. [33] studied factors that may influence consumers' decision to engage in Web-based shopping, and found that perceived compatibility has the strongest impact on intention of use, followed by perceived complexity, relative advantage and image. Ilie et al. [37] added to the understanding of adoption and use of instant messaging by examining gender differences in perceived innovation characteristics. Different patterns were discussed in their study. For females, perceived ease of use and visibility were significant predictors of intention to use, while for males, perceived relative advantage, ease of use and result demonstrability were significant.

These studies confirmed the innovation characteristics identified by Rogers [27] and by Moore and Benbasat [23]. They explained technology adoption behavior in specific technology contexts, and produced inconsistent results in terms of salient perception factors. Tornatzky and Klein [32], in a meta-analysis of research on innovation characteristics, found that only three innovation characteristics — perceived relative advantage, perceived complexity, and perceived compatibility — are consistently related to innovation adoption.

2.3 TAM Versus PCI

The Technology Acceptance Model (TAM) has received considerable attention in research into individual-level technology adoption due to its parsimony. Moreover, the two constructs employed in TAM constitute a subset of PCI antecedents. Relative advantage is similar to the concept of perceived usefulness of TAM. Ease of use is also part perception of the TAM [13]. To contrast with TAM, PCI provides more richness in modeling technology adoption decision. As an innovative learning method, the adoption of e-learning involves the adoption of information technology and modification of learning approach. Learners have more control over selection of learning topics in e-learning than in learning in conventional classrooms. Hence, this investigation compares the explanatory powers of TAM and PCI in order to understand factors that may affect the intentions to continued use e-learning.

3 Research Methodology

3.1 Characteristics of the Sample and Study Context

To compare the performance between the antecedents of TAM and the PCI set, an e-learning website was specified as a representative of the innovation of e-learning. A survey was undertaken on students who were enrolled in a project management (PM) course at a comprehensive university in Taiwan. Digital materials related to performing PM on Microsoft Project 2003 were developed, and could be used by students on the e-learning website.

The system utilized in the experiments was designed explicitly for this investigation, and ran on a Pentium IV PC with a 17" monitor. Subjects applied Internet Explorer 6 to browse the teaching materials stored on a university server. Retrieval of information, including video clips, was almost instantaneous when using this configuration. The e-Learning website was developed using the Wisdom Master, which was developed by SUN NET Technology Corporation, and is one of the most popularly adopted Learning Management System (LMS) platforms in Taiwan. Wisdom Master is also the first software in Taiwan that conforms to the highest standard (RTE3) of the SCORM 1.2. The synchronous mode of teaching is not always better than the asynchronous mode [25]. Most e-learning is conducted asynchronously [11]. Therefore, an asynchronous e-learning system was developed for this study. The high-resolution monitor enabled subjects to see clearly the facial expressions of the people in the video clips on the e-learning website.

Subjects received a one-hour, hands-on demonstration on using the e-Learning website before the course began. Subjects could use the e-learning web system free by connecting to the Internet from anywhere at any time. The students were asked to complete a questionnaire survey after finishing the free 4-week course. Completion of the survey was voluntary, and could be done outside class. A total of 137 surveys were completed. The age range of the sample was 20–30 years old. Of the 137 respondents, 59 were female (43%) and 78 were male (57%).

3.2 Instrument Development

Moore and Benbasat's [23] questionnaire of scales of perceptions of innovation characteristics was employed as the foundation for the development of the PCI instrument. To fit the e-learning study context, the visibility construct was not considered when constructing the PCI model. The model was composed of a total of 24 items, with each scale comprising of a minimum of two items. The original items proposed by Davis [12] were utilized for the TAM constructs. The "ease of use" construct of PCI is part of the TAM [3]. Hence, the items of perceived ease of use were not repeatedly listed in the questionnaire. Additionally, the intention of continued use was assessed with three items built following the recommendations of Agarwal and Prasad [3] to assess future usage intentions.

The measures of both models were modified to fit the e-learning websites contexts. The items were operationalized to evaluate the learners' perceptions of the e-learning website and the new learning approach. Respondents scored on a seven-point Likert-type scale with the end-points as "strongly disagree" and "strongly agree", except for items intended to collect demographic data.

4 Analysis and Results

Both research models were measured with the partial least squares (PLS) structural modeling analysis approach. PLS is appropriate for predicting highly complex models [7] and maximizing the variance explained for the constructs in a model [9]. Moreover, the sample size in the study was smaller than the minimum recommended for structural modeling approaches [8]. Therefore, the TAM and PCI models were selected and tested with PLS.

4.1 Measurement Model

The TAM and PCI measurement models were tested for estimated construct reliabilities, convergent validities and discriminant validity of instruments [6], [9], [18]. Table 1 presents the numbers of items, means, standard deviations and reliabilities of the constructs of TAM and PCI. All reliability measures were 0.8 or above. The alpha-level of the sample indicates a reasonable level of reliability (⟨>0.70) [24], revealing adequate internal consistency.

Table 1. Construct Means, Standard Deviations, and Reliabilities

Model	Construct	Number of Items	Mean	Standard Deviation	Cronbach Alpha
TAM	Perceived Ease-of-Use	4	4.936	0.792	0.868
	Perceived Usefulness	6	4.653	1.063	0.946
PCI	Relative Advantage	5	4.817	0.845	0.932
	Ease of Use	4	4.936	0.792	0.868
	Compatibility	3	4.609	0.942	0.917
	Image	3	3.897	1.362	0.962
	Result Demonstrability	4	4.950	0.745	0.884
	Trialability	2	4.549	0.992	0.844
	Intention to Continued use	3	4.792	1.051	0.951

Table 2 shows the each variable' the square root of AVE and intercorrelations, ranging from 0.159 to 0.650. Convergent validity of the instrument is appropriate when the constructs have an average variance extracted (AVE) of at least 0.5 [15]. The square root of AVE should exceed the intercorrelations for satisfactory discriminant validity [6]. The AVE for every construct is larger than the correlation between the construct and other constructs in the model. Table 3 presents the factor loadings and cross-loadings of the items measured in this investigation. All items loadings of each construct are larger than cross-loadings of that construct with all other constructs in two models. Hence, the convergent validity and discriminant validity in the work were adequate.

4.2 Structural Model

The result of the structural model testing includes the path coefficients and the R^2 values. The path coefficients denote the relationships between the dependent and independent constructs. The R^2 values represent the degrees of variance explained by the independent constructs. Figure 2 illustrates the results of the structural model for both the TAM and PCI models. The TAM model explained variance in perceived usefulness (R^2=31.8%) and intention to continued use (R^2=53.1%). However, perceived ease-of-use did not significantly influence intention toward continued use. The result is not consistent with earlier research [22], [29], [35], [38].

The PCI model accounted for 54.0% of the variance in that measure. Relative advantage (®=0.367), compatibility (®=0.239), and triability (®=0.270) significantly affected intention to continued use. The R^2 of the PCI model was higher than the TAM model (⊿R2=0.9%). Therefore, the PCI model adds a slight significance to the prediction of intention of continued use in the e-learning context.

Table 2. Correlations and Average Variance Extracted (AVE)

	1	2	3	4	5	6	7	8
1. Perceived Ease-of-Use	**0.847**							
2. Perceived Usefulness	0.558**	**0.889**						
3. Relative Advantage	0.567**	0.594**	**0.888**					
4. Compatibility	0.650**	0.474**	0.464**	**0.927**				
5. Image	0.274**	0.264**	0.341**	0.387	**0.965**			
6. Result Demonstrability	0.463**	0.551**	0.594**	0.332**	0.331**	**0.901**		
7. Trialability	0.437**	0.538**	0.320**	0.521**	0.159	0.389**	**0.931**	
8. Intention to continued usage	0.484**	0.638**	0.559**	0.576**	0.280**	0.477**	0.454**	**0.898**

** Correlation is significant at the 0.01 level
Diagonal **bolded** elements are the square root of AVE.

Table 3. Factor loadings and cross-loadings

	1	2	3	4	5	6	7
1. Relative Advantage	**0.924**	0.488	0.441	0.205	0.613	0.339	0.587
	0.882	0.590	0.451	0.251	0.534	0.362	0.621
	0.891	0.470	0.419	0.353	0.513	0.312	0.548
	0.864	0.455	0.359	0.353	0.458	0.225	0.450
	0.879	0.518	0.396	0.344	0.545	0.182	0.467
2. Ease-of-Use	0.378	**0.766**	0.563	0.346	0.285	0.346	0.397
	0.570	**0.857**	0.540	0.444	0.408	0.351	0.357
	0.471	**0.882**	0.592	0.149	0.390	0.338	0.409
	0.538	**0.891**	0.523	0.027	0.493	0.436	0.506
3. Compatibility	0.457	0.556	**0.900**	0.359	0.312	0.502	0.523
	0.429	0.605	**0.941**	0.341	0.316	0.509	0.495
	0.417	0.640	**0.938**	0.379	0.314	0.435	0.531
4. Image	0.326	0.269	0.405	**0.948**	0.277	0.100	0.225
	0.324	0.233	0.355	**0.975**	0.355	0.183	0.248
	0.312	0.259	0.369	**0.973**	0.335	0.170	0.248
5. Result Demonstrability	0.556	0.452	0.271	0.304	**0.920**	0.292	0.436
	0.492	0.349	0.275	0.244	**0.885**	0.343	0.388
	0.571	0.461	0.358	0.344	**0.899**	0.425	0.516
6. Trialability	0.241	0.319	0.481	0.126	0.278	**0.927**	0.493
	0.367	0.494	0.486	0.168	0.458	**0.934**	0.518
7. Intention to Continued Use	0.609	0.513	0.578	0.267	0.506	0.519	**0.989**
	0.524	0.440	0.563	0.254	0.451	0.416	**0.866**
	0.496	0.454	0.530	0.281	0.437	0.360	**0.799**

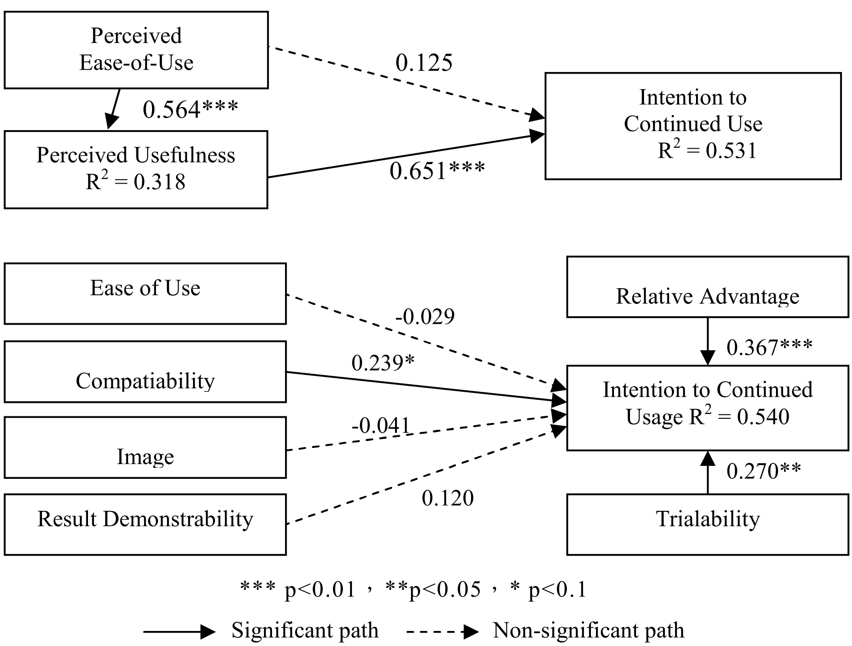

Fig. 1. TAM versus PCI model Results

5 Discussion

A fair comparison of models or theories includes careful empirical design, operationalization and measurement [10]. The research design in this study was undertaken in the same e-learning context and using the same respondents to measure the constructs of TAM and PCI model. The findings of this study provide a preliminary test of the viability of the two research models within the context of e-learning websites. Analytical results indicate that the PCI constructs explain slightly more variance (0.9%) in users' intentions of continued use than the TAM antecedents. Both the PCI and TAM perceived constructs are highly reliable, and have considerable prediction power in terms of exploring a user's continuing intention to use e-learning websites. However, the TAM model has fewer measurement items (12) than the sort-form PCI instruments (25). The TAM model places fewer strains on respondents and researchers than PCI model.

The results of TAM model demonstrate that the perceived usefulness construct plays an important role in predicting users' intentions of continued use, while the perceived ease-of-use has a significant impact on it. Conversely, the PCI results report that while relative advantage construct plays a critical role in explaining the intentions of continued use, trialability and compatiability constructs are also significant. Hence, teachers or marketing staff can try to enhance the innovation perception of trialability and compatiability, in addition to the perception of relative advantage, to raise the continued use of e-learning websites. The study also adds to the literature on comparing performance of TAM versus PCI, using data gathered in a naturally occurring and field-based adoption process.

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Exploring a Computer–Assisted Managing System with Competence Indicators in Taiwan

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Abstract. Grade 1-9 Curriculum connects elementary school and junior high school in Taiwan with Competence Indicators (CIs). CIs are the references for editing teaching materials, designing instruction, planning and implementing evaluation. Teachers can follow CIs while designing the teaching materials or offering supplement teaching materials. In order to allow the instructors to acquire suitable teaching materials from Internet and the students to access to the learning materials suitable for them from Internet, this study proposes a computer-assisted learning system which uses a clustering strategy to systematically access instructional materials according to learning map and CIs, so that correct learning components can be found efficiently and learning sequence can be designed effectively. This study takes numbers and quantities of mathematics at third grade students of elementary school as an example, then further investigate the changes of 32 students' mathematics achievement after learning. This study conclusion is that the students can enhance the learning effects by learning on their own.

Keywords: Grade 1-9 Curriculum, Competence Indicators (CIs), Learning strategies.

1 Introduction

In recent years, "Grade 1-9 Curriculum" is a key issue of educational revolution in Taiwan. Grade 1-9 Curriculum aims at bridging the students' learning gap, enhancing non linear-and-circular characteristics of learning on the curriculum design [1], and emphasizing the cultivation of students' portable capacity instead of the pure memory of knowledge [2] [3]. "Competence Indicators" means to transform the capacity items the students should possess into quantitative measure for observation and evaluation in order to assess the students' learning performance [4] [5]. CIs can be divided into detailed subitems. Based on detailed subitems of CIs, the teachers can draw learning objectives, edit teaching materials, design activities, and implement evaluation. Currently, various versions of textbooks are used in elementary schools in Taiwan. Although learning units in textbooks are associated with a CI or a set of CIs, it is inefficient to collect a set of learning units associated with CIs teachers or learners give. In other

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words, teachers or students have to manually search for the learning units indexed by CIs in textbooks. This manner is time-consuming and causes collect incomplete learning units for given CIs.

Nowadays, e-Learning is a rapid growing trend [6]. Large amount of teaching materials can be readily access through WWW over Internet. However, too many websites and connections lead to the users' information overload. In order to find out useful materials they want, they usually should spend plenty of time to evaluate, screen, and choose related materials on Internet [7]. It is not easy to search for the proper teaching materials for learners, especially for pupils [8] [9]. The reason is that most instructional materials on the Internet are not associated with CIs. Therefore, this paper proposes a computer-assisted learning management (CALM) system which structurally manages learning materials with CIs. Students can use the system to avoid losing their direction or inappropriately ending the courses. Additionally, questionnaire survey is also conducted to validate the system to comply with the requirement on curriculum schedule in elementary school. Furthermore, in order to investigate learning effects of using the system for student, a quasi-experiment is designed to assess effects. In the quasi-experiment, the CALM system provides a set of course units in Mathematics for the concept of "number" and "quantity".

The rest of the paper is organized as follows. Section 2 describes the CALM system. Section 3 shows the experiment. Finally, results and conclusions are drew in Section 4 and Section 5, respectively.

2 Grade 1-9 Curriculum Learning System

2.1 System Structure

Based on CIs, the system uses detailed subitems of CIs at different grades for classification of knowledge uses and further categories different learning and evaluation components. The system is divided into two segments, the teacher and the student. The teacher can upload and download the instrumental elements based on the CIs, and the student can make progress in the learning activity based on both the instrumental course and self-ability. The system is the WBI (Web-based Instruction) system providing the teachers access teaching components and the students' self-learning. In this system, the students can surf learning components and receive the tests. If the students cannot pass the evaluation of certain detailed subitems of indicator at different grades, they can surf the learning components again in the system for learning activities in order to find out the tips for passing the evaluation. Fig. 1 illustrates the proposed system architecture.

2.2 CIs and the Index of Knowledge Map

Ordinary searching engine does not provide "teaching components" information designed on learning perspective. Using a set of information attributes to describe data content, so that the users can manage and search the resources [10]. The searching effect is better than ordinary one if the learning component information is divided into different categories by field, subject, and learning stage in Grade 1-9 Curriculum.

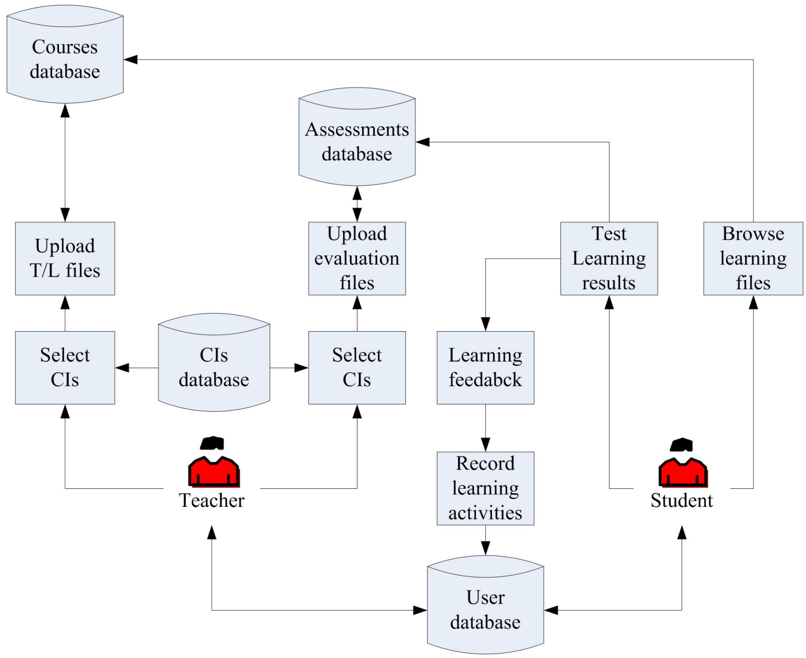

Fig. 1. The system architecture

CIs of numbers and quantities in mathematical field in Grade 1-9 Curriculum are in order. Each competence indicator is divided into several detailed subitems according to different grades. The serial numbers of CIs are in order. The small serial number should be learned first and the large one should be learned later. According to different grades, each competence indicator sets up different detailed subitems of different grades with different levels. Detailed subitems of different grades refer to the levels of teaching materials in different grades in the same competence indicator, such as CIs:

N-1-01: being capable of counting, reading, listening and writing the numbers less than ten thousand, comparing their size and conversing calculation of the units.

Symbol N represents the numbers and quantities of head line, 1 represents the first stage (grade 1 to 3 in elementary school) and 01 is the serial number of competence indicator. Two of the detailed subitems of N-1-01 are found below:

1-n-01: able to perform counting within range of 100, and name one-digit and two-digit numbers.

1-n-02: able to apply numbers to express quantity, size, and order.

Symbol 1 represents grade 1, n represents the key subject (Numbers) of lowercase letter, and 01, 02 are the serial numbers of detailed subitems of CIs.

Following the advances achieved through the teaching, the students, in accordance with the spiral curriculum structure, learn basic capabilities designated by detailed subitems of CIs. Fig. 2 expresses the relationship graph of the flow of learning time and detailed subitems of the CIs when the students of grade 3 are studying the subjects of number and quantity.

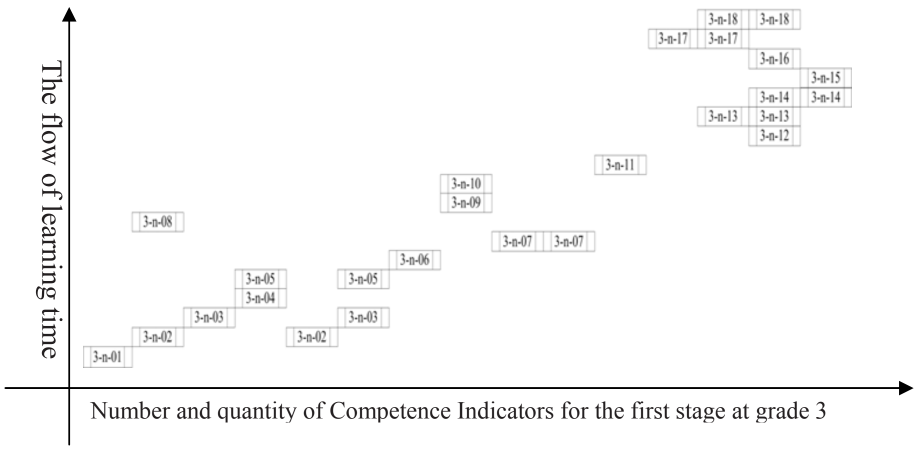

Fig. 2. The relationship graph of the flow of learning time and detailed subitems of the CIs

2.3 System Components

Interface agent. The interface agent supplies teachers and students with a friendly and succinct screen. The functions include: account management, authorization, and enquiries. After teachers register and enter the system, they can upload the teaching elements, upload evaluation components, inquire or use every component and students' learning conditions. After students register and enter the system, they can browse the teaching components, accept evaluation, and check their learning conditions. Because the contents of the category system are classified based on Competence Identifiers, teachers and students can find the adaptive current instruction needed, progress instrument and evaluation elements, easily. The students can, in accordance with the current instrumental advancement and contents, learn on the Internet and take tests to determine their degrees of learning.

Learning component module. Learning component is a kind of outward knowledge. Detailed subitems at different grades can be treated as knowledge map. IT management can be applied to management. The teacher users uploads teaching and learning components through WWW and the system classifies the teaching components uploaded by the teachers according to general classification standard of detailed subitems at different grades which can avoid the complexity generated by programmed teaching method on detailed item classification of teaching materials. The system treats the detailed subitems at different grades of CIs in Grade 1-9 Curriculum as the base for classification and provides unified form for the users. The teachers can surf, check and cite the teaching components for the use of teaching and the students can check and surf teaching components according to current teaching progress, which allows them to acquire the expected capacities [11] [12].

Evaluation component module. Test is the most convenient method for teachers to collect students' competences and learning conditions in short time [13], and the teaching evaluation should be explored from three dimensions: evaluation duration, level of educational goal and degree of clearness [14]. Skinner believed that strengthening training is the main mechanism of the organism's learning process. When a stimulus is presented repetitively and it can cause proper reaction, the reaction is considered to be controlled by the stimulus. The construction of stimulus control depends on two conditions: (1) active practices: practicing several times for the right reaction; (2) following enhancement: after practices, enhancement should be operated. The answer of the previous question is the base of the next concept.

Learning feedback module. The current learning position of the student is in the ADL. The system records the students' learning conditions in the database to provide evaluation items on learning effects. Fig. 3 shows that if the student could complete the test within the expected time and achieve the skilled level, the student is considered achieving the level of realistic development. Then, the system provides teaching components of the Competence Indicator for the next stage, which goes into the ZPD. The learning components provided by the system are regarded as the new framework. In a test, if the student gives a wrong answer, the system will display an error message, or an encouraging message if answered correctly, so that students could have feedback immediately. It could be used as the reference of correction for continuous learning activity. When the student fails the test, the system guides the student back to the previous Competence Indicator item.

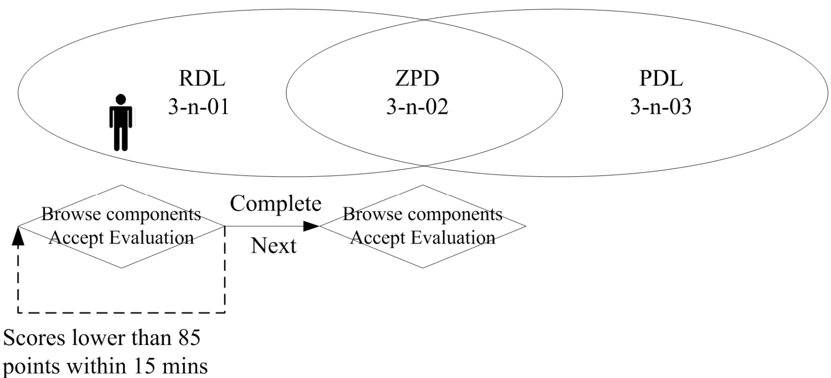

Fig. 3. The feedback flow chart of learning and test

3 Method

3.1 Experimental Environment

After teachers sign up for an account and login the system, they can use it. When teachers upload learning components with various file formats, the system stores them in the course database according to the selected detailed subitems of the CIs for teachers' or students' usage. Teachers select the uploading files and give detailed subitems of CIs. Then the system stores learning components in the course database according to detailed subitems of the CIs. When the teacher clicks the link of a component, the system searches for the component in the database, and transmits the component to the teacher's computer screen. After students login the system, it provides students with a teaching material list based on their learning conditions. Students select one of the teaching materials and the system will transmit the elements to the students' monitors. Fig. 4 expresses an example of students browsing learning components. After students login the system, it provides students with an evaluation list based on their learning conditions. Students click to accept evaluation and the system provides students with questions in random order, and one by one. Students have to complete all of the questions in a limited time (ex: fifteen minutes) or they have to start from the beginning again. The system's evaluation components adopt the selection form, and every question can include a help file. If needed, each choice can also be inserted into the help file.

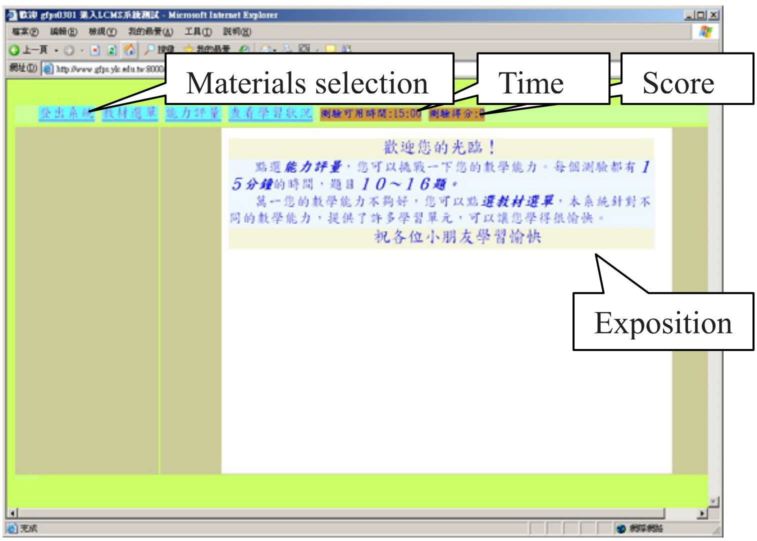

Fig. 4. Students browse the learning component

3.2 Participants

There are thirty-two third-grade students randomly selected from an elementary school participate in this experiment. The system provides course units for students' practice in number and quantity. These course units are not given yet in official programs in the school. Students spent one hour on the practice for related courses at noon break or after school every day. After two months, students take a test for their third-grade mathematical learning effects.

3.3 Equipment

This study is to ascertain students' learning effects with Mathematical Achievement Test which is edited referring to Elementary Schools' Mathematics Curriculum Standard and the guidelines of grade 3 Mathematics Instruction. The CIs range from 3-n-01 to 3-n-10. The test has two of learning categories of numbers and quantities of mathematics. It contains 40 questions including three parts: Subtest One for mathematics concepts (13 questions), Subtest Two for arithmetic operations (14 questions), and Subtest Three for conceptual application ability (13 questions). The test-retest reliability of the test is 0.80 and the split reliability is 0.89. The validity of the test accuracy was analyzed and tested by the mathematical scholars, experienced test designers, and two-way testing table; therefore, it has content validity.

4 Results

This study takes statistical software package to analyze data. Data are analyzed by the method of descriptive and inferential statistics including mean, standard deviations, and t test. In order to compare the difference between control and experiment groups for the system, the independent t-test is applied and the significant level is 0.05. The mean and standard deviation of scores of the mathematical tests are listed in Table 1. We conduct a t-test for the pre- and post-test scores in the experimental and control groups.

Table 1. Mean (*M*) and standard deviation (*SD*) of the pre- and post-tests

Students	*n*	Test	Pretest		Post-test		*t* value
			M	*SD*	*M*	*SD*	
Grade 3	32	Subtest One	37.56	21.56	43.66	23.36	0.08
		Subtest Two	34.38	21.36	42.34	23.92	0.00*
		Subtest Three	41.60	23.01	49.38	19.71	0.04*
		Total	36.88	20.42	43.25	18.87	0.02*

*α<0.05

This study adopts t statistical tests of difference of mean from two dependent samples to test whether the difference of mean between pre-tests and post-tests is equal, or whether the difference of mean reaches statistical significance. According to the guidance of Mathematical Achievement Test, the students' original total test scores and subtest scores should be transformed into percentage scores referred to normal model when applying or interpreting the test results. The mean (M) and standard deviations (SD) of the translated percentage scores are shown in Table 1. After Subtest One's original scores are transformed into percentage scores. The scores in the pre-tests (M = 43.66, SD = 23.36) are significantly better than those in the post-test ones (M = 37.56, SD = 21.56) .The α value of t-test is 0.483. It shows that the scores in pre-tests and post-tests are not different (t = 0.08, α > 0.05). It indicates that the system is not helpful for students in the teaching of mathematical concepts.

After Subtest Two's original scores are transformed into percentage scores. The scores in the pre-tests (M = 42.34, SD = 23.92) are significantly better than those in the post-test ones (M = 34.38, SD = 21.36) .The α value of t-test is 0.00. It shows that the scores in pre-tests and post-tests are different (t = 0.00, α < 0.05). It indicates that the system has a positive effect on students' calculation ability. It should be the result that the system is effective to the training of the numeric fluency.

After Subtest Three's original scores are transformed into the percentage scores. The scores in the pre-tests (M = 49.38, SD = 19.71) are significantly better than those in the post-test ones (M = 41.60, SD = 23.01) .The α value of t-test is 0.483. It shows that the scores in pre-tests and post-tests are different ($t = 0.04$, $\alpha < 0.05$). It indicates that the system is helpful for students in the ability of mathematical application.

After the total original scores are transferred into the percentage scores, the scores in the pre-tests (M = 43.25, SD = 18.87) are significantly better than those in the post-test ones (M =36.88, SD =20.42) .The α value of t test is 0.02. It shows that the scores in pre-tests and post-tests are different ($t = 0.2$, $\alpha < 0.05$). It indicates that the system can upgrade the students' learning effects.

Teaching of mathematical concept might not be a field where computer system can develop. The elements provided by the system can not complete teaching of mathematical concept. Improvement of students' calculation ability might be pushed under the training of the system and pressure of time. Most of the evaluation elements are application questions and solving more application questions helps students solve questions. Feasible learning resource categorization method is established in order to build the networked learning environment.

5 Conclusion

Using ICTs on teaching activities cannot guarantee the upgrading of teaching quality and learning effects [15] [16]. This study proposes CIs of Grade 1-9 Curriculum as the learning resource classification in the system and further constructs networking learning environment. System feasibility analysis and empirical study prove that this system can allow the students to upgrade their math capacities by self-learning. Thus, we infer that using detailed subitems at different grades of CIs in Grade 1-9 Curriculum as the teaching material classification and control of learning progress is feasible.

As to the advantages of computer supporting teaching, for the students with low degree of academic performance, in particular, as long as they absorb supplement teaching, their academic performance can be upgraded. This system uses the detailed subitems at different grades of CIs which the teachers are familiar with to classify the learning components and employs XML language to re-packaging raw data file (teaching materials) uploaded by the teachers so that these teaching materials become the learning components LCMS or LMS can manage or re-arrange. It is thus easier for the teachers to look for teaching materials. The system uses SCORM standard to re-seal the learning components and allows the learning components to be shared at different LMS or LCMS that fulfills the goal of resource share. Through the mechanism of learning process control and feedback, the students can learn on line on their own and facilitate their academic performance.

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e-Learning Issues under an Affective Perspective

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Abstract. The aim of this paper is to present an Affective Educational Module for distance learning which is called MENTOR. MENTOR constitutes of three main components, the Emotional Component, the Teacher Component and the Visualization Component and its main purpose is to motivate appropriately the student in order to accomplish his learning goals. The basic concern of MENTOR is to retain the student's emotional state positive during the learning process. To achieve this, it recognizes the emotions of the students and takes them under consideration to provide them with the suitable learning strategy. This kind of strategy is based both on the cognitive abilities and the affective preferences of the student and is stored in the student's model. The student model supplies the educational system with necessary information with the aim to adapt itself successfully to the student's needs.

Keywords: e-Learning, Affective Computing in Education, Pedagogical Issues.

1 Introduction

During the learning process in the real class, a creative teacher usually invests a significant amount of his efforts and time to identify the personality and the mood of his students in order to find the suitable ways of increasing their motivation [1]. The intrinsic ability of a good teacher to balance subtly and accurately their students' emotional predisposition, their individual needs and preferences and their current disposition, while he directs them adroitly to their goals' achievement, is one of the major factors to the student's progress and successful attainment of learning.

Despite the importance of the affective factor, in most educational systems, this crucial parameter seems to have been ignored, since the significant process of learning is supported by methods which are mainly concentrating on the cognitive abilities of the student. Indeed, these systems in their majority develop their educational dimension, based only on cognitive parameters such as learning styles, without taking into consideration the emotional factors that are related to the mood and the personality of the student. Many Web learning designers realize that this omission deprives the education from a very important pedagogical dimension. Thus, they conceive the necessity to turn their attention to affective subjects that influence learning.

As a result, few contemporary educational systems began to consider their operation under an affective perspective with the aim of modelling the emotional processes which are taking place during the educational session [2], [5], [7]. Corresponding

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affective techniques are being incorporated more frequently in educational systems with the aim of recognising student's emotions, mood and personality [10], [13], [15]. The traditional student model starts to be modified in order to be capable of storing affective information.

According to this point of view, we developed the MENTOR which is an Affective Educational Module capable of supporting the learning in the distance education [11]. Although, this Module consists of three main components, which are the Emotional, the Teacher and the Visualisation Components respectively, in this paper we are concentrating particularly on the Emotional and the Teacher Component, demonstrating the tasks which are taking place during their interaction.

As it has already been stated, MENTOR takes into account the personality and the emotional state of the student, in order to decide which is the appropriate affective tactic for him. In traditional learning we refer to teaching as denoting mainly the method which is followed by the teacher for the development of the student's cognitive abilities. This definition implies also, however without stating it clearly, that the teacher is responsible for the emotional control and support of their students [4].

The architecture of the MENTOR is designed with equal respect to the cognitive and the emotional dimension of teaching as well. So, we consider that the Teacher Component which is in charge of the formation of teaching consists of two subcomponents, the Teaching Generator and the Pedagogical Generator which are responsible for providing the cognitive and emotional tactic respectively. Therefore, we use the term affective tactic so as to denote that the learning method which is suggested by the Teacher Component is a two-dimensional combination of cognitive and emotional guidance and support.

Taking the above points into consideration, it seems clearly that the main purpose of the MENTOR is to create or to maintain a positive mood to the student, keeping him in track of his learning goals. To achieve this, we need to be aware of the student's emotional state in every moment. That is stored in the affective student model, which consists of cognitive and emotional information, and it is provided by the Emotional Component. In accordance with this plan, the model selects and supplies accurately the student with the proper affective tactics. In this manner, it involves effectively the student into the learning process under a fruitful pedagogical perspective.

In the next section, we analyse the significant role of the student's personality and emotions in learning. In the following section we present the architecture of the MENTOR demonstrating how it takes advantage of the Emotional and the Teacher Components to select the appropriate affective tactic and engage consequently the student efficiently into the learning process. We describe the basic structure of these components and their operation as well. Finally, we cite the conclusions and further work.

2 Basic Issues of Affective Computing

The term Affective Computing involves the intention of Artificial Intelligence researchers to model emotions in intelligent systems. According to Picard [18] an affective system must be capable of recognizing emotions, respond to them and react "emotionally". In fact, the affective computing area could be considered from four major perspectives. The first one comprises methods for the automatic recognition of the affective state of a person or mechanism in order for a computerised system to express emotional behaviour in human-computer interaction. The second studies the relationship between cognitive and affective factors which characterize processes such as learning. The third deals with the use of the affective information in order for the system's adaptation to be achieved. Finally, the affective computing relates to the designing and simulation of lifelike agents which are software entities capable to exhibit believably emotional behaviour optimizing in this way the effectiveness of human-computer interactions.

2.1 Personality and Five-Factor Model

The personality determines all those characteristics that distinguish one human being from another. It is related to its behaviour and mental processes and has a permanent character. The most known model of personality is the Five Factor Model (FFM) [14] and results from the study of Costa and McCrae [6]. It is a descriptive model with five dimensions: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Due to these dimensions the model is also called OCEAN model. This model describes an Openness person as accessible to new experiences, creative, imaginative, intellectual, interested in culture, social, emotional aware, with a significant sense of freedom and exploration. According to the intensity of these characteristics a person who belongs to the Openness category is characterized either as Explorer, or as Moderate or as Preserver. Conscientiousness refers to a person who is well-organised, dutiful, responsible, persistent in achieving goals, thinking and planning in detail before acting, controlling his impulses, with consolidated points of view. According to the intensity of these characteristics, a person who belongs to the Conscientiousness category is characterized either as Focused, or as Balanced or as Flexible. Extroversion refers to a social, energetic, talkative person who is liable to make new acquaintances easily and to demonstrate positive emotional behaviour. According to the intensity of these characteristics a person who belongs to the Extroversion category is characterized either as Extrovert, or as Ambivalent or as Introvert. Agreeableness refers to a person who is cooperative, modest, friendly, accommodating, trusting, positive motivated in his interactions with other people and lucks antagonistic intentions. According to the intensity of these characteristics a person who belongs to the Agreeableness category is characterized either as Adapter, or as Negotiator or as Challenger. Finally, a negative emotionality is predominant in a Neuroticism person, so this person usually feels nervous, anxious, in pressure, insecure, emotionally unstable and prone to pessimist thoughts. According to the intensity of these characteristics a person who belongs to the Neuroticism category is characterized either as Reactive, or as Responsive or as Resilient. The descriptive character of FFM and the particular characteristics that accompany each type of personality (traits) allow us to model the student's personality [15] and use this information in educational applications [5].

The FFM provides us with a reliable way in order to connect a student's personality with his mood and emotions that he possibly develops during the learning process. This is very useful because we are able to initiate a student's emotional state and select the suitable pedagogical strategy.

2.2 Emotions, Mood and the OCC Model

Although many efforts have taken place there is not an explicit definition for the emotion. It is easy to feel, but it is hard to describe it. According to Scherer [19], emotion is the synchronized response for all or most organic systems to the evaluation of an external or internal event. Nevertheless, various attempts have been made, but the cognitive theory of emotions, known as OCC model, which formulated by Ortony, Clore and Collins [16], keeps a distinctive position among them. The three authors constructed a cognitive theory of emotion that explains the origins of emotions, describing the cognitive processes that elicit them. The OCC model provides a classification scheme for 22 emotions based on a valence reaction to events, objects and agents. Events are situations which are interpreted by people in a certain way. Objects are material or abstract constructions. Agents can be human beings, animals, artificial entities which represent humans or animals and software components which act in a specific way. The origin of emotions relate to the subject's perspective against Goals, Standards, and Attitudes. The events are evaluated in terms of their desirability, according to the goals of the subject. Standards are used to evaluate actions of a subject and objects are evaluated as appealing depending on the compatibility of their attributes with subject's attitudes.

Emotion is analogous to a state of mind that is only momentary. Mood is a prolonged state of mind, resulting from a cumulative effect of emotions [19]. Mood differs from the emotion because it has lower intensity and longer duration. It can be consequently considered that mood is an emotional situation more stable than emotions and more volatile than personality. Based on this definition we categorize mood into two categories named, positive and negative. We consider that the student has either a positive mood when he feels emotions like joy, pride, hope, satisfaction, gratification, love, or a negative mood when feels emotions like sadness, fear, shame, frustration, anger, disappointment, anxiety. Depending on this mood we speculate the possible emotions of the student.

In our work we adopt the OCC model, because it elicits the origin of emotions under a cognitive aspect and it is possible to be computerized. So, based on this model we are able to classify and interpret a student's emotions in the learning process. The authors of the OCC model consider that it could be computationally implemented and help us to understand which are the emotions that the human beings feel, and under which conditions. Furthermore, they believe that relying on this model we could predict and explain human reactions to the events and objects. This is the main reason we use the OCC model in our study. The perspective by which, we construct the following component is interdisciplinary and focuses in the intersection of Artificial Intelligence and Cognitive Psychology.

3 The Architecture of the MENTOR

The Adaptive Educational Systems (AES) are intelligent systems that improve a student's performance by adapting their operation according to his needs and interests and by supporting them with the appropriate learning strategy. An AES interacts dynamically with the student, using adaptation techniques like adaptability and adaptivity. It uses knowledge about the student (user model), in combination with specific knowledge (domain knowledge), to achieve through a set of pedagogical rules (teaching model), the adaptation of the system via the adaptive engine [3]. Thereby, an AES determines the educational content and the teaching process in a way that it appertains to teaching in a real classroom.

In the real educational process, the teacher takes into consideration the emotional state of his student by motivating him effectively and achieving thus, the desirable learning goals. Consequently, the investment in individual differences and the emotional "potential" of the student in combination with his cognitive abilities could be a significant factor, so that the learning goals can be achieved more efficiently, from a pedagogical aspect of view. Many researchers have demonstrated the pedagogical value of emotions and personality and have incorporated this perception in their educational systems [2], [5], [7].

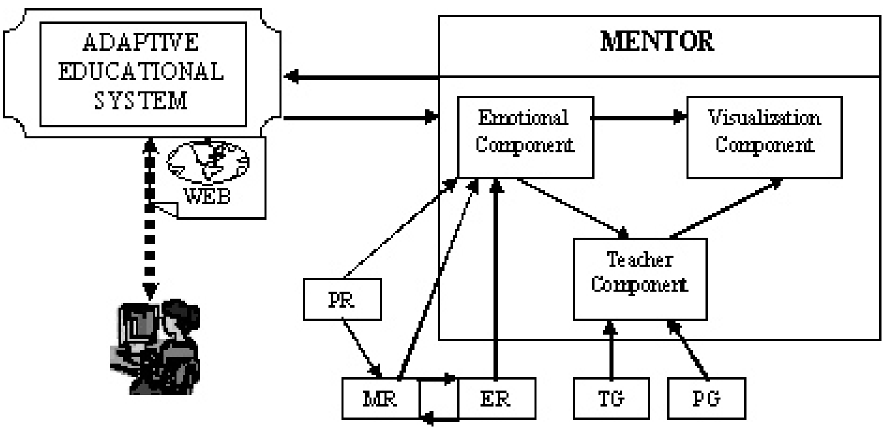

Fig. 1. The architecture of the Mentor

MENTOR is an "affective" module which aims to recognize the emotions of the student during his interaction within an educational environment and thereafter to provide him with a suitable learning strategy. The operation of MENTOR is based on the FFM [14] and the OCC model [16]. The module is being attached to an Educational System providing the system with the essential "emotional" information in order to determine the strategy of learning in collaboration with the cognitive information. The architecture of MENTOR is presented in Figure 1.

The MENTOR has three main components: The Emotional Component (EC), the Teacher Component (TC) and the Visualization Component (VC), which are respectively responsible for: a) the recognition of student's personality, mood and emotions during the learning process, b) the selection of the suitable teaching and pedagogical strategy and c) the appropriate visualization of the educational environment. The combined function of these components "feeds" the AES with the affective dimension optimizing the effectiveness of the learning process and enhancing the personalized teaching. The main purpose of MENTOR is to create the appropriate learning environment for the student, taking into account particular affective factors in combination with cognitive abilities of the student offering in this way personalized learning. In the next two sub-sections the Emotional and the Teacher Components are being analyzed in more details. The analysis of the operation of the Visual Component is beyond the scope of this paper.

3.1 Recognizing the Emotions of the Student

The necessity of recognizing the student's emotion during the learning process, especially in distant learning environments is crucial and has been pointed out by many researchers in the e-learning field. Because of this need, many methods have been proposed with the aim of recognizing or predicting a student's emotions. Some of them are based on the detection of physical and biological signs [18] and others are based on AI techniques like Dynamic Decision Networks (DNNs), Machine Learning Techniques or Transition Networks [5], [15], [17]. Inferring student's emotions in an on-line educational environment is a multi-parameter and highly demanding task closely related to the current mood and the personality of the student.

Concerning the MENTOR, responsible for the recognition of the student's emotions is the Emotional Component. This component (Figure 1) is composed by three subcomponents, the Personality Recognizer (PR), the Mood Recognizer (MR) and the Emotion Recognizer (ER), which are responsible for the recognition of the personality, mood and emotions of the student. As it has been already mentioned, there are five personality types. When the student uses the system for the first time, the PR subcomponent selects a suitable dialogue specified by the FFM to assess the type of a student's personality. The dialogue is articulated in accordance to Goldberg's questionnaire [8]. As a result, the student's traits are being recognized and are being used by the Teacher Component for the suitable selection of pedagogical and teaching strategy. For example, a student that has been recognized as Openess, according to FFM is imaginative, creative, explorative and aesthetic [6]. These characteristics are evaluated by the TC providing the system with an exploratory learning strategy, giving more autonomy of learning to the student and limiting the guidance of the teacher. The MR subcomponent provides the system with a dialogue that can elicit emotions depending upon the semantics and its context. This dialogue is used in every new session and defines the current student's mood. Based on this dialogue the student's mood is recognized either as positive or as negative. In our approach, good mood consists of emotions like joy, satisfaction, pride, hope, gratification and bad mood consists of emotions like distress, disappointment, shame, fear, reproach. As a result, we have an initial evaluation of the current emotions of the student. Thus, if the student is unhappy for some reason, the MR recognizes it and in collaboration with TC, it defines the suitable pedagogical actions that decrease this negative mood and try to change it into a positive one. Finally, the ER subcomponent is in every moment aware of the student's emotions during the learning process, following the forthcoming method.

So as to deal effectively with the emotions elicitation process, the Emotional Component has an affective student model where the affective information is stored. Ontology of emotions is used for the formal representation of emotions. Ontology is a technique of describing formally and explicitly the vocabulary of a domain in terms of concepts, classes, instances, relations, axioms, constraints and inference rules [23]. It is a formal way to represent the specific knowledge of a domain, providing an explicit and extensive framework to describe it. Lastly, except form AI, a lot of fields in Information Science like knowledge engineering and management, education, applications related to Semantic Web, Bio-informatics make use of ontologies [21]. Our ontology has been built to recognize 10 emotions which are: joy, satisfaction, pride, hope, gratification, distress, disappointment, shame, fear, reproach. The former five emotions compose the classification of positive emotions and are related to the positive student's emotional state. The latter five emotions compose the classification of negative emotions and are related to the negative student's emotional state. The construction of the ontology was based on the OCC cognitive theory of emotions. Thus, the concepts of the ontology are defined in terms with this theory. For instance, the positive student's emotional state is described as follows:

(POSITIVE-EMOTIONAL-STATE
(SUBCLASSES
(VALUE (JOY, SATISFACTION, PRIDE, HOPE, GRATIFICATION)))
(IS-A (VALUE (EMOTIONAL-EVENT)))
(DEFINITION (VALUE ("emotions or states, regarded as positive, such as joy, satisfaction, pride, hope, gratification"))))

We use the DL-OWL (Description Logic – Ontology Web Language) as a reasoning and inference mechanism to acquire the essential production rules, as well as to analyse the domain knowledge and interaction data. For instance, the emotion of fear is represented as:

$fear_{ti}(P, \neg G)$ means that the student who is performing a plan P, feels the fear the particular period of time t_i that will not accomplish his learning goal G. (1)

In this way, the formal and flexible representation of an emotion can be efficiently achieved in relation to the learning goal of a student. The proposed ontology of emotions was implemented with the Protégé tool.

Furthermore, we adopt a decision tree approach, an AI technique (C4.5 algorithm [22]) to extract information from the proposed "emotional" ontology and to make inferences about the emotions of the student. This process comprises three steps which respectively are the following:

1. The creation of the decision tree
2. The extraction of the rules from the decision tree
3. The triggering of the extracted rules to infer student's emotions

This approach, which is used for carrying out the representation and the inference of emotions is based on the OCC model which combines the appraisal of an Event with the Intentions and Desires of a subject. Thus, taking advantage of this model, MENTOR infers about the student's emotions after the occurrence of an educational event which is related to his learning goal.

3.2 Providing the Student with the Appropriate Affective Tactic

As it has already been stated, the objective of the MENTOR is to foster the appropriate affective conditions, since these are a crucial factor for the learning process and to obtain the student with the suitable learning method. The latter goal is achieved by the Teaching Component which is responsible for providing the student with the appropriate affective tactic considering his emotional state. It consists of two subcomponents, the Teaching Generator and the Pedagogical Generator, which are responsible respectively for the appropriate teaching and pedagogical strategy as illustrated in Figure 1.

The Teaching Generator is a sub-component which is responsible for the selection and the presentation of the suitable educational material, according to the student model. The student model provides information about the cognitive status of the student such as his learning style, the knowledge that has already been acquired and his learning preferences and goals. Evaluating this information, the Teaching Generator decides about the sequence of the educational material, if a theoretical or practical subject will be presented next to the student and what kind would this be, for example a more or less detailed theoretical topic or an easier or a trickier exercise.

The Pedagogical Generator is a sub-component which is responsible for the formation of the pedagogical actions which will be taken into account during the learning process. Once the recognition of the student's emotions and his emotional state has been stored in the affective student model, the Pedagogical Generator has all the necessary information in order to support and motivate the student to the direction of the achievement of his learning goals. As a teacher does in the real class [12], the Pedagogical Generator encourages the student, gives him positive feedback, congratulates him when he achieves a goal, and keeps him always in a positive mood, with the view of engaging him effectively in the learning process.

Combining the interaction of its two sub-components, the Mentor Component forms the appropriate affective tactic for the student. In this way, a traditional instructional tactic is enhanced with a motivational one and this would be proved beneficial to the student from two aspects [20]. The first concerns the planning of the teaching strategy and the educational content, which and what topic will be taught to the student next and which method will be used for it. The second is more related to the delivery planning, how this topic will be taught.

At this point, it should be noted, that the outputs of the two sub-components might be contradictory. For example, the Teaching Generator evaluates the current knowledge state of the student and suggests a difficult exercise. On the other hand, relying on his current emotional state, the Pedagogical Generator recommends an easier one, because it judges that the student's confidence is low. So, resolving an easier exercise, it estimates that his confidence will be reinforced. In that case, the Mentor Component is designed so that, it would rather promote its Pedagogical Generator recommendation.

Let us examine the reverse case, where the Teaching Generator suggests a trivial problem to a confident openness student. This suggestion might be considered as motiveless by the Pedagogical Generator, compared to the student's current emotional state. To tackle with this conflict, a more difficult problem is presented by the Mentor Component, demanding the student's harder effort and challenging his interest further.

The role of the Pedagogical Generator, however, is not restricted only to the reassurance of the appropriateness of the teaching method or the educational material. It is concentrated also on providing the student with encouraging actions in order to preserve his positive emotional state. The pedagogical actions which have been implemented in the current version of our system are shown in Table 1.

The main concern of the Mentor Component, as it is already mentioned, is to ensure that the student's mood is positive every time. This condition is very crucial in order to involve the student efficiently in the process of learning [4], [9]. To achieve this, the Mentor Component has to be aware of the student's emotions. The input that comes from the Emotional Component, which is in charge of the detection of the student's motivational state, is evaluated appropriately and thereafter the Mentor Component adapts his reaction adequately to motivate the student either by encouraging him or by praising him and in every case sustain his disposition flourishing. Once the Mentor Component is aware of the student's emotions, it can proceed into the selection of the proper affective tactic.

Table 1. The pedagogical actions of the Pedagogical Generator

Ask for giving some help	Explain the need for help
Give Help to student	Reassure the appropriateness of help
Express satisfaction after a successful help	Express unhappiness after an unsuccessful help and ask for trying again
Give explanations in an appropriate way	Express sympathy in case of fail
Encourage the student	Congratulate the student
Praise the student	Express admiration for the student
Reinforce student's efforts	Play a game with student
Give hope	Open a dialogue with the student
Play a music video clip	Present a part of a movie
Present a photo	Tell a joke

Let us examine, for example, the case of a student whose personality belongs to the Extraversion category, but his mood is recognized in the current session as negative. For this type of student the Teaching Generator has already selected an exploratory teaching method without examining his emotional state. Before the Mentor Component applies this method, it interacts with the Pedagogical Generator. By analysing furthermore why his mood is negative, it comes to light that the student is anxious for some reason. The system takes upon making the student feel relaxed firstly by opening a short dialogue with him. Thereafter, it presents to him either a joke or a funny video clip, according to his preferences which are stored in the student model. Finally, it motivates him either by encouraging him or by praising his abilities.

Another case is when a Conscientiousness student fails to accomplish a given task. Then negative emotions such as sadness or disappointment can appear. He seems to be less confident in the current session and there is the danger of giving up the trial. He fears maybe that he has not got the ability to deal with a project that was assigned to him and he will not live up to his teacher's expectations. According to Table 1, there are pedagogical actions which can be applied in order to eliminate the student's negative emotions. For instance, the system may praise him for his effort, give him help and encourage him to try again. Then the Mentor Component presents him an easier problem to reinforce his confidence and to foster positive emotions. In this way, the student has great chances to resolve the problem, so that his confidence would be regained and positive emotions such as happiness or satisfaction can preserve an upbeat to the student's mood.

```
If exercise.accomplish <> done then
        Show_message (personality_type, type_of_message)
        Give_help (personality_type, type_of_task, type_of_help)
        Motivation (personality_type, task_accomplish, type_of_task)

If help.student = request then
        Show_message (personality_type, type_of_message)
        If student.emotion = shame then
                Show_message (personality_type, type_of_message)
                Give_help (personality_type, type_of_task, type_of_help)

If unit.accomplish = done then
        Show_message (personality_type, type_of_message)
        Animated_Agent (type_of_agent, attitude, verbalization)
        Multimedia_support (play_video(), play_music(), show_picture())
        Motivation (personality_type, task_accomplish, type_of_task)
```

Fig. 2. The production rules of the Affective Tactics

Similar analyses have been made for the rest of the cases that have been implemented in our system. At this moment in time, there are 20 affective tactics implemented in our system in order to deal with 10 different cases respectively. In Figure 2 are exemplified the production rules of some of these cases.

We mentioned above some cases with the aim of showing how the Mentor Component selects and suggests which affective tactic will be used. Our system is scheduled to deal with domain-independent educational environments. It would be used therefore for teaching any domain of subject and this is the major point that our work is diversified from the others.

4 Conclusions and Further Work

During the last years, the significance of the affective factors in human – computer interaction has been established and great scientific efforts have been attempted towards this direction. As emotions have long been a major concern, more and more computer scientists have recently paid close attention to these factors in order to build their systems. The significant role of personality and the influence of emotions on memory, thinking, reasoning and creativity, which are basic constitutes in the learning process, have been taken into account in the integration of modern educational environments.

In this paper, we presented the MENTOR Affective Module which is responsible for inferring students' emotions and providing them with the appropriate affective tactic in distance learning. The MENTOR is integrated in a Web Adaptive Educational System with the aim of providing personalized learning. The implementation of the MENTOR has been achieved by using the PHP5 language for server-side scripting and the MySQL for the data-base management, supported by Apache HTTP server 2.2. The recognition of emotions is based on a formal representation of emotions using an appropriately designed ontology which is implemented with the Protégé tool and is achieved by a decision tree method. A DL-OWL inference engine has been used to make predictions about the emotional state of the student.

The main purpose of the MENTOR, except from the recognition of emotions, is to create and / or preserve a positive mood in the student, since this is a crucial factor for the learning process. Moreover, it aims at providing the system with suitable information about the personality and emotions of the student and also with appropriate pedagogical actions enhancing the student's motivation to “conquer” the intended knowledge. At this time, we have implemented 20 affective tactics. The designation of these tactics has taken into account the professional opinion of teachers and psychologists.

Furthermore, we are developing this component bearing in mind to be independent from the specific domain model of educational systems, so that it has the capability to be used by a wide range of them. In advance research, we intend to improve the accuracy of our system so that we are capable of recognizing more emotions and more complicated emotional situations. We hope that in future versions the number of affective tactics will be further evolved so as to include more cases. When the integration of the MENTOR will have been completed, we will be able to testify its reliability conducting a web evaluation.

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Recommendation in Education Portal by Relation Based Importance Ranking

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Abstract. Recommendation in education portal is helpful for students to know the important learning resources in schools. Currently, previous methods which have been proposed to solve this problem mainly focus on page view counts. A learning resource is important just because many students have viewed it. However, as the metadata in a resource is becoming available, the relations among the resources and other entities in real world are becoming more and more. Unfortunately, how to use such relations to make better recommendations has not been well studied. In this paper, we present a complementary study to this problem. Specially, we focus on a general education portal, which consists of different typed objects, including resource, category, tag, user and department. The recommendation object is resource. However, we have found that a resource's importance rank can be affected by its relations to other typed objects. Thus, we formalize the resource recommendation as a ranking problem by considering its relations to other typed objects. A random walk algorithm to estimate the importance of each object in the education portal is proposed. Finally, the experimental result is evaluated in a real world data set.

Keywords: Recommendation, Importance Ranking, Random Walk.

1 Introduction

Recommendation has been proven to be a useful approach for reducing users' efforts to find information which may be interesting. It has been applied to many popular commercial web based applications, e.g., www.amazon.com, www.facebook.com, imdb.com and so on. In education portals, it's also important to recommend resources to users, especially, recommend learning resources to students. It can be very helpful to benefit the students to get more interesting topics and affect the efficiency of learning. For example, the MIT's open course ware is helpful for students in the whole world.

Recently, many methods have been proposed for the recommendation in academic and industry, for example, content based filtering [1], clustering model [2], association rule based approach [3], and graph model [4]. The proposed methods are mainly applied to the open web applications, which mean that the application's end users are normal users in the internet. Different from the open web, the education portal is aimed at providing services to students and the resources in education portal have

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many kinds of available relations. In this scenario, how to use the semantic explicit relations among the resources in the education portal to make better recommendation becomes a new challenge.

In this paper, we propose a complementary study on using the relations between resources and other entities in education portal to do recommendation. Therefore, we separate this problem to the following two problems:

1. Formalize the recommendation problem in the education portal;
2. Using relations of the resources and other typed entities to do better recommendation in education portal.

For an education portal, the recommendation usually happens when a user enters the portal. A user can enter the portal by logining in or just using a guest account (anonymous viewer for the web page). In these two scenarios, recommendation is needed to choose the important learning resources in the education portal to be displayed in the first web page when users enter the portal. In this paper, we mainly focus on this kind of recommendation. By calculating the important rank of each learning resource, we can decide which resources should be placed in the recommendation block of the portal to attract users.

Advantages of the proposed approach are as follows:

1. It can make use of the resources' relations in the education portal. The relations can be dynamically added and removed;
2. The approach is easily adapted to recommend other types of entities, for example, to recommend categories.

An example of the resources' relation diagram is as figure 1:

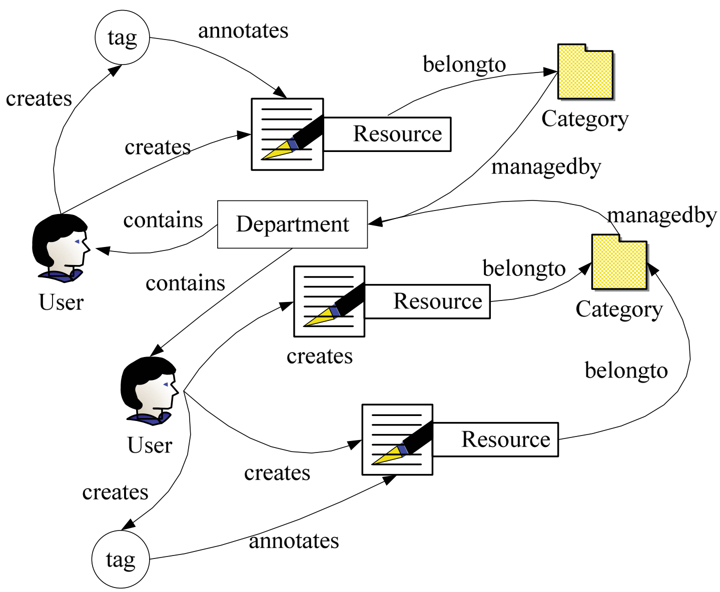

Fig. 1. An example of the learning resources' relations

The rest of the paper is organized as follows: in section 2, we formalize the recommendation of education portal in this paper. In section 3, the proposed important ranking approach is presented in detail. In section 4, we analyze the experimental results. Finally, after giving the related works in section 5, we discuss the conclusions in section 6.

2 Problem Statements

Every education portal may have its own structure for entities and relations in it. This paper proposes a general method to be easily adapted to fit for the specific structure in different education portals. In problem statements, we will use the scenario in figure 1 to give example. Such example doesn't affect the generality of the proposed approach.

First, we give the definition of the entities of an education portal as follows:

$$\{R, U, C, T, D\} \tag{1}$$

Where *R* indicates resource, which is a core element for recommendation; *U* indicates user, *C* indicates category, *T* indicates tag, and *D* indicates a department in the university. In practical case, a resource may be a series of web pages for an online course, or a web page for some knowledge tips, or even a web page for an announcement of academic forum. Category is usually used to indicate which topic the resource is, for example, the resource is about Information Technology. Tag is widely used in Web 2.0 in published resources. It can be any keywords to help users to understand the resource or to give summarization of the resource. Department is a specific concept in education portal, for example, the Department of Computer Science.

Except entities, relations are also important in the education portal. Here we define the relations as follows:

$$\{RC, UT, UR, TR, DU, CD\} \tag{2}$$

Where *RC* indicates the resource-category (belongto) relation; *UT* indicates user-tag (creates) relation; *UR* indicates user-resource (creates) relation; *TR* indicates tag-resource (annotate) relation; *DU* indicates department-user (contains) relation, *CD* indicates category-department (managedby) relation.

Thus, the education portal network can be represented by nodes and edges, which can be represented as follows:

$$network = V \bigcup E \tag{3}$$

Where *V* is as follows:

$$V = \{V_r \bigcup V_u \bigcup V_t \bigcup V_c \bigcup V_d\} \tag{4}$$

Where V_r indicates all the resources, V_u indicates all the users, V_t indicates all the tags, V_c indicates all the categories and V_d indicates all the departments.

E is as follows:

$$E = \{E_{rc} \bigcup E_{ut} \bigcup E_{ur} \bigcup E_{tr} \bigcup E_{du} \bigcup E_{cd}\} \tag{5}$$

Where E_{rc} indicates all the relations of resource-category; E_{ut} indicates all the relations of user-tag; E_{ur} indicates all the relations of user-resource; E_{tr} indicates all the relations of tag-resource; E_{du} indicates all the relations of department-user; E_{cd} indicates all the relations of category-department.

The network model can be formalized as figure 2.

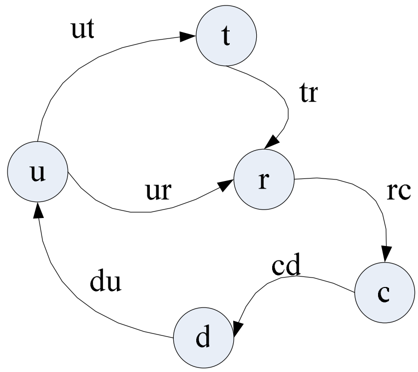

Fig. 2. The formalization of education portal network model

We define the transition probabilities λ for different relations. As for random walk, the transition probability can be viewed as the probability of a user jumps to another entity when he/she is visiting an entity in the network. According to the transition theory, we have the following formula:

$$\begin{cases} \lambda_{ut} + \lambda_{ur} = 1 \\ \lambda_{du} = 1 \\ \lambda_{tr} = 1 \\ \lambda_{rc} = 1 \\ \lambda_{cd} = 1 \end{cases} \qquad \lambda_{mn} > 0 \tag{6}$$

Based on the above analysis, the recommendation in education portal can be formalized as follows:

Recommend top n important resources in the education portal network by importance ranking.

For other kinds of structures in education portal, the V and E can be different. However, other structures can be easily adapted to our formalization by turning entities into nodes and relations into edges.

3 Relation Based Importance Ranking

In this section, we will present our approach in detail. Firstly, we will introduce our approach briefly. And then, the detail is presented step by step.

3.1 Brief Introduction of Our Approach

Our approach is mainly focus on using the relations between entities to calculate the importance of the resources. This approach is similar to PageRank [5] in web search. The major difference is that in PageRank, there is only one type of entity, which is web page, and one type of relation, which is hyperlink. However, in an education portal, there have some semantic explicit relations between different typed entities. Therefore, our approach can be divided into following steps:

1) Decide the transition probability. In this special case, only λ_{ut} and λ_{ur} needs to be decided.
2) Importance Ranking Calculation. The calculation is similar to PageRank in web search except that we have several types of entities and relations.
3) Recommendation. After the importance ranking calculation, recommendation is simple. The top n ranked resources will be selected to recommend to users.

For the first step, a simple method is to give equal values to them. Another method is to try different pairs of values and use experimental results to select a proper one. The second step is the core element in our approach and we will mainly describe the second step in the next section. The third step is straight forward enough in current scenario.

3.2 Detail Introduction of Our Approach

In this section, we will present our approach in detail. A random walk [6] based approach is applied to calculate the importance rank of the resources. Firstly, we will give the random walk algorithm in this scenario. For example, if you are visiting a user, which is a node of V_u in our network, you can have the probability of λ_{ur} to browse the resources the user creates. Furthermore, if the user has created n resources, for each resource the user created, you have λ_{ur}/n probability to visit it.

We can formalize this scenario. For any two entities in the network i and j, there is a transition probability t_{ij}, for example, if i is a node represents a user and j is a node represents a resource, the t_{ij} is as follows:

$$t_{ij} = \frac{1}{count(i->V_r)} \times \lambda_{ur} \tag{7}$$

Where $count(i\text{->}V_r)$ is the number of all the resource nodes the node i has user-resource relation with. In the same way, for any two nodes x and y, we can calculate the transition probability of x and y by this method.

Therefore, we can get the transition matrix A, whose element at row i and column j represent t_{ij}. Reference to PageRank, there is a random jump parameter α. Random jump parameter means that users can randomly jump to any other nodes in the network other than the neighbor nodes. We set $\alpha=0.15$ in this case.

$$\mathrm{A}' = (1-\alpha)A + \alpha E,\ E = (1,\ldots,1)(\frac{1}{n},\ldots,\frac{1}{n})^T \tag{8}$$

Where n is the number of the entities in the network. The importance score can be viewed as a vector S as follows:

$$S = [s_1, ..., s_n]^T \tag{9}$$

Where s_k represents the important score of entity k, there are n entities totally in the education portal.

Thus, the calculation of S is as follows:

$$S' = (A')^T \times S \tag{10}$$

The calculation of S is similar to PageRank by using iterative method. In the following section, we will describe the calculation methods in detail.

Decide the transition probability. In traditional PageRank in web pages, the transition probability is the same in the link relation because there is only one type of relation, which is hyperlink. However, in education portal, there may be different types of relations between entities. For example, in our scenario, there are user-resource and user-tag relations in the user entity. How to give transition probability to them is a problem. Here we simply use the equal values to give transition probability to them, which means $\lambda_{ut}=\lambda_{ur}=0.5$. In experimental evaluation section, we will compare the result of different parameters' values.

Calculate the importance rank. According to the formula (7) ~ (10), the calculation of importance rank is as follows:

1) Give the initial importance to every node in the network. Here we initialize every entity's importance equally, which is *1/n*. n is the number of all the entities in the network.
2) Calculate the transition matrix A' using the formula (7) and (8).
3) Begin to calculate the importance rank of every entity in the network. Until one of the finish conditions is met.

   The finish conditions are as follows:

   1. If the sum of all the entities' importance ranks' variation is smaller than a value, which is marked as ε.
   2. If the number of iteration has reached m.

4) Output the importance rank of every entity.

The process can be summarized as follows

1. Initialization. Input all the transition probabilities j_{ut}, j_{ur}, j_{du}, j_{tr}, j_{rc}, j_{cd}; Initialize the importance vector S=[1/n, … , 1/n]; Initialize the number of iteration as *m*.

2. Calculate the transition probability matrix A' using formula (7) and (8);

3. Iteratively calculate the importance rank vector. Let S be the current stage, which is number n iteration, result of importance score. Then $S' = (A')^T S$, S' is the importance rank result in $n+1$ iteration. Calculate the variance of all the entities' importance rank in S' and S by $v = \sum_i (s_i' - s_i)$.
4. if ($v < \varepsilon$ or n==m) goto 4; else repeat 3.
5. Output the importance rank of every entity in the education portal.

Recommend the top *n* resources. Although in our approach, the importance of every entity can be achieved, we only recommend the top *n* resources to web page visitors. However, if we want to recommend other typed entities like users, it's also straight forward to do that kind of recommendation.

4 Experiments

In this section, we give experimental result in a real world data set. The real world data set is made up of academic papers published by three departments of Tsinghua University: Department of Computer Science, Department of Electronic Engineering and Department of Automation. The network can be constructed by the following elements:

1. Resource: paper is the resource in this experiment;
2. User: paper author is the user in this experiment;
3. Tag: keyword of the paper is the tag in this experiment;
4. Department: there are three departments in this experiment;
5. Category: research fields in these three departments are categories in this experiment;
6. User-resource relation: author of a paper will have this relation between him/her and the paper;
7. User-tag relation: author of a paper will have relations between him/her and the paper's tags;
8. Tag-resource relation: tags of a paper will have relations between them and the paper;
9. Resource-category relation: the papers belong to one research field will have relations between them and the category represents the research field;
10. Category-department relation: the research fields belong to one department will have relations between them and the department;
11. Department-user relation: the department will have the relation to users if the users are belonged to this department.

By this method, we extract 300 papers in these three departments. The papers are from the IEEE Explorer [7] web site. We get the network with the following numbers of nodes and relations:

Table 1. The number of entities and relations

Entity	Resource	300
	User	82
	Tag	412
	Department	3
	Category	18
Relation	User-resource	950
	User-tag	1330
	Tag-resource	542
	Resource-category	300
	Category-department	18
	Department-user	82

The tags are prepared by extracting the keywords from the papers in the following two approaches: the first one is to extract the words in the "keyword" section in the paper. If the paper doesn't contain the "keyword" section, the tags are extracted by getting the first three frequent words in the papers' abstract. The tags are extracted mainly in a manual way.

The categories are prepared by using the papers' conferences and journals in which the paper is published. The conferences and journals have been classified to different categories, for example, database, communications, machine learning.

To evaluate the performance of our importance rank calculated by our approach, we use people to annotate the results output by our approach. The algorithm outputs 500 pairs which contain two resources, the first resource's importance score is larger than the second one. If a tester agrees with this result, he/she will approve this result. Otherwise, he/she will decline this result. Because different testers may have different opinions about the results, the final result is achieved by a voting method. We use five undergraduate and graduate students as the tester and randomly generate 500 pairs of the results for them to annotate. The evaluation factor is the error rate of the evaluation result.

$$err_{rate} = \frac{number(declined\ \ result)}{number(result)} \tag{11}$$

And we have repeated generation 500 pairs for five times, for each time, the error rate is as follows:

Table 2. The error rate in five randomly generated test sets

Test set 1	Test set 2	Test set 3	Test set 4	Test set 5
0.20	0.18	0.21	0.23	0.20

The average error rate is *0.20*, which is acceptable for users to find information which may interest him/her.

We also try to use different λ_{ut} and λ_{ur} values to inspect how the values affect the results. We calculate the average error rate using the same method in above. We repeated generation 500 pairs for five times and calculate the average error rate. The experimental results are as follows:

Table 3. The result comparison in different values of λ_{ut} and λ_{ur}

λ_{ut}	λ_{ur}	Average error rate
0.9	0.1	0.28
0.8	0.2	0.26
0.7	0.3	0.24
0.6	0.4	0.20
0.4	0.6	0.18
0.3	0.7	0.21
0.2	0.8	0.25
0.1	0.9	0.27

We can find that in this scenario, the results are better when λ_{ut} is relatively a little smaller than λ_{ur}. However, we can get the best result when λ_{ut} = 0.4 and λ_{ur}=0.6, which is *0.18*. And it's not much different from *0.20*, which is obtained when we set λ_{ut}=λ_{ur}=0.5.

5 Related Works

Recommendation has been a popular research topic in both industry and academic. However, there are still few researches about recommendation in education portal. Thus, we will review the current methods in other kinds of applications.

Online sellers usually use recommendation to encourage customers to buy more items. For example. www.amazon.com, www.joyo.com and www.taobao.com all have their own methods on recommendations. Usually, such recommendation approaches consider different aspects like discovering the associations of different items and users [8], mining the users' profile and behavior logs [8], and the matching of item profiles [9].

Except online sellers, many web based applications use recommendation to push the potential interesting items to users when users are searching for something or viewing something. For example, www.youtube.com recommends related videos to users when they are viewing a video. http://news.sina.com.cn recommends related news when user is viewing a piece of news. Related item recommendation is usually implemented using the similarity calculation based on contents and metadata of the items [10].

6 Conclusions

In this paper, we have investigated the problem of recommendation in education portal. We have noticed the semantically explicit relations between entities in the education portal and used them to get better results of recommendation. We have formalized the recommendation as an importance ranking problem. By using the approach based on random walk, we have calculated the importance rank of each entity in the education portal. Finally, we have evaluated the results of our approach in real world data set.

Future works can be summarized as follows:

1. We will apply this approach into the real education portal inside Tsinghua University, which is http://info.tsinghua.edu.cn, this web site is managed by our department and we are now working on adding this recommendation to it. The scenario could be as follows: When a student logins into Tsinghua's education portal, the most important and useful courseware for the student will be recommended and displayed explicitly.
2. We will use this approach in more complex recommendation scenario. For example, to combine this approach in recommendation of entity query. In entity query, the importance rank will be combined with the content relevance to do recommendation.

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Research on Learning Resources Organization Model

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Abstract. The paper studies the adaptive learning content organization model and algorithm, which takes knowledge point as a unit. At first, it defines granularity of learning object, designs learning content level framework, which takes knowledge point as the meaning unit, builds up the reusable and sharable foundation of learning resources. The second is to provide the basic scheduling model for learning content organization. The model involves in pre-test, survey, knowledge point scheduling modules, summary, and post-test. Learning content scheduling algorithm is designed to choose learning content according to the learning content sequence, learner's styles, learning evaluating outcomes and application context. Lastly, the scheduling algorithm is proved effectiveness and stable in E-learning Service Platform.

Keywords: learning objects, Organization model, scheduling algorithm.

1 Introduction

As an opening learning form, e-learning has broken the time and space limit in traditional education, enables the learner to carry on the effective active learning. Research on control, management and evaluation of learning process, learning and teaching model, adaptive learning system etc. have become the hotspot in e-learning. The adaptive schedule of learning content has become the key of active, personalized, effective learning. Now, the learning content scheduling algorithm mainly focuses on subjective characteristic, learning content characteristic, learning strategy and intelligent decision-making. Along with the development of information technology, some problems come out as follows.

The first problem is granularity of learning object [1]. In order to reuse and share learning resources, many e-learning technology standards organizations, such as IEEE, IMS[2], have formulated the correlative standards in abundance, in which they show the freedom definition for the granularity of learning object as a knowledge point, or a unit, or a curriculum. However, the effective scheduling and combination

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of learning content depend on small granularity of learning content, which should be a meaningful and perfect learning content unit.

The second is adaptation of learning object for different environments. Adaptive schedule of learning objects involves in some related specifications. The IMS Simple Sequencing Specification (SSS) provides a means to represent information needed to sequence learning activities in a variety of ways [3]. It is, however, a general purpose sequencing method and may be incorporated in other applications or environments. LOM Specification already provides a level of description and potential access to units of learning using its existing fields and vocabularies. However, it does not include elements for either Learning Objectives or Prerequisites, which are explicitly included in the Learning Design model [4]. The ADL Sharable Content Object Reference Model (SCORM) describes a Web-based learning content aggregation model and runtime environment for learning objects [5]. These specifications provides general methods for scheduling learning content, but lacks in the adaptive organization in learning content with the similar knowledge according to equipment, bandwidth, and file formats as well as other factors.

In addition, many scholars provided some benefits in learning content's organization. Mohammad etc. [6] showed adaptation models for personalization in web-based learning environment including learners' styles, inferring engine, learning content library and result analysis, and so on. Nobuko [7] studied student model, in which it provided the appropriate learning content for the similar characteristic learners according to knowledge point's LOC (mastering level), LOD (difficulty level) and DBC (the distance between knowledge points). Others researches focused on knowledge taxonomy, knowledge expression, inference mechanism and adaptive selection and presentation of learning content [8-11].

The paper studies the adaptive learning resources organization model based on learning objects by considering different granularity and different learning environments, who takes knowledge point as units. The second analyses status of art of learning content schedule. In the third, it defines the granularity of learning object, discusses the relations such as prerequisite, successor, parallel and so on between knowledge points, designs learning content level framework, which takes knowledge point as the meaning unit, builds up the foundation of learning resources reuse and share through the granularity definition of learning resources. The forth is to provide the basic scheduling model for learning content organization. Lastly, the scheduling algorithm is proved effectiveness and stable.

2 Learning Object and Its Granularity

The learning object is a component of learning content [2] which could be reused. It may be a knowledge point, also lesson content. According to the learner's individual demand, the realization of learning content's dynamic construction have the special demand on learning objects. The learning content is formed by some relatively independent learning units, which are combined by some ways. And the learning unit is also formed by certain knowledge points by similar ways. Thus, a knowledge point possibly can appear in many different learning units. So, the paper takes knowledge point as learning object.

2.1 Granularity of Learning Object and Learning Content Hierarchy

According to the granularity of learning content, a learning content may be divided into atomic knowledge, knowledge point, knowledge cluster, and knowledge tree.

Atomic Knowledge: $\forall$ a,b is the learning content, and a$\cap$b=$\varnothing$, then a, b is the atomic knowledge. Atomic knowledge is the knowledge unit, who is cannot be divided again in knowledge system, also is the smallest unit, who can embody concept, rule, and theory and so on.

Knowledge point: a_i (i=1,2,……,n) composes the set K, a_i is atomic knowledge, $\forall a_i \in$ K, $a_1 \cup a_2 \cdots \cup a_n$ = A (i=1,2,……,n) ,also A$\neq \varnothing$, then A is knowledge point. Knowledge point "A" is the relative integrated learning content. A knowledge point is composed of learning content, appraisal content and practice content and so on.

Knowledge cluster: $\forall$ A_i is knowledge point, $A_1 \cup \cdots \cup A_n = \alpha$ (i = 1,2,……,n) , then α is the knowledge cluster. Knowledge cluster comprised with knowledge points is basic independent knowledge organization unit in the learning resources scheduling process. According to learner's memory characteristic in psychology, a knowledge cluster is composed of 7+2 knowledge points.

Knowledge tree: In knowledge system, all knowledge clusters is in terms of certain strategy or sequence, for instance, instruction sequence is called the knowledge tree.

In learning resources, knowledge point is not isolated, but has some correlations. The knowledge points' relations mainly include inheritance, prerequisite, successor, parallel, connection, similar and so on.

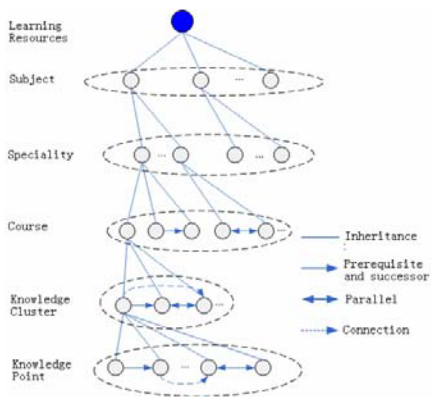

Fig. 1. Resource hierarchy model based on knowledge point

2.2 Learning Content Hierarchy

Learning resources hierarchy is showed in fig 1. The figure shows that learning resources is on the top of the hierarchy. In their returns, there are subject, specialty, course, and knowledge cluster and knowledge point. The top conception is composed of the below, the relation between different levels is inheritance, but in identical level, possibly includes prerequisite and successor, parallel as well as relevancy and other relations.

The knowledge point has many kinds of manifestations and different presentation formats. The same knowledge point may represent by some similar learning object, each learning object according to its own demand. In the scheduling process of learning content, organization algorithm and the learner's characteristic are the key factors to realize the optimization of learning process. Fig 2 shows the knowledge points' sequence result. Knowledge point 1 has learning object LO1, LO2, and LO3 with high similar degree. One learner's possibility learning sequence is: [KP1, LO1] → [KP2, LO3] → [KP3,L02] → [KPn,LO1]

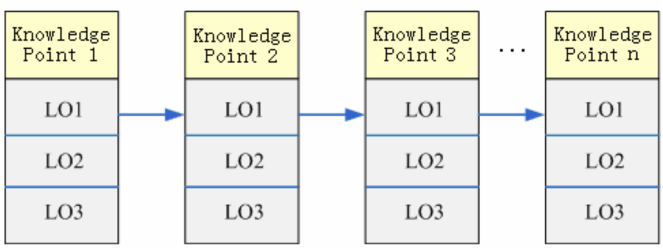

Fig. 2. The sequence representation of the similar knowledge points

3 Learning Resource Organization Model

Learning content defines a knowledge cluster as the basic learning unit. Fig 3 is the model of learning content organization, which includes pre-test, content outline, 7±2 knowledge points, brief summary, knowledge tree, post-test and evaluation [12]. According to the results of testing and the sequence of knowledge trees, the system provides the learner with the appropriate knowledge point.

3.1 Pre-test

It needs a pre-test to test whether the learner have the ability to learn the knowledge cluster after choosing it. There are more questionnaires and testing during the pre-test. If the learner does not pass the test, the system will tell him to carry on remediation learning or advise the learner to learn other knowledge clusters. otherwise, the learner begins to learn the knowledge cluster or the next knowledge cluster.

3.2 Scheduling Algorithm of Knowledge Points

3.2.1 Choosing the Knowledge Points

To choose knowledge points is the key of personalized scheduling of learning content, which is mainly choosing the learning knowledge points on the basic of knowledge

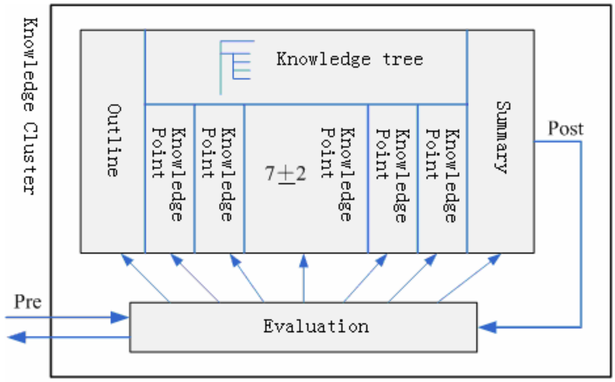

Fig. 3. Learning content organization Model

points' relations. If K is the learning knowledge point, and it is included in knowledge cluster KC, we can choose the successor knowledge point according to the following rules.

Rule 1: if K has only one successor, the learning knowledge point is the successor.

Rule 2: if K has many successors, the learning knowledge point is the nearest successor.

Rule 3: if K has no successor, the learning knowledge point is the knowledge point paralleling with K.

Rule 4: if K is the last knowledge point of KC, and the learner studies all, the system will provide a test, according to the result, the system determines to whether learn the next knowledge cluster or not.

3.2.2 Knowledge Point Relations Graph

The knowledge points' relations are illustrated by using knowledge concepts graph. Knowledge concepts graph is a directed graph, and it has some characteristics.

(1) Each node represents a knowledge point.

(2) Node A points to Node B, which means knowledge point A is the prerequisite of knowledge point B.

(3) Each node has a weight value, the value is bigger, the degree of knowledge master is more important.

The knowledge concept graph comes into being on the foundation of analyzing learning objectives and the courses' structure. In order to provide knowledge point for the learner, and the present knowledge point and the sequences of knowledge points' relations are considered. Figure 4 shows five knowledge points' relations in a KC (Knowledge Cluster).

The relations of the five knowledge points can be illustrated by using prolog as follows.

Nonpre (K1) K1 has no prerequisite knowledge point.
Nonpre (K2) K2 has no prerequisite knowledge point.
pre (K3,K1) K1 is one of the prerequisite knowledge points of K3.

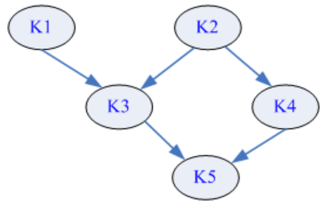

Fig. 4. The figure of knowledge sequence

According to the rules of choosing knowledge points as above, if the learner wants to learn a knowledge point, he must learn all prerequisite knowledge points. For example, if he wants to learn K3, he must have learned K1 and K2. Also, if he wants to learn a knowledge cluster, he must have learned all knowledge points of the prerequisite cluster and passed the test.

3.2.3 Personalized Presentation of Knowledge

Choice of the knowledge point determines the learning contents be learned, but each knowledge point has several kinds of manifestations. How to choose appropriate learning content is the key of knowledge point's schedule according to learning environments and personalized needs. Also, the same knowledge point has several similar contents. The system can find the best personalized presentation according to the knowledge attributes and personalized characteristics of the learner. The method is explained as the following.

Supposing the learning style of the learner is that:

S: field dependent (0.6), field independent (0.4). auditory (0.4), visual (0.3), kinesthetic (0.1)

The selective learning object attributes of choosing knowledge is:

LO1: field dependent (0.2), field independent (0.8), auditory (0.4), visual (0.3), kinesthetic (0.3)

LO2: field dependent (0.7), field independent (0.3), auditory (0.2), visual (0.5), kinesthetic (0.3)

LO3: field dependent (0.9), field independent (0.1), auditory (0.5), visual (0.2), kinesthetic (0.3)

The system can choose the knowledge point in the similar learning object, like LO1, LO2, LO3, according to the relativity of learning objects' attributes and learning style. The calculation is expression (1).

$$\rho = \frac{\sum_{i=1} x_i y_i}{\sum_{i=1} \sqrt{(x_i - \bar{x})^2} \sqrt{(y_i - \bar{y})^2}} \tag{1}$$

$\rho=0$ is irrelevant, $\rho=1$ is complete correlation. $\bar{x}$, $\bar{y}$ means the average of stat about x_i and y_i.

According to calculate, LO3 is the most appropriate learning object in the example.

3.2.4 Learning Content Scheduling Algorithm

The scheduling algorithm of learning contents explains how to choose a appropriate learning object when the learner begins to learn a knowledge cluster. At first, it determines the knowledge point according to the sequence relations of knowledge, and then chooses the best learning object according to the learner's learning style and the learning context. The organization of learning contents mainly includes two aspects. One is how to show the appropriate learning contents after choosing the knowledge cluster to learn, the other is how to diagnose difficult knowledge points and choose the appropriate learning content when the learner ends the learning and does not pass the test. Fig 5 shows the relation of knowledge points sequence relations and personalized manifestation.

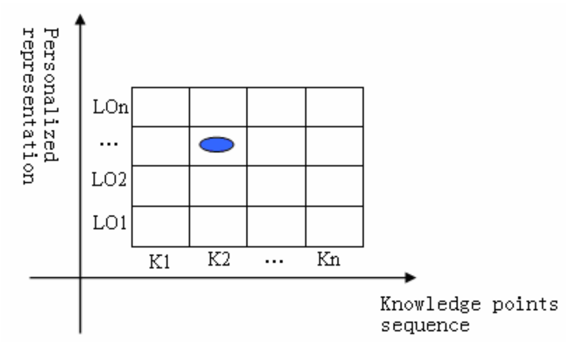

Fig. 5. The relation of knowledge points sequence relations

When the learner begins to learn a new knowledge cluster, the system runs the scheduling algorithm as follows.

(1) The learner chooses a knowledge cluster according to his needs.

(2) The system provide the learner with pre-test according to his learning state and the selected knowledge cluster, in order to test whether the learner has the ability to learn the knowledge cluster.

(3) Providing the learner with the best appropriate knowledge point on the basic of knowledge points' sequence relations. Choosing knowledge points is the strategy of presenting the learning object according to the learner's learning style, personalized characteristic, etc.

(4) Providing the learner with the appropriate learning object from the same knowledge.

(5) Repeating (3), (4) , and providing all the knowledge points in the knowledge cluster to the learner step by step.

When the learner finishes the learning of a knowledge cluster, but he does not pass the test, the system will find the difficult knowledge point, and then choose the appropriate learning object of the knowledge point according to the learner's personalized characteristic.

3.3 Post-test and Evaluation

The result of examination may be changed with different environment or psychological condition, so it is inaccurate to judge his master degree depending on the result of examination. Therefore, we should consider the examination result, and also we should consider the learner's learning activity, such as participating in discussion, answering the questions and so on during the evaluation, teachers can evaluate the learner according to the information of his learning activity. The system can get the final result by considering the examination and the teachers' evaluation and provide the grade to the learner.

4 Application of Learning Resources Organization Model

We implement our algorithm in our system named E-learning Service Platform (ELSP), which has been developed with J2EE. ELSP is a complex e-learning system included learning management system, content management system, testing system and so on. According to the content organization algorithm, the related databases include information of the learner, attributes of knowledge, attributes of knowledge cluster and learning state and style and so on. In which, the learner's information is comprised of name, sex, birthday, password, ID, telephone and email etc. Knowledge point attributes include name, up-node, sub-node, cognitive rank, etc. The learning state and style includes name, learned knowledge cluster, ability level, style, attempt times, test time, difficult knowledge point and the progress of learning and so on. At same time, we design e-learning courseware named "database theory and technology" with a lot of learning objects. The courseware is used for college students in Education Technology in Central China Normal University. The knowledge tree is presented in Fig 6 based on database.

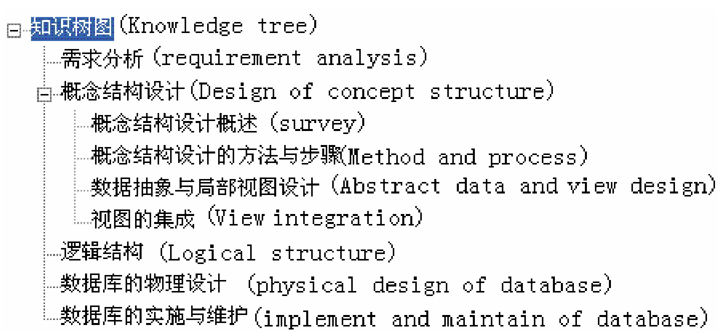

Fig. 6. The dynamic knowledge tree

The following information in fig7 shows the learner's progress, the level of learned knowledge cluster, attempt times and learning time. It reflects the learning situation dynamically.

Name	Learned Knowledge Cluster	Mastering Level	Trying times	Testing time	Difficult knowledge point	Next Knowledge point
Zhang min	Requirement analysis	Better	1	2006-3-20	Null	Design of concept.
Wang fang	Design of concept.	Bad	1	2006-4-20	View integration	Logical structure
Li hai	Design of concept.	Good	3	2006-4-19	Null	Logic structure
Liu ruibing	Logical structure	Good	1	2006-4-26	View integration	Physical design.
……	……	……	……	……	……	……

Fig. 7. Organization and schedule of learning resources

Compared to Simple Sequence Specification, Learning Design Specification, our designed algorithm focuses on the organization and schedule of learning resources according to different learners and learning situation. It mainly has the following merits:

(1) It can dynamic construct the learning content, and provide different content to learners, which met the personalized needs better.

(2) The resources described with e-learning technology standards can realize the resource to be reused and shared.

(3) During the learning process, the algorithm is checking learning situation and learners' state to schedule learning resources, so its performance is better, its efficiency is higher.

5 Conclusions

The paper constructs the learning resources framework model, defines granularity of the learning object, designs the learning content scheduling algorithm, which includes pre-test, knowledge points learning, post-test and evaluation. The paper put forward the learning content scheduling algorithm from knowledge sequencing and personalized representation as two dimensions. the following work mainly includes: (1) the learning activities as an important origin of the testing data, needs the further designing and developing. (2) how to obtain the information of learner's personalized characteristic needs to have further research. (3) the algorithm of personalized presenting the learning object needs to perfect.

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Web Contents Extracting for Web-Based Learning

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Abstract. Web mining has been applied to improve web-based learning. Content-based Web mining usually focuses on main contents of web page. This paper proposes a novel approach to automatically extract main contents from web pages. Compared with existed studies, the method may determine whether a web page contains main contents, and then extracts main contents without using DOM-Tree and template. Main contributions include: (1) Introducing a new concept of Block and proposing a method to partition web page to blocks. Main contents and noise contents may be well partitioned into different blocks. (2) Introducing a concept of Web Page Block Distribution and studying its feature. Based on Block Distribution, we may effectively determine whether the web page contain main contents, and then extract main contents via outlier analysis. Experiments demonstrate utility and feasibility of the method.

Keywords: Web-Based Learning, Web Contents Extracting, Web Mining.

1 Introduction

Web mining has been applied to improve web-based learning. Content-based Web mining usually focuses on main contents of web page, and regards advertisements, navigation sidebar and copyright notice, etc as noise. Noise has a negative impact on analysis of web contents, for example, reducing accuracy of web classification and clustering. Some studies [1, 2] analyzed how noises harm web mining.

In Content-based web mining, usually, it needs to collect web pages, and then determine whether web pages include main contents. We refer having main content page and not having main content page to content page and non-content page respectively. We need to extract main contents from content pages. The existed methods have some limits on applications: (a) all web pages are assumed to be content pages. This assumption, however, is indefensible in application. In most cases, the collected web pages are mixture of content pages and non-content pages. (b) template-based methods assume that web pages coming from same web site have same layout. Hence they may correctly extract contents from web pages matching with template. To get correct contents from all web pages, however, it is necessary to build templates for all involved website. This is a very arduous work. (c) DOM-Tree-based method firstly converts a piece of web pages to a Dom-Tree, then extract contents from the DOM-Tree. Refer to our naive purpose that get main contents from web pages, Dom-Tree, with complicated structure and rich functions, is obviously cost-expensive.

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To solve above problems, a new method need to be proposed. It should be able to distinguish content pages from non-content pages, and then extract main contents from content pages without using template and DOM-Tree.

In this paper, we propose a novel main contents extracting method. Main contributions include:

(1) Define a new concept of block and propose a block-partition method for web page. Without using DOM-Tree and template, main contents and noise may be well partitioned into different blocks.
(2) Define a concept of Block Distribution and study its features. Based on these features, we employ classification method to distinguish content page from non-content page, and then employ outlier analysis to get main contents from Block Distribution.

The remaining of this paper is organized as follows. Section 2 gives a brief introduction to related works. Section 3 represents blocks partition method for web page. Section 4 introduces block distribution concept and its statistics feature. Section 5 gives a thorough study on performance of new method. Section 6 summarizes our work.

2 Related Works

Some works [3, 4, 5] have studied template-based methods on contents extraction of web pages. Li [3] proposes a hybrid method that employed both tag sequence matching and tree matching to extract news from news web pages. Geng [4] firstly generates mapping rules from specified news pages. Then employ these rules to extract information from web page which have same page structure. Yi [5] assumed that layout of web pages is fixed in same website. He builds a Style Tree for the website. Contents of web pages of the website may be well extracted by using Style Tree.

Lin [6] partitions web page to blocks, then build profile vector for each block. According to the entropy value of each feature in a content block, the entropy of the block may be derived. By entropy, blocks are determined being either informative or redundant. Cai [8] utilizes visual cues of web pages, such as layout font size and color, to extract information. Wang [9] proposes STU-DOM tree data structure which may be regarded as a DOM tree with some semantic contextual attributes. Having been pruned, the STU2DOM tree can be used to automatically and accurately extract the useful and relevant contents from HTML document. [10] uses heuristic method to partition web pages, and then calculate probability of individual block. Contents will be extracted from blocks with high probability.

There existed three kind of methods for web pages partition. DOM-Based [11], Location-Based [12] and Visual-Based[8]. [6] uses tag <TABLE> as basic granularity to partition web page. [7] proposes an efficient fragment-aware data structure to model dynamic web pages and detect fragments that are shared among documents.

3 Block Partition of Web Page

On extracting main contents from web pages, some studies firstly convert the web page to a DOM-Tree, and then get contents by traversing the DOM-Tree. Compared with these methods, we want to directly partition web page to blocks, and then store them to a list structure without using DOM-Tree. Due to saving complicated operation on DOM-Tree, Such method may have better time performance on extracting main contents than DOM-based method.

In many studies [6, 10, 12], block is defined as a portion of web page between an open-tag and its corresponding close-tag. Such blocks may contain much noise besides main contents, or main contents will be scattered to multiple blocks.

We try to put main contents to one block without noises, therefore give a new definition of block.

Definition 1 (block and sub-block)**:** Let *S* be a sequence of characters, which represents a piece of HTML document. For a pair of tags in *S*, <TAG>and </TAG>, *s*=(<TAG>,..,</TAG>) $\subset$ *S* is a sub-sequence in *S* starting from <TAG> and ending in </TAG>. For any sub-sequence $s_i \subset S$, if $\exists$ $s_j \subset s_i$, (s_i - s_j) is called as Block, otherwise s_i is called as Block, denoted as *B*. s_j is called as sub-block of s_i.

Block *B* consists of a pair of tag <TAG>, </TAG> and contents *c* between the two tags. s_i, s_j are two sub-sequence corresponding to blocks b_i, b_j in *S* respectively. If $s_i \cap s_j \neq \emptyset$, we call $b_i \cap b_j \neq \emptyset$.

Definition 2 (Block List)**:** Let BSet be a block collection of a partitioned web page, Block-List be a List storing BSet. A node in Block-List corresponds to a block $b \in$ BSet. Each node consists of two fields *t* and *c* where *t* registers open-tag of block *b*, *c* registers content of *b*.

Figure 1 gives an example for Block-List. By analyzing structure of web page, we get Observation 1.

Observation 1: (1) most of tags in HTML documents usually occur in pairs. A pair of tags consists of an open-tag <TAG> and a close-tag </TAG>. Contents of web page appear between tags. Tag pairs occur in embedment, for example, <table><tr></tr> </table>. (2) Some tags may appear in crossing, for example, <Table><Form></Table> </Form>. (3) Some tags may occur in single, for example,
,<p>. (4) Some web pages do not strictly comply with HTML regulation. Some tags fail to occur in pairs, we call them *missing tag*.

After eliminating *crossing tags*, *single tags* and *missing tags*, all tags in HTML documents will occur in pairs and embedment. Such HTML documents is called normalized HTML document, which may be made by using some techniques. This paper assumes all HTML documents involved in our work are normalized.

With some tests, we have observed that following techniques may well partition web page. (1) Holding tags involving structure of web page, for example <TABLE>, <TR>, <TD>, <DIV>. (2) Neglecting denoting tags, for example <FONT>, <SPAN>. (3) Skipping tag-pairs which are unrelated with contents of web page, for example <STYLE>, <SCRIPT>. (4) <A> are regarded as structure tag.

To partition a piece of web page to blocks defined in this paper, new method need to be proposed.

We use a stack to aid blocks-partition for web page. On scanning web page, once an open-tag is met, a block will be built. Then the block is inserted to Block-List, in the meantime the open-tag and reference of the block are pushed to stack. Top tag in the stack will be popped when a close-tag is met. Whatever tag is met, contents between the tag and former tag will be extracted. Then insert them to block corresponding to top element in stack.

This method is simpler than DOM-based method. Algorithm 1 describes the process of blocks-partition.

Algorithm 1. web page partition block

```
Input: HTML document f
Output: Block-List BL
s←build_aid_stack (); BL←build_Block_list ();
while( NOT EOF of f){
  tag←getNextTag();
  content←getContent();  //get contents between current tag and former tag
  block←getTop();        //get block corresponding to top tag in stack
  insert (content, block)   //put contents to the block
  If (isNeglect (tag) ) continue;  // is insignificant tag?
  If (isJump (tag))   //is skipped tag?
    {jump(); continue;} //skip tags and contents between them
  If (isOpenTag (tag)) {    //is open tag?
    block←new Block(tag)
    insert (BL, block);   // insert new block to Block-List
    push (s, tag, block);  // put tag and reference of block to stack
  }else                   //is close tag?
    pop (s);
} /* end of while */
```

Lemma 1: Given a piece of HTML document *f*. Time cost of building Block-List and DOM-Tree for *f* are t_1 and t_2 respectively. $t_1 < t_2$ may be concluded.

Rational: Let t_1_T and t_2_T be time cost of scanning *f* on building Block_List and DOM-Tree respectively, t_1_I, t_2_I be time of inserting contents to Block_List and DOM-Tree respectively. $t_1 \approx t_1$_T+t_1_I, $t_2 \approx t_2$_T+t_2_I. (1) On building Block-List, some tag-pairs may be omitted or skipped. However each tag will be process on building DOM-Tree. Thus, t_1_T < t_2_T. (2) inserting contents to Block_List is a simple operation by getting reference of block from top element of stack. However, before inserting contents to DOM-Tree, inserting position must be located in DOM-Tree. Thus, t_1_I < t_1_I. (3) By (1) and (2), thus, $t_1 < t_2$.

Example 1: Use Algorithm 1 to build Block-List for web page shown in Fig.1(a). Fig.1(b) is derived Block-List.

```
<DIV>Hello
  <TABLE><TR><TD>USA</TD></TR>
  <TR><TD>CHN</TD></TR></TABLE>
  <DIV>GBK</DIV>World
</DIV>
```

Fig. 1(a). A portion of HTML document

DIV	TABLE	TR	TD	TR	TD	DIV
Hello World			USA		CHN	GBK

Fig. 1(b). Block-List

4 Block Distribution and Main Contents Extraction

In practical application, before extracting contents from web pages, first step is to determine whether web pages contain main contents. Web pages may be are divided to two types, content page and non-content page. For non-content page, there are various information in the page except for main contents. For content page, it contains a main contents. Fig 2 gives an example of content page and non-content page.

To distinguish content page and non-content page, it is needed to study features of web page, and then use these features to classify web pages.

Fig. 2 (a). Non-content page

Fig. 2(b). Content page

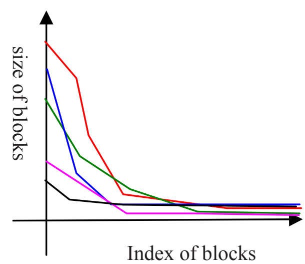

Fig. 3. Curve of block distribution

Definition 3 (Block Distribution and Block Distribution Curve)**:** Given a Block-List *BL*. Let o be a node in *BL*, c be content of o. n be size of c. A collection of $\{n_1,\ldots, n_k\}$ represents size of all blocks in *BL*. After the collection is sorted in descending order, we call the sequence $D =(n_1,\ldots, n_k)$ as block distribution of web page. Let y-axis represents n_i and x-axis represents index of n_i in D. D is represented in a piecewise curve, called Block Distribution Curve.

By using Algorithm 1, we can derive Block Distributions for web pages. Fig 3 shows example of Block Distribution Curve. Algorithm 1 may well put main contents to one block, and scatter noise to multiple blocks. If content block is large enough, then Block Distribution of content page and non-content page will appear obvious difference. For example, in Fig. 3, Block Distribution Curve of content page, Curve 1, is steeper than a Block Distribution Curve of non-content page, Curve 5.

Lemma 2: Let Var (D) denote variance of block distribution. $D_1=(n_1,\ldots, n_m)$, $D_2=(n_1 +k,\ldots, n_m)$, k>0, are block distributions of two piece of web page. Value of D_1 is equal to D_2 except for value in index 1. Then Dev (D_1)> Dev (D_2) can be concluded.

Proof: see appendix

Lemma 2 shows that the larger size of main content block is in a Block Distribution, the larger variance Block Distribution has. Because there are not obvious large block in Block-Distribution of non-content page, its variance will be small. Therefore variance may be used to distinguish content pages and non-content pages.

However, sometimes only using variance could not get enough good result. Test 2 in section 6 demonstrates that only using variance to distinguish content and non-content page could not get enough good accuracy. So we introduce a new feature for block distribution.

Definition 4 (Bending of Block Distribution β)**:** Let $D=(n_1,\ldots, n_m)$ be Block Distribution of a piece of web page. In Block Distribution Curve of D, α_i (i=1,…,k-1) is rate of slope of a piece of curve. $\beta(D)=\left|Max(\alpha_1,...,\alpha_{k-1})-Min(\alpha_1,...,\alpha_{k-1})\right|$ is called as the bending of D.

If there existed two blocks that have same size in a Block Distribution, bending means maximum difference between two adjacent blocks in the Block Distribution. For example, bending of Block Distribution $D1$=(5, 2, 2, 2, 2) are $\beta(D1)$=3.

After deriving variance and bending of each Block Distribution, classification algorithm may be employed to distinguish content pages from non-content pages. Test 2 shows that classification methods may well distinguish content pages and non-content pages based on the two features.

In content pages, main content block is large and sparse. Corresponding to noise blocks, it is suitable to consider content blocks as outlier. In application, we employ deviation-based outlier detection algorithm [13] to derive content blocks. Contents in content blocks are main contents of a piece of web pages. Experiments demonstrate feasibility of our method.

5 Experiments and Results

In this section, we will perform a thorough analysis for our method. All experiments were implemented in Java and conducted on an Intel P2.6G system with 512M of RAM.

5.1 Dataset

Experiments are conducted on three data sets. Dataset1 consists of 543 piece of web pages (220 for content pages (news page), 323 for non-content pages) collected from website SOHU, YAHOO, CHINA and Netease. Dataset2 come from Chinese Web

Training Set CCT2006 in CWIRF[1]. It consists of 1200 piece of content pages. Dataset3 consists of 184 piece of content page collected from SOHU.

5.2 Experiment 1

Experiment 1 compares time performance of building Block-List and DOM-Tree. Fig. 4 illustrates accumulating time on building Block-List and DOM-Tree for all web pages in Dataset2. Accumulated time difference on building Block-List and DOM-Tree is increasing while more pages are processed. At the end of experiment, building Block-List spends about 30 second lesser than building DOM-Tree. It can be concluded that building Block-List need lesser time than building DOM-Tree.

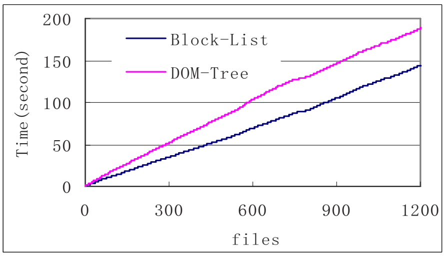

Fig. 4. Comparison of time performance

5.3 Experiment 2

Experiment 2 evaluates validity of using variance and bending of block distribution to distinguish content pages and non-content pages.

Firstly, we get block distribution of each web page in Dataset1 and Dataset2, and then compute their variance and bending. Experiment 2.1 uses Naïve Bayes, KNN and ADTree provided by weka[2] to conduct classification on dataset1. Table 1 shows results of the classification which use Accuracy as criterion.

$$Accuracy = \frac{correctly \quad labeled \quad documents}{all \quad documents}$$

Data of experiment 2.1 in Table 1 shows best classification can be derived by using AD-Tree whose accuracy is 98.3%. Experiments 2.2 uses Dataset1 as training set to build classifier based on NB, ADTree and KNN respectively. Then it uses these classifiers to conduct classification on dataset2. Table 1 shows result of Experiment 2.2 where ADTree wrongly classify 81 pieces of web pages, which have too short main contents.

Experiment 2.3 and 2.4 also use Dataset1 as training set to build classifier. Then they conduct classification on Dataset2 by separately using variance and bending. Table 1 shows we can get best accuracy by using variance and bending together than do so by separately using one of two features.

[1] http://www.cwirf.org

[2] http://cs.waikato.ac.nz

Table 1. Classification test

	Exp. 2.1	Exp. 2.2	Exp. 2.3	Exp. 2.4
NB	96.9%	88.5%	79.4%	84.6%
ADTree	98.3%	93.3%	85.9%	89.5%
KNN	95.6%	86.3%	80.5%	81%

Experiment demonstrates that three kind of classification algorithm all can derive good result. Thus using variance and bending to distinguish content and non-content pages is effective.

5.4 Experiment 3

Experiment 3 uses outlier detection algorithm to extract main contents from a new dataset, which consists of 220 pieces of content page in Dataset1 and 1119 pieces of pages being correctly classified on Dataset2 by ADTree. If the algorithm may extract most of main contents and not contain noise, it will be regarded as correct extraction. Table 2 shows the number of pages being correctly or wrongly extracted. By using outlier detection, accuracy of main contents extract may reach 99%.

Table 2. Extracting of main contents

	correct	incorrect	accuracy
Dataset1	215	5	97.7%
Dataset2	1103	16	99%
Total	1318	12	99%

5.5 Experiment 4

Experiment 4 compares our method (B-D in short), template-based method (T-B in short), which use idea of [4], and K-FeatureExtractor (K-F in short) on 220 pieces content pages of Dataset1 and Dataset3 respectively. Uniformly with Experiment 3, if most of main contents of a piece of web page can be extracted and not contain noise, we will consider extraction being correct.

Tabel 3. Comparison of algorithm

	Dataset1	Dataset3
T-B	26.8%	98.9%
B-D	97.7%	97.2%
K-F	85.3%	88.6%

On dataset3, T-B and B-D both have high accuracy. However, when we use template built from SOHU website to extract main contents on Dataset1, accuracy is only 26.8%. B-D has 97.2% high accuracy. This show that template-based method only can get high accuracy in web pages whose template has been built. It has great limits in practical application. We will fail to get correct contents unless template has been built.

K-F always contains some noises in the derived main contents. Accuracy of K-F is 8%~11% lower than B-D when it is strictly regulated that extracted main contents must not contain noise.

6 Conclusions

In many web mining applications, there are needs to determine whether web pages contain main contents, and then extract main contents from content pages. This paper defines the new concepts of blocks and block distribution and proposes block-partition algorithm to meet the need. Main contents and noise of web page may be well partitioned to different blocks by our algorithm. Based on feature of block distribution, classification algorithm may well distinguish content and non-content pages. Regarding main content block as outlier, this paper uses outlier detection algorithm to extract main contents from block distribution. Experiment shows the new method is effective and efficient. The new method has been employed to web mining applications and has got good effect.

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Appendix: Proof of Lemma 2

Proof: Let $\overline{n}$ be average value of D_1. All values in D_2 is equal to value in D_1 except for value in n_1 is K lager than in D_1.

Let DEV(D_1)= $\frac{\sum_{i=1}^{m}(n_i-\overline{n})^2}{m}$, DEV(D_2)= $\frac{(n_1+k-\overline{n}-\frac{k}{m})^2+\sum_{i=2}^{m}(n_i-\overline{n}-\frac{k}{m})^2}{m}$ be Variance of D_1, D_2 respectively. Because $\sum_{i=1}^{m}(n_i-\overline{n})^2 = (n_1-\overline{n})^2+\sum_{i=2}^{m}(n_i-\overline{n})^2$

$$\tag{1}$$

and $(n_1+k-\overline{n}-\frac{k}{m})^2+\sum_{i=2}^{m}(n_i-\overline{n}-\frac{k}{m})^2=$

$$(n_1-\overline{n})^2+2(k-\frac{k}{m})(n_1-\overline{n})+(k-\frac{k}{m})^2+\sum_{i=2}^{m}\{(n_i-\overline{n})^2-2(n_i-\overline{n})(\frac{k}{m})+(\frac{k}{m})^2\} \tag{2}$$

To prove DEV(D_1)< DEV(D_2), it is sufficient to prove

$$2(k-\frac{k}{m})(n_1-\overline{n})+(k-\frac{k}{m})^2+\sum_{i=2}^{m}\{-2(n_i-\overline{n})(\frac{k}{m})+(\frac{k}{m})^2\}>0 \tag{3}$$

To prove equation 4, equation 5 need be proved

$$\frac{2k}{m}((n_1-\overline{n})+\sum_{i=2}^{m}(n_i-\overline{n}))<2k(n_1-\overline{n})+(k-\frac{k}{m})^2+(\frac{k}{m})^2 \tag{4}$$

To prove equation 5, equation 6 need be proved.

$$\frac{2k}{m}\sum_{i=1}^{m}(n_i-\overline{n})<2k(n_1-\overline{n})+(k-\frac{k}{m})^2+(\frac{k}{m})^2 \tag{5}$$

Because n_1 is the largest value in D_1, Therefore Equation (7) may be got.

$$n_1-\overline{n}>\frac{1}{m}\sum_{i=1}^{m}(n_i-\overline{n}) \tag{6}$$

By (7), Equation (8) can be got

$$\frac{2k}{m}\sum_{i=1}^{m}(n_i-\overline{n})<2k(n_1-\overline{n}) \tag{7}$$

According to (8), Equation (6) may be proved if $0<(k-\frac{k}{m})^2+(\frac{k}{m})^2$

Because k>0, we can get $(k-\frac{k}{m})^2+(\frac{k}{m})^2>0$, Therefore, lemma 2 may be proved.

ERDRM: A Digital Rights Management System Model for Educational Resources

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Abstract. The intellectual property protection problem has been an obstacle to restrict the development of distance education. Enhancing the intellectual property protection of educational resources will make great realistic significance in improving quality of distance education. DRM provides technological support to the intellectual property protection in distance education. In the first part of this paper, we introduce the current situation of DRM technology and its fundamental features. And then, through analysis of the special demands of the educational field and contrastive study of security technology available currently, we bring forth the ERDRM, a digital rights management system model for educational resources.

Keywords: distance education, educational resources, intellectual property protection, DRM.

1 Introduction

In the era of knowledge-based economy, it has been accepted to all that we should set up lifelong education system and build a learning society. The foundation and premise for these is the development of modern distance education, which is most important in a populous nation such as China. Quality is all a lifeline of distance education, but the intellectual property protection of educational resources has been an issue which restricts the quality of distance education. There have been a number of relevant laws do with the intellectual property protection on the Internet, but just legal restriction is far from enough, technological support is needed.

Digital Rights Management [1] (DRM for short) is a series of hardware and software technologies which protect the rights and benefits involved in all kinds of digital contents. It ensures that the digital resources is legally used in its total life cycle, balances the benefits and requirements of all entities involved in the value chain, and promotes the information dissemination and the development of whole digital market. Concretely, DRM includes the description, identification, transaction, protection, supervision and auditing of multiform usage of digital resources. DRM provides permanent protection measures for the resources, which prevent unauthorized or authorized limited access to the digital resources.

F. Li et al. (Eds.): ICWL 2008, LNCS 5145, pp. 69–78, 2008.

The main driving force of DRM comes from industry [1]. The most representative sample is the protection of eBook, electronic music, and digital movie. Several famous international companies have release their own solutions and productions, such as Microsoft's WMRM, Real Networks' Helix DRM, Adobe's Content Server, and IBM's EMMS.

2 Current DRM Systems

2.1 Classification of DRM Systems

Existing DRM systems could be classified into different categories according to different standards (such as safety technique chosen, protected object, etc.). The protected objects include: software, eBook, images, stream media and contents on mobile devices.

The main function of software-protected DRM system is the precaution of software piracy. The protection of software appeared in the 1980s, which could be regarded as the earliest application of DRM. In the early times, the methods to prevent software piracy include the usage of key floppy disk, copy-proofed CD, encryption card, etc. Many new software-protection forms appear along with the development of DRM technology and network technology.

The eBook-protected DRM systems have two kinds of applications: the online bookstore (such as Amazon, eReader), and the digital library (such as netLibrary, Apabi). The online bookstore sells eBook directly to the readers while the digital library only provides borrowing service, and both of them have to protect the rights against infringement by third parties.

The images-protected DRM systems are somewhat complex. Some websites attach their own logo onto the images to prevent others from using it illegally. But the visible logo sacrificed the image's quality. Another preferable method is to embed the copyright information into the images by digital watermarking. If someone used the images without authorization, the owner could detect the copyright information hided in the images with special software, and prove it. Now the companies who focus on digital watermarking include: Digimarc in USA and High Water Signum in England. They provide similar service. In China the "Patriot Banshen" digital watermarking system could satisfy the requirement [8]. Digital watermarking could also be used in stream media market.

The stream media-protected DRM system protects electronic music, electronic movies and videos. Now some marketers have used DRM technology. Some famous stream media systems have their own rights management solutions, such as WMRM, EMMS and Helix DRM, etc.

The DRM system used on movable device can protect images, ringtone, mp3, mp4, etc. Because the movable platform is different from PC platform, the embedded systems present new technological demands on DRM. At present, some mobile phone (such as Nokia) has applied DRM technology supporting OMA DRM. [15] Along with the development of intelligent mobile phone, the DRM still cannot achieve real copyrights protection.

2.2 Decisive Concepts in DRM

The research on DRM always includes the architecture, content security, rights expression, as well as authentication. The systems are different in those points. This section is mainly about their characteristics, and gives a contrast on current DRM systems.

Architecture. The generic DRM architecture accepted to all includes three core components: the content packaging server, the license server and the client [2], [3].

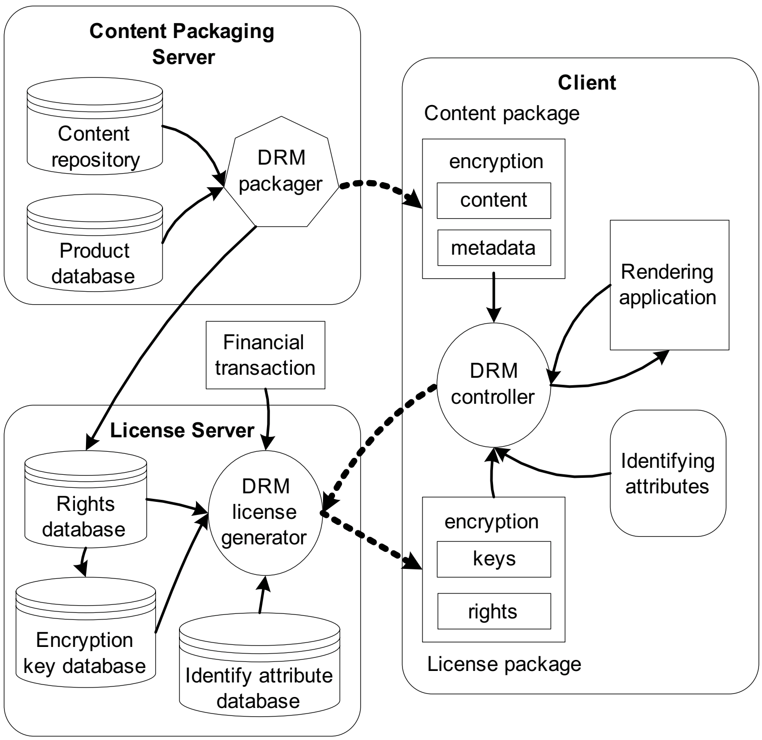

Fig. 1. The generic DRM architecture

The DRM packager in content packaging server encrypts the content and transfers them to the user through P2P, email, or downloading service, etc. the rights package will be transferred to license server.

The DRM controller in client determines the way the user using the content, through policies bound to the package and implicit in the packaging format, that the requested use requires authorization. If the license cannot be found on the user's machine or has expired. The DRM controller should make rights request by packaging and sending attributes of the user and the content to a license server.

The license server verifies the submitted client identification or attributes credentials, creates license, packaged and transferred to client securely.

For more information about DRM architecture, you may access [2], [3], [4].

Content Security. Generally, the protection of digital content is based on encryption technology, namely encrypting the digital content at first before distribution. So the unauthorized user cannot get valuable information even they have intercepted the content during transmission successfully. Digital watermarking is a new direction in information security field. It can protect the copyright and integrity of information. Digital watermarking is applied in those fields: remote monitor and control, owner authentication, ownership verification, operation tracking, content identification, copy restriction and device control.

Rights Expression. Rights Expression plays an important role in DRM, it works by rights expression language (REL). Existing works in this area include the INDECS project. One of the basic distributions of this project is clearly separating and identifying the three core entities: Users, Content, and Rights [3]. Users can be any type: from a rights holder to an end consumer. Content also can be any type of content at any level of aggregation. The rights entity is an expression of the permissions, constraints, and obligations between the Users and the Content. Most of the existing RELs are XML-based. The two most developed RELs are XrML [14] and ODRL [12], [13].

Authentication. Authentication is a fundamental part of any DRM system, because it is the foundation of rights management. The DRM system verifies the reality and validity of the user's identity, then determines whether make authorization or not with the results. The most applied authentication technologies are password-confirming and hardware binding.

Table 1. A Contrast among the systems

Concepts / protected Objects	Architecture	Content Security	Rights Description	Authentication
Software	C/S Structure	Encryption, Digital Watermarking		Hardware ID Software ID
eBook	Typical Structure	Encryption, Digital Watermarking	EBX	User/Password
Stream Media	Typical Structure	Encryption, Digital Watermarking	XrML/ MPEG REL	User/Password Hardware ID
Mobile	Typical Structure	Encryption	OMA DRM	User/Password Hardware ID
Image		Digital Watermarking		

A Contrast among Systems. Actually, the DRM systems have both same and special characteristics in the four aspects mentioned above. As shown in Table 1.

The digital rights management of images is somewhat complex, and the relevant technologies are not mature enough. Most of the researches are limited to the declaration of the rights ownership and the tracking of rights by digital watermarking. It is always used after the act of tort has happen. We will not make a conclusion in this paper.

3 Digital Rights Management in Education

Digital rights management is complex and difficult regardless of the application domain. Nonetheless, education places some very specific demands on it. This section introduces the specific requirement presented by education for DRM, discusses the security technology available, and analyzes their merits and demerits.

3.1 Specific Requirements Presented by Education

IEEE LTSC DREL Study Group makes a deeply study on the domain features of education, learning, and training [4]. The prominent ones of them are listed below:

- In the education area, the education resources may have multiple authors for the joint authorship is very common. The educational resources may be reconstructed from multiple learning objects. The rights expression language of the DRM system must be able to identify rights information associated with component learning objects and with contributing authors as distinct from rights associated with aggregate works.
- In web-based education, the users participate in learning, reuse the educational resources, and all of these will raise the privacy problem, for the privacy may be protected by privacy acts and local policies. The DRM system has to consider these acts and policies carefully.
- Learning, education and training are all highly local activities, yet the education resources will be created and distributed across jurisdictional and domain boundaries in a distributed education. So the rights should be expressed from a combination of local and global context.
- Actually, Profits is always not the main objective of creating the intellectual property in education, and the attribution seems more important. Most of the authors are wish to share their ideas if they are in fact properly acknowledged with some constraints, even the constraints may be different according to the practical situation.
- In the copyright laws, there are always some items about "fair use" refers to education and research, as a result, maybe we cannot just divide the users simply into the authorized and the unauthorized.

3.2 Security Technology Issues

Security technology issues must be considered in digital rights management application. Actually these issues include authentication and content security which were mentioned above in section 2.

Authentication is the foundation of rights management, and it is also a very important part of DRM system. The DRM system verifies the reality and validity of the user's identity then make decision with the results. Most of the e-learning systems are made up by databases and platforms, in which different platforms provide different services. The COLIS project [5] in Australia use SSO to realize the integrity of services. SSO means a user signs on once in a system, he or she could access all the systems that trust the first system. SSO is integrity on the "Authentication" level.

Content Security can be realized by digital watermarking or data encryption technology. Also there is web scripting technology can be used in DRM for educational resources for most of the resources can be formatted by HTML.

Digital Watermarking. Digital watermark is a pattern of bits inserted into digital images, audio or video files that identifies the file's copyright information (author, rights, etc.), but these information are always invisible, or in the case of audio clips, inaudible. Moreover, the actual bits representing the watermark must be scattered throughout the file in such a way that they cannot be identified and manipulated. And finally, the digital watermark must be robust enough so that it can withstand normal changes to the file. The purpose of digital watermarks is to provide copyright protection for intellectual property that's in digital format.

Digital watermark is just for tracking the copyright information other than assuring the security of content. It can be used in the protection of sharable educational resources.

Data Encryption. Data encryption is the basic security technology in the network. Encryption is the most effective way to achieve data security. It is a proactive defense policy, provides huge security with very small cost. There are two main types of encryption: asymmetric encryption (also called public-key encryption) and symmetric encryption.

Encrypting digital works is foundational in copyrights protection. The content protection in DRM is mainly based on encryption. To read the encrypted file, you must have access to a secret key or password that enables you to decrypt it. Most of the existing stream media DRM systems are based on data encryption technology. Although very safe, these systems go against retrieval, go against the sharing and communication of educational resources.

Web Scripting Technology. The web scripting technology controls access to the web page's content by inserting functional scripting code into the source code. Such as disabling right click, disabling select, disabling edit, disabling printing, and so on. It also could restrict the time of access and operation. This method can protect educational resources on certain level, but this low security is only satisfied the demands of some valueless resources.

Data encryption and digital watermarking both have their own merits and demerits, as shown in Table 2.

Table 2. Comparison of data encryption and digital watermarking

Data Encryption	Digital Watermarking
Control the access to the content	Detect and track the hiding content
Content-irrelevant	Content-relevant
The terminal has to demonstrate the decryption process	The terminal has not to demonstrate the decryption process
Attacking techniques is mainly signal processing, which will make the content hides invaliable	Attacking techniques is mainly decryption.
Has intensity of D/M and M/D	Has no intensity of D/M and M/D
System security has nothing to do with the terminal device	System security is determined by security of terminal device

4 The ERDRM System Model

Based on the previous sections, this section brings forth the ERDRM, a digital rights management system model for educational resources.

4.1 Functional Components of the Model

Educational resources is based on a collection of files, including text, images, video and other multimedia formats, but most of the formats cited above can be expressed by HTML files, and HTML, GIF and JPG are common formats used in learning objects. Our system applies C/S infrastructure. There are server-side and client-side in this model. The server provides three services: content packaging, licensing management, content distributing. The core of Client is the trusted Add-on, which is in charge of the requesting and executing of rights. Fig. 2 describes the functional components in detail.

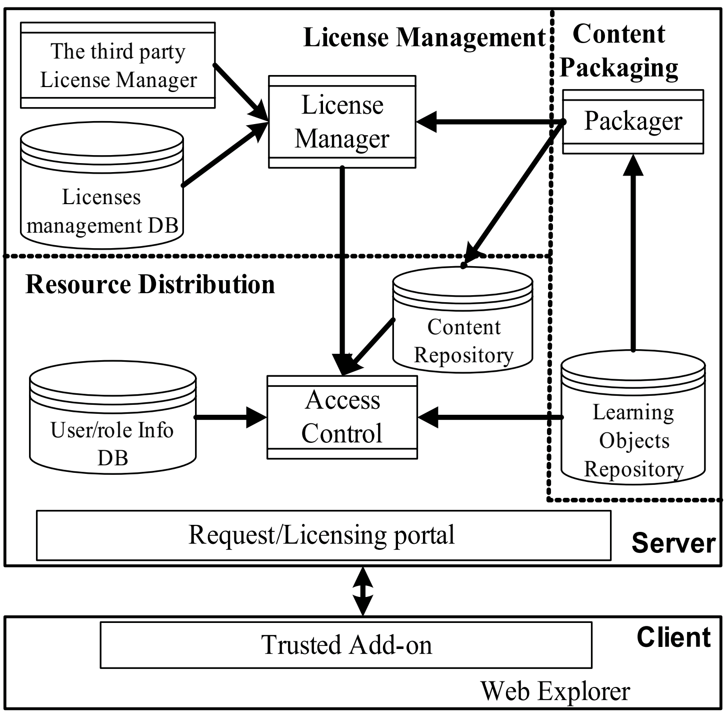

Fig. 2. The model's functional components

Content Packaging. This module includes learning objects repository and packager. Granularity is a key issue must be considered in the protection of resources. This model encrypts and protects the content in denomination of learning object. The educational resources to protect are stored in the learning objects repository. The packager encrypts and packages the educational resources, and sends to users along with the metadata. It also creates the rights, keys and other information which will be delivered to license management module.

License Management. This module includes license manager, license management DB, and the 3rd party license manager. It is mainly used to receive the request comes from client, create and distribute license. License is a computer file consists of permissions, keys and information about the author and distributor. Enlightened by Osvaldo's work [11], we use the third party license manager because of the reusable features of educational resources. If the learning object is aggregated with another object and that one was protected, the third party license manager works.

Resources Distribution. This module includes user/role information DB, content repository, and access control, as well as a request/licensing portal. It handles the user authentication, access control policy, education resource distribution and financial business.

Client. This is a web explorer which contains a trusted Add-on. It helps users to access and use the educational resources. The trusted Add-on collects users' identities and other information, controls the usage of the content. If no license is found, it will make a license request to license manager.

4.2 Expression, Control and Implementation of Rights

Expression, control and executing of the rights information flow are very important in DRM. As mentioned in section 1, both XrML and ODRL are XML-based and they have been accepted by several standards organization. XrML is perfect but complex, its parser is bulky and takes long time to download and run. XrML is protected by patents. All these make it is far from a suitable REL for educational resources DRM systems. On the other hand, ODRL has been a standard of OMA's mobile DRM rights expression language. COLIS, OPENIPMP and many other projects have applied ODRL as an REL. In our model, we still apply ODRL as reference REL.

4.3 DRM System on e-Learning Platform

Digital rights management of educational resources is part of the e-Learning platform, so it has to integrate seamlessly with the other systems, such as learning management system, learning content management system and resources management system (Fig. 3).

All entities in DRM-enabled e-Learning platform have to support the expression, management and control of the learning object's rights information. Learning object's rights information flow exists in the whole lifecycle. A simple example, learning content management system gain educational resources with rights attributes from resources management system, and delivered them to learning object exchange system in security, the DRM system protects the learning objects to be distributed and add relevant authentication and rights information on them, then learning management system manages the license and permissions. The user accesses and uses protected learning objects while he or she participates in the activities of learning management system as authorized. The user can reuse the learning object to create a totally new learning object.

Modules in a whole e-Learning platform have all kinds of interactions, which isn't limited to the situations mentioned above. In DRM-enabled e-Learning platform, DRM system works on the Parties directory, learning object exchange system and learning management system. In a broad sense, all entities have participated in the implementation of digital rights management.

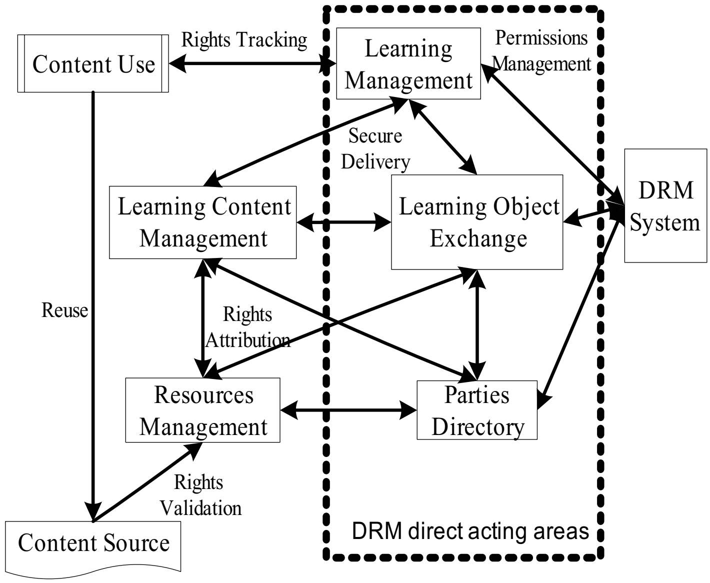

Fig. 3. DRM-enabled e-Learning platform

5 Conclusion

Many e-Learning organizations and high schools have attempted to apply DRM technology in web-based education, but most of them focus on rights expression language and the standards. There is no real mature solution for the realization of digital rights management. By analyzing the education's particular demands on digital rights management, we proposed a digital rights management system model for educational resources. We studied the expression, control and execution of rights and the relationship between DRM system and other systems on e-Learning platform in section 3. Our next work is developing the product system based on the model. Many of these open issues and problems are intertwined and will require an integrated approach to be satisfactorily resolved, and this is the work we should make great efforts in the future.

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14. eXtensible rights Markup Language, http://www.xrml.org/
15. Open Mobile Alliance, http://www.openmobilealliance.org/

Course Material Research Based on Perti Net

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Abstract. Many designers pay much more attention to establish an e-learning system but ignore to judge what material is proper for courseware merger. This paper tries to realize it via the Petri net. The relationship between material and knowledge point (KP) is closely. So, in order to use the Petri net, it presents the relationships among KP as the net firstly. Based on the relationships among KP, It analyzes the relationships among material in detail and brings forth the material sets (MS) net. And then, it gives the formalization description of the material Petri net (MPN) based on the Petri net (PN) and provides the method of the transformation from the MS net graph to MPN. When material is merged into the courseware, some speciality of material can be checked by the MPN. The experiments shows that the MPN can validate the reasonableness of the material merger effectively.

Keywords: Petri net, material, courseware.

1 Introduction

The syllabus consistes of some knowledge point (KP), and KP may be reflected in the different types of material. The method, which puts material and KP together, aids teacher to organize the individual courseware automatically. Some researchers concern the researchs of the KP[1, 2, 3], others concern the construct of e-learning[4, 5, 6]. They have the good idea of utilizing e-learning[7, 8]. However, many intelligent tutor systems organize the material into a suitable special courseware ineffectively. Although the KP is in closely connection with the material, the KP and the material have a lot of different still. The KP in the syllabus is always reflected in some material, and the material always reflects some KP. When the material is discussed, the relationships between the material and the KP must be concerned together. If we ignore this point, we would have difficulty to validate some cases.

- When the courseware is designed, any KP reflected in the material in the courseware does not excess the scope of the syllabus.
- If the material is learned in the courseware, it must reflect in one or more KP in the syllabus.
- the material taught at the earlier stage does not use the KP reflected in material taught at the latter stage.

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- When adding new KP to the syllabus, the material reflecting this KP must be added into the courseware also.
- When the KP does not longer present in the syllabus, any material reflecting this KP must be deleted in the courseware. Meanwhile, the KP reflected in the remaining material must be enough for the students to learn the syllabus.

In order to deal with these cases, this paper discusses the relationships among KP and the relationships among material. On the basis of them, it provides material Petri net (MPN) to validate some material property. It is organized as follows. Section 2 describes the KP net and clarifies the relationships among KP in the syllabus. Based on KP net, Section 3 presents the material net. Section 4 introduces Petri net and gives the definition of MPN. Then, it researchs some material property by the MPN. In the section 5, it draws a conclusion and presents the future work.

2 Knowledge Point

2.1 Overview of KP

The whole knowledge in a book consists of some KP, and these KP distribute from the various charpters. It is essence that various material reflecting KP is learned in the e-learning. In order to describe material, we must give some related conception of KP firstly.

Well-known, the KP is an teaching unit including knowledge in the learning process.

From the conception of KP, we know that KP is demarcated according to requirement. It brings forth a question about how to divide knowledge into KP properly? It is the basic principle of the knowledge demarcation that the partial completeness must be ensured[4]. For example, one chapter in the book may be a large KP. The contents of chapter may be divided into some sections also. A section of in the chapter may be divided into some less KP again. However, if KP is continuously divided, it would not reflect concrete knowledge contents lastly. Hence, we have two conceptions:

- Atom KP: if the knowledge of the KP is further splitted, there would not exist any completeness knowledge contents. This KP is called as Atom KP.
- Composite KP: if the knowledge of the KP may be divided into less KP reflecting knowledge contents, this KP is called as Composite KP. If the KP C consists of the KP A and KP B, it is called as the parent of KP A and KP B. KP C is a Composite KP. The KP A and the KP B are called as children of KP C. All of children of one KP are called as brother KP each other.

2.2 Relationships among KP

The parent-child, the association and the parallel are three relationships among KP:

- parent-child relationship: it is the relationship between a Composite KP and its children KP.
- association relationship: it is the relationship that a KP may be learned directly after another KP have been mastered.
- parallel relationship: if the relationship between two KP is not the parent-child relationship and the association relationship, it is a parallel relationship.

In the association relationship among KP, if a KP must be mastered directly before another KP is learned, it is called as the Ancestor KP for another KP. if a KP may be learned directly after another KP has been learned, it is called as the Descendant KP for another KP.

2.3 KP Net Diagram

The relationships among KP are described with a net structure[4]. The Composite KP can be divided into some little KP. On the grounds of parent-child relationship, if a material reflects in an Atom KP, it will also reflect in the parent KP of this atom KP. So, on the discussion below, we assume that all KP should be atomistic.

An arc is expressed as the association relationship among KP. The arrowhead directs from the Ancestor KP to the Descendant KP. If a KP has an arc pointing at it, this arc is called as In-arc for this KP. If a KP has an arc backing at it, this arc is called as Out-arc for this KP.

Definition 1 KP net: it is the net that is made up of the KP and the relationships of them. The node means the KP and the arc means the association relationship of the KP.

In an ordinary way, the KP net is an directed acyclic graph. See figure 1.

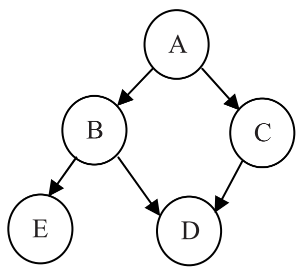

Fig. 1. KP Net

At the figure 1, *A, B, C, D* and *E* means some Atom KP in the courseware. The relations of *A* and *B, A* and *C*, *B* and *E, B* and *D, C* and *D* are the association relationships. *A* is the ancestor *B* and *C*. *B* and *C* are the descendant of *A*. Likewise, *D* is descendant of *B* and *C*. *B* and *C* are the ancestor of *D*. the relationship between *B* and *C* is the parallel, and the relationship between *D* and *E* is the parallel also.

3 Material

3.1 Material Set

Material is a media that can reflect some KP independently. It may be a document, picture, sound, etc. The relationship between the material *X* and the KP *A, B* can be expressed as *X={A,B}*. The expression *X={A,B}* means that the material *X* reflects the KP set, which includes KP *A* and *B*.

The relationship between the material and the KP is many to many. One material may reflect with much KP, and one KP may be reflected with much material. The material reflecting one KP can be learned only if learner masters the Ancestor KP of this KP. Further, learner must master the Ancestor KP of this Ancestor KP. Obviously, the KP set, which includes the Descendant KP and the Ancestor KP, is redundant. It might be simplified. The algorithm is described as follows:

Step 1. selecting any element in the KP set described by material;
Step 2. searching all paths from starting KP to this KP;
Step 3. in the KP set reflected in the material, deleting all elements in the paths except for itself;
Step 4. selecting the remain element in the KP set, and repeating step 2. and step 3;
After all elements in the KP set reflected in material are selected, the KP set, which only includes the surplus elements, is the simplest KP set of this material.

Example 1: To figure 1, Supposed the KP sets reflected in some material as follows. *X1={A}, X2={A}, X3={A,B}, X4={A,B,C,D}, X5={A,C}, X6={A,B,C}, X7={E}*. After simplified, the KP sets is described as follows. *X1={A}, X2={A}, X3={B}, X4={D}, X5={C}, X6={B,C},X7={E}*.

Because there are much material reflecting the same KP set, we concern a material set rather than single material.

Definition 2 material set (MS): if all elements in a material set can replace with each other when they reflect KP, this set can be called as a material set.

About example 1, the MS are *X12={X1,X2}, X3={X3}*, etc.

All material in the MS reflect the same KP set. Below, we do not discuss the single material except for the MS.

3.2 Relationship among Material Set

Because all material are equal when they reflect KP, there does not exist the parent-child relationship among material. The association and the parallel are two relationships among MS.

- association relationship: it is the relationship that the MS may be learned directly after another MS have been mastered.
- parallel relationship: if the relationship between two MS is not association relationship, it is parallel relationship.

In the association relationship, if a MS must be mastered directly beore another MS is learned, it is called the Ancestor MS for another MS. if a MS may be learned directly after another MS has been mastered, it is called the Descendant MS for another MS.

It is relative about the Ancestor MS and the Descendant MS. If MS *A* is the ancestor of MS *B*, MS *B* is the descendant of MS *A* also.

3.3 MS Net

An arc is expressed for the association relationship among MS. The arrowhead directs from the Ancestor MS to the Descendant MS. If a MS has an arc pointing at it, the arc is called as In-arc for this MS. If a MS has an arc backing at it, the arc is called as Out-arc for this MS. The figure 2 is the MS net graph of the example 1.

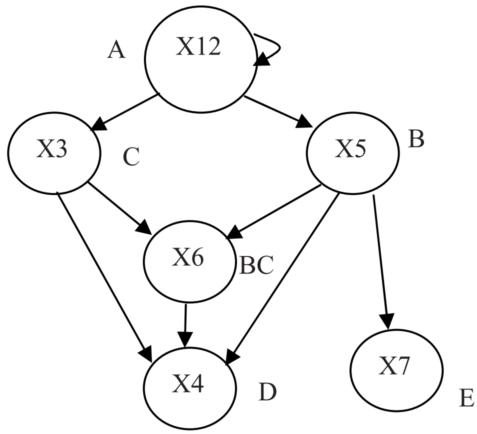

Fig. 2. MS Net

Definition 3 MS net: it is the net that is made up of the MS and the relationships among them. The node means MS and the arc means the association relationship of MS.

A MS may be ancestor and descendant of itself also. MS net is an cyclic directed graph.

At the figure 2, *X12, X3, X4, X5, X6* and *X7* means some MS in the courseware. *A, B, C, D, E* and *BC* means KP reflected in MS. The relationships of *X12* and *X3, X12* and *X5*, *X3* and *X6, X5* and X6, *X5* and *X7, X3* and *X4, X5* and *X4, X6* and *X4* are the association relationship. *X12* is the ancestor of *X3* and *X5*. *X3* and *X5* are the descendant of *X12*. etc.

4 The MS Specialty Research

4.1 Material Petri Net (MPN)

It is an effective system model verification tools for Petri net (PN)[9,10,11].

Definition 4 Petri net: it includes six items, $PN=(P,T,F,K,W,M_0)$

P: is place set.

T: is transition set $(P,\ T\neq\varnothing, P\cap T=\varnothing)$.

$F\subseteq(P\times T)\ \ (T\times P)$: is flow relation.

K: defines the maximum token in a place.

W: defines the weighted coefficient in token.

M_0: is a start label.

Definition 5 path: is a transition sequence $\sigma=M_0t_1M_1t_2M_2\ldots t_nM_n$ in Petri net. It is for short $\sigma=t_1t_2\ldots t_n$, and called as trigger sequence of transition.

Definition 6 accessibility: if it has a sequence transition $t_1, t_2, \ldots, t_n$ from M_0 to M_n in PN, it can be say that M_n is accessibility from M_0.

Definition 7 Supposed $N=(P,T,F,K,W,M_0)$ is Petri net. N is MPN, if and only if two conditions is satisfied as follows:

- there are two special places, which are M_{start} and M_{stop}. M_{start} place is the beigin-ing, and M_{stop} is the end.
- There are a special transition t_{stop}, all places can arrive at M_{stop} only via t_{stop}.

Definition 8 material accessibility: if it has a sequence transition t_1, t_2, …, t_{stop} from M_{start} to M_{stop} in the MPN, it can be say that M_{stop} is the material accessibility from M_{start}.

4.2 Transformation from MS Net Graph to MPN

On the procession of the learning in the courseware, if the MS has been learned, which means that the KP reflected in this MS has been mastered, other KP in the sequence may be learned continuously. Therefore, the MS may be treat as place *(P)*, and the KP may be treat as transition *(T)*. The maximum of token *(K)* in the place is the element numbers in the MS. In order to describe the relationship of MS in MPN, some definition must be introduced.

- Stop KP set: it is a set where all KP had been learned.
- Stop MS: it is a virtual MS included all KP that have been finished.
- Void KP: is a virtual KP without any real knowledge. the Void KP transits without fail.
- Void MS: is a virtual MS without reflecting any real KP. The learning of Void MS does not need any premise.

The transformation about four special relationships of MS are given through the figure 3.

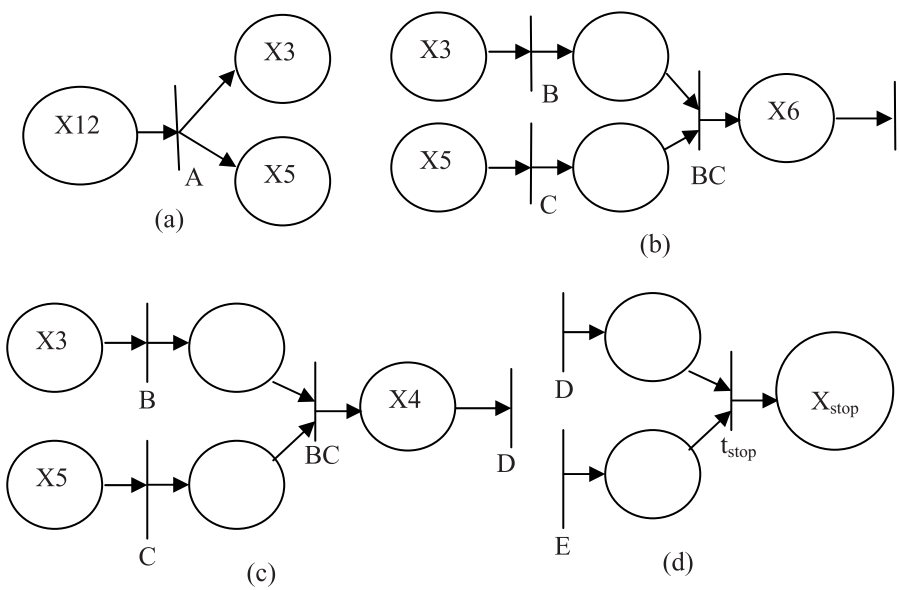

Fig. 3. Four Special Relationship in the MPN

"○" means Void MS, "|" means Void KP, t_{stop} means the Stop KP set, and X_{stop} means the Stop MS. (a) a MS is the Ancestor MS of other two MS, for example *X12*; (b) a MS reflects KP set with two or more KP, for exaple *X6*; (c) a material can be taught until two or more KP are mastered. Different from (b), it describes a material reflecting a new KP, which has two or more In-arc in KP net, for exampe *X4*; (d) the end of the courseware means that all KP without Out-arc in the KP net migrate to the Stop MS, For example KP *D* and *E*.

4.3 Experiment

Based on the material accessibility of MPN, the dynamic behaviour of MS can be analyzed. In the graph of a MPN, *(n)* means that this MS have *n* number material.

Example 2: About example 1, assumed

X12 has three material, *X5* has three material, etc. See figure 4.

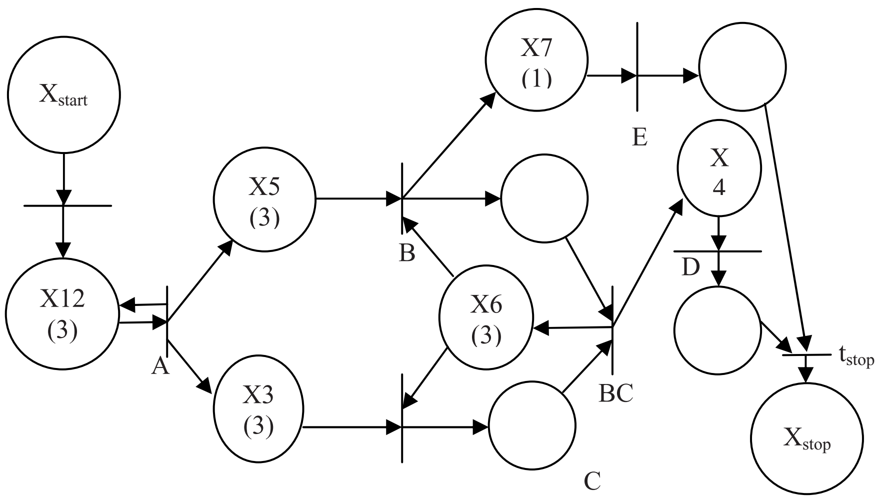

Fig. 4. MPN of the Example 2

Based on the figure 4, some conclusions can be given:

- A transition sequence X_{start}, *X12, A, X5, B, X3, C, BC, X7, E, X4, D*, t_{stop}, X_{stop} can be found. Therefore, it has a path from X_{start} to X_{stop} without the MS *X6*. Of course, if *X6* is learned, the impressions of KP *B* and KP *C* can be enforced.
- If the KP *B* does not longer present in the syllabus for teaching innovation, the transition *E, BC* and *D* would not be accessed and the MS *X4, X6* and *X7* can not be learned in the courseware.
- It is assumed that a KP sequence *A, C, D*, t_{stop} exists. But, we can not find any path conforming with it. Thus, the assumption is inconsistent with teaching requirement.
- The t_{stop} is the Stop KP. If one KP does not be learned, it would not exist a transition from t_{stop} to X_{stop}. Thus, if some KP are not reflected in the selected MS, this courseware will not be able to cover with the syllabus.

- If a new KP F is increased, there would not have a transition sequence from Xstart to Xstop. Thus, the MS reflecting KP F must be increased in the courseware.

5 Conclusion

Nowdays, many researcher concern the auto-generation courseware in e-learning, and ignore what MS is fit of the courseware. The MPN can be used to analyse some property of MS. It can validate the case whether the KP reflected in MS exceeds the scope of the syllabus. It can also solve the problems what MS should be deleted when the KP does not longer present in the syllabus. And, it can judge whether the selected MS are enough to illustrate the syllabus. When new KP is added to a syllabus, it can also tell us about whether all MS in the courseware are enough to illustrate the syllabus still. The future work is how to construct knowledge component based on this research and to develope the courseware generation system.

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The Practice and Experience Sharing of Three-Year Peer Coaching Program in Taiwan

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Abstract. The Peer Coaching Program has been in place in Taiwan for more than two years. We have not only trained 165 local facilitators, but also held 92 training courses for the coaches. In addition, we have established the website, PBL.NET, which provides personal experience sharing, online materials search, and online courses. Currently, more than 7,000 elementary, junior, and senior high school teachers and students participate in the program. PBL.NET includes more than 2,100 WebQuest lessons and provides more than 1,180 online courses. The evaluation results indicate that the Peer Coaching Program is very successful in Taiwan. Our ultimate goals are to implement a professional development model so as to provide an excellent digital learning environment, to advance teachers' skills, to enhance standards-based instruction through engaged learning and technology, and finally, to increase students' learning achievements.

1 Introduction

With the exponential growth and development of Information and Communication Technologies (ICT), teachers must be able to prepare students to adapt to the changes in this technology-driven society. Because technology is prevalent in nearly all our activities, the public expects it to be used to enhance student achievement and prepare future business owners and employees (Schwab, 2000). Both national and state policymakers have acknowledged its importance and are working to ensure its incorporation into K-12 education (Austin, 2004). Recently, the Taiwanese government has endeavored to promote various projects to construct a digitalized and informationalized learning environment. Although how to build a complete coaching model to improve teachers' ability of using digital technology is one of the biggest challenges in Taiwan, many studies (Miller, 1998; Saye, 1998; Tonkin & Baker, 2006) suggested that peer coaching can be a successful model. It is because peer coaching offers the teachers opportunities to become involved in meaningful discussions and planning, observe other teachers, be observed, and receive feedback (Loucks-Horsley, Hewson, Love, & Stiles, 1998) to help teachers use technology in ways that promote engaged learning. Therefore, now that we have had the chance to introduce the Peer Coaching Program

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into Taiwan, we believe that this program is one of the best solutions to such challenges.

2 Team Members of the Peer Coaching Program

The principle investigator of the Peer Coaching Program in Taiwan is Professor Chi-Sung Laih from the Department of Electrical Engineering, National Cheng Kung University. He has taken the responsibility to plan and implement the whole program. There are also three other professors in Educational Technology who are involved in the program—Jia-Rung Wen (Dean of the University Development Committee, Shu-Te University), who is in charge of designing the WebQuest training session, Chi-Syan Lin (Professor in the Department of Information and Learning Technology, National University of Tainan), who is taking responsibility for the design of the "Knowledge Management & Learning Community System" training session, and the development of the PBL.NET website, and Ya-Ting C. Yang (Associate Professor in the Institute of Education, National Cheng Kung University), who is responsible for the design of the "Coaching Skills" and the implementation of the program evaluation. In addition, our team includes one full-time project assistant and six graduate teaching assistants who work collaboratively to provide logistics support for the training sessions, perform on-site practical work such as data collection for the evaluation of this program, and interact regularly with the schoolteachers and professors in a timely, helpful, and professional manner.

3 Implementation Procedure of the Peer Coaching Program

Professor Lai was in charge of the implementation procedures of this program. The tasks in this part included planning the content and details of the whole training program, supervising how each member preceded with his/her tasks, and most important of all, communicating with the Ministry of Education and the Education Bureaus and helping them understand the goal of the Peer Coaching Program in order to receive full support from the government. In the two conventions held so far, we received some very helpful supports, which are listed as follows:

- The Ministry of Education has given us full support without any intervention.
- Delegates from 23 counties and cities in Taiwan are involved in this program. All of them show high willingness to participate in the training activities.
- The purposes of the Peer Coaching Program have been highly accepted by most of the participants. Our team provides resources and contact points that help and lead all the Peer Coaching training initiatives in Taiwan.

The relationships among the elements are shown in Figure 1. The promotion and implementation of this project require the participation and cooperation of government and elementary, junior, and senior high school teachers from all the counties and cities in

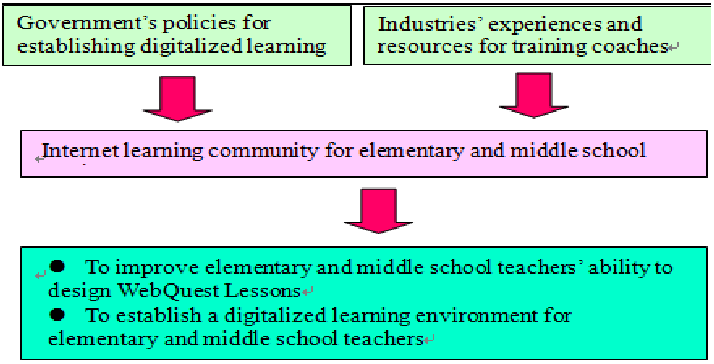


Fig. 1. The relationship of constructing a digitalized learning environment

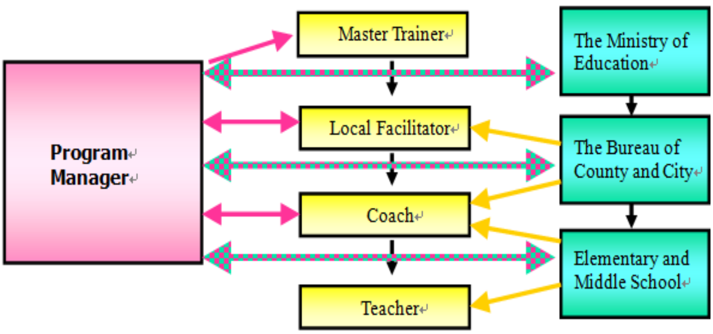


Fig. 2. The implementation of the Peer Coaching Program for elementary and junior high school teachers

Taiwan. Figure 2 shows the relationships among them and the way this project is being implemented in Taiwan.

The training mode of local facilitators (LFs, teachers who have experience in teaching information technology relevant classes) and coaches (teachers who have taken information technology relevant courses) is flexible based on the responses from participants. The first year we recruited 45 groups of LFs (a total of 90 LFs) to participate in a three-day training program. Most of the coach training sessions were held by LFs in the first year (with a total of 24 coach training sessions). Due to the unexpected success, we held the LF training sessions in three different places (north, mid, and south Taiwan) during the second year. In addition, each LF only needed to be responsible for training 25 coaches (each LF was responsible for training 36 coaches during the first year). We also held two principal training sessions in the north and south of Taiwan, and several coach training sessions through the education bureaus of cities and counties that we contacted directly. In the third year, Microsoft School of the Future project was initiated in Kaohsiung; thus, we held one LF training session at Kaohsiung for the project. We also offered online courses for coach training to attract more teachers to participate our program. Due to these arrangements for training, we influenced more than 16,000 elementary, junior, and senior high school teachers and more than 10,000 students to learn from the PBL.NET. (Note: The number was conservatively calculated by this formula: the influenced people = the registered people on the PBL.NET * 3.) So far, all cities and counties in Taiwan have LFs, coaches, teachers, and schools that have been influenced by the program.

Besides being responsible for the training of LFs, we also offer financial support for the regional training of coaches, and for the administration and materials for LFs. In order to improve the results of the training, we encourage teachers to design their own WebQuest lessons. After the training for all levels is finished, we will hold a competition and offer some prizes for those teachers with high quality performance.

4 Design of Training Material for the Peer Coaching Program

The training materials have basically been adopted from the original Peer Coaching materials, with some parts localized such as WebQuest lessons. Moreover, we have also incorporated some professors' expertise and practical experiences. We have already finished the design of the training materials for the LFs. As to the training materials for coaches, there will be some modifications depending on how the training for the LFs proceeds. Table 1 is a list of the areas that are covered in the materials both for the LFs and for the coaches.

Table 1. Training subjects, abstract and training hours

Subjects	Training Hours	Abstract
Introduction of Peer Coaching Program in Taiwan	LF: 3 hrs Coach: 1hr	The introduction of digitalized learning environment, learning community, purposes, implementation method, organization structure, and evaluation method for the Peer Coaching Program in Taiwan.
Knowledge Management and Learning Community System	LF: 3 hrs Coach: 1hr	The introduction of online platform design and system construction, the functions of knowledge management and learning community, and the functions of teaching and class management.
WebQuest	LF: 4.5 hrs Coach: 2hrs	The introduction of Internet learning environment, class design strategy, scenario teaching, and WebQuest design skills and application.
Operational Knowledge Management, Community System and Application	LF: 3 hrs Coach: 1hr	The publication and sharing of WebQuest material and the organization and operation of learning community.
Coaching Skills	LF: 1.5 hrs Coach: 1hr	The introduction of the coaching roles and responsibilities, and the demonstration and practice of the communication skills.

5 The Application of the PBL.NET in Professional Development

5.1 Framework of the PBL.NET

The PBL.NET (http://pbl.linc.hinet.net/) is a website dedicated to teachers' professional development using a peer coaching strategy. Teachers are encouraged to use the "WebQuest Design Template", a user-friendly WebQuest lesson editor, to design PBL instructional materials and share them with peers in "Digital Library". As the name implies, "Digital Library" is a warehouse of PBL instructional materials designed by teachers. Teachers can search the instructional materials with multiple searching approaches in the library and store selected ones in their "Teaching Pad" for reference. The library also provides the function of peer evaluation of the artifacts. Users can provide comments and rating for the artifacts they have used or reviewed inside the library.

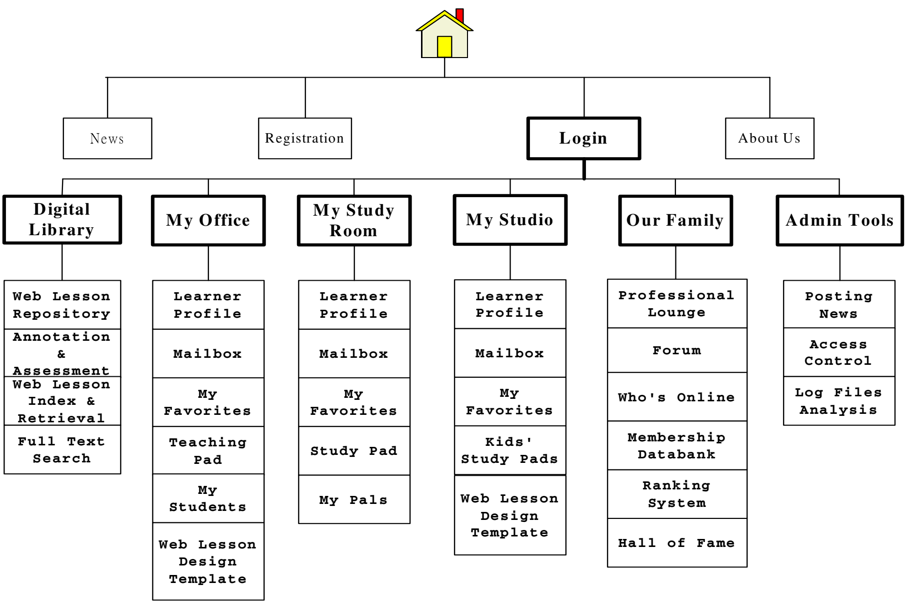


Fig. 3. The Platform of PBL.NET

5.2 Significance of the PBL.NET

As of October 2007, there are 3440 schoolteachers and 1090 schools using the PBL.NET. The numbers are outstanding when they are compared with national statistical data pertaining to schools in Taiwan. In other words, 2% of school teachers and 32% of schools in Taiwan already took part in the PBL.NET project. The number of WebQuest lessons submitted by teachers is also an indication of significance. As of

October 2007, over 2000 WebQuest lessons were shared in the "Digital Library." The wealth of instructional materials in the PBL.NET is a promise of success.

6 The PBL Materials with WebQuest Design

A WebQuest is an inquiry-oriented activity in which some or all of the information that learners interact with comes from resources on the Internet (Dodge, 1995). A WebQuest is a highly valued instructional strategy of constructivism during which learners actively build their own critical understanding of a topic. Authentic or real-world questions or problems are often researched, and learners may work cooperatively to find solutions. Dodge proposed that creating a WebQuest is not much different from generating any kind of lesson. It requires getting learners oriented, giving them an interesting and doable task, giving them the resources they need and guidance to complete the task, telling them how they will be evaluated, and then summarizing and extending the lesson. The procedure of a WebQuest learning activity is as follows: (a) Introduction: a good introduction makes the topic relevant to the learner's past experience and future goals: attractive, visually interesting, and important because of its global implications, urgent because of the need for a timely solution, and fun because the learner will be playing a role in making something; (b) Task: a description of what the learner will produce by the end of the exercise. It provides a goal and focus for student energies and it makes concrete the curricular intentions of the designer; (c) Process: the teacher suggests the steps learners should go through in completing the task. It may include strategies for dividing the task into subtasks, or descriptions of roles to be played or perspectives to be taken by each learner; (d) Resources: it lists web pages and other materials pre-selected for the learner so that attention can be focused on the topic; (e) Evaluation: a new addition to the WebQuest model to justify the expense of using the web for learning and to be able to measure results. This rubric gives specifics in fulfilling the requirements so that there is no room for disagreeing with the scoring; (f) Conclusion: an opportunity to summarize the experience, to encourage reflection about the process, to extend and generalize what was learned, or some combination of these activities.

7 Evaluation of Peer Coaching Project in Taiwan

7.1 The Purpose of Evaluation

The purpose for evaluating the Peer Coaching project in Taiwan is to understand the opinions and suggestions of school principals, teachers, and students through a different lens, based on which we can effectively improve the performance of the project. The evaluation includes four surveys (Post-Unit Survey, Feedback Survey for Peer Coaching Training, Skills and Practice Survey, and Local Facilitators' Attitude Survey), empirical evaluation of the research results, and interviews. Table 2 briefly displays the objective, participants, and time of administration for each of the evaluation instruments.

We quantitatively analyzed the performance of our first-year project. To further explore the teachers' and students' feelings and perspectives, a qualitative and discovery-oriented interview was included in our second year evaluation. Thus, from these two complementary instruments, we are not only able to understand the current overall status of the project through quantitative analysis but also to qualitatively identify participants' thoughts and needs and identify the factors that influence the willingness of the teachers (including LFs and coaches) who promoted this project. In addition, we conducted vigorous empirical analysis of the research results, which showed the effectiveness of the WebQuest instructional strategy (one type of web- and inquiry-based instructional strategy) in improving students' higher order thinking, learning motivation, and academic achievement. Finally, in the second year, we transformed the paper and pencil surveys into web-based surveys (using PBL.NET), greatly saving us time and human resources and helping us to evaluate the project more efficiently and effectively.

Table 2. The Evaluation Instruments

Evaluation Instrument (Participants)		**Objectives**	**Format**
1. Post-Unit Survey (LFs)		Investigate LFs' understanding of the training materials	5-point Likert Scale
2. Feedback Survey for Peer Coaching Training (LFs)		Receive feedback on the promotion of Peer Coaching training	5 open-ended questions
3. Skills and Practice Survey (LFs and Coaches)		Investigate LFs' and coaches' ICT skills and their willing to integrate ICT skills into their instruction	7-point Likert Scale
4. Local Facilitators' Attitude Survey (LFs)		Investigate the LFs' willingness and needs to promote the Peer Coaching project	5-point Likert Scale
5. Empirical Research (Students)	**Awareness of ARCS Model Motivation Inventory**	Investigate the effectiveness of WebQuest on learning motivation	35 5-point Likert Scale questions
	Critical Thinking Test-Level I	Investigate the effectiveness of WebQuest on critical thinking ability	(1) 25 multiple-choice questions (2) Maximum score = 25
	New Problem Solving Survey	Investigate the effectiveness of WebQuest on problem solving ability	15 questions
6. Interview (Teachers and Students)		Understand teachers' and students' opinions and suggestions for taking part in PiL project and using WebQuest in their teaching and learning	(1) 13 open-ended questions for teachers (2) 10 open-ended questions for students

7.2 Results and Discussion

7.2.1 Post-unit Survey

A total of 45 LFs filled in surveys in the 2nd and 3rd years, respectively. In the 3rd year, we cancelled "Coaching Skills" parts because teachers in the 2nd year asked to have much time to design the WebQuest. Table 3 shows the results. We found that LFs gained a clear understanding of the course content.

Table 3. Results of Post-Unit Survey

Topic / Area	Knowledge Management and Learning Community System	WebQuest	Coaching Skills
2nd year	4.07	4.24	4.28
3rd year	4.14	4.35	

7.2.2 Feedback Survey for Peer Coaching Training

A total of 45 and 39 LFs filled in the 2nd and 3rd year survey, respectively, and provided some training suggestions as follows:

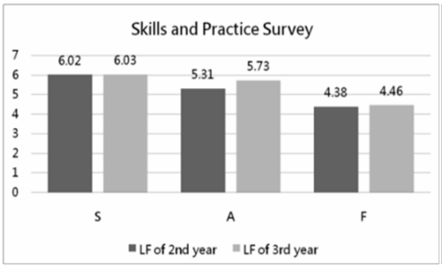
(1) Increase the time for WebQuest activities
(2) Increase the stability of the system and provide a new hard disk for file upload
(3) Provide LFs with standard workbooks and handouts
(4) Choose suitable people for training

7.2.3 Skills and Practice Survey (S & P Survey)

(1) Pretest for the 2nd and 3rd years
A total of 281 teachers filled in the survey, including 59 and 56 LFs and 82 and 84 coaches in the 2nd and 3rd years, respectively. From Figures 4 and 5, we observed that teachers possess the ability to integrate ICT skills into their teaching. However, they made infrequent use of this skill, which suggested that they were capable but did not know how to integrate ICT skills into their teaching. Therefore, in the 3rd year, we will focus on increasing real practice based on ICT skills and fostering the teachers' willingness to participate. In addition, as shown in Figure 5, the coaches of the 3rd year have lower scores than those of the 2nd year because most of the teachers in the 3rd year come from remote areas such as Miao-Li and Kaohsiung Counties. We purposely promoted this program to remote areas to bridge the digital divide between urban and suburban areas.

(2) Pretest and posttest S & P results
In the 3rd year, from the 281 teachers in the 2nd and 3rd years, we sampled 50 LFs and 30 coaches who participated in the project over the past six months to conduct the posttest of the Skills and Practice Survey. The results of the *t*-test indicated that the pretest scores of three (S, A, and F) subscales for LFs were

all significantly higher than those on their posttests, t=3.48, p=.00, t=2.80, p=.01, and t=2.50, p=.02, respectively; for coaches, t=5.31, p=.00, t=5.47, p=.00, and t=5.10, p=.00, respectively. These results showed that both LFs and coaches did improve their skills and practice after training (at least 6 months later), including the skill in computer technology (S), the ability to integrate technology into teaching (A), and the frequency of integrating technology into teaching (F).



Note: The skill in computer technology (S); the ability to integrate technology into teaching (A); The frequency of integrating technology into teaching (F)

Fig. 4. Results of LFs' S & P Survey **Fig. 5.** Results of coaches' S & P Survey

7.2.4 Local Facilitators' Attitude Survey

A total of 45 and 44 LFs participated in the 2nd and 3rd year attitude survey, respectively. The results show that teachers are pleased to participate in the promotion of coaches' training if bonuses, certificates, and some practical assistance are provided.

(1) 83% of teachers obtained information from educational websites and official school documents.
(2) 81% of teachers took serious interest in the topic and hoped the activity would be useful for their teaching.
(3) LFs are more willing to conduct Peer Coaching activities if a certificate or prize and sufficient sponsorship are provided.
(4) Most LFs required assistance in printing handouts and sending out memos to teachers.
(5) In terms of teacher acceptance and willingness to popularize Peer Coaching activities: out of a total score of 5, means of 4.29 and 4.14 were observed for the 2nd and 3rd year.

From the points given above, we observe that LFs who joined the Peer Coaching activities agreed with the ideas of the Peer Coaching project and were glad to announce related information to their co-workers. However, they had a low intention to hold Peer Coaching activities because of the lack of administrative and resource support. From the third and fourth points, we realized that more LFs would be willing to hold the activity if basic resources and assistance were provided. We, thus, arranged to provide some support, certificates and handouts which could be freely downloaded from our website. Moreover, we offered the location, announcements and lecturers to assist in holding Peer Coaching activities if required

7.3 Empirical Studies

We conducted two empirical researches (pretest and posttest quasi-experimental designs) in the first and the second year, respectively. The main purpose of this 1st study was to investigate the effectiveness of WebQuest in promoting higher order thinking and learning motivation for elementary school students. The participants included 104 sixth grade students in three classes at an elementary school in Tainan. The independent variable was instructional strategy with three levels: traditional instruction, WebQuest with no resources provided, and WebQuest with resources provided. The dependent variables were the students' HOT scores (critical thinking skills and problem solving skills) and learning motivation. The results of this study are summarized as follows: (a) no significant differences were found among the three groups in terms of students' critical thinking skills; (b) students' problem-solving skills improved after the implementation of WebQuest with resources provided; (c) no significant differences were found among the three groups in terms of learning motivation; (d) the factors influencing WebQuest instruction included HOT levels, process explicitness, learning style, and description of links of resources; (e) the advantages of engaging students in WebQuest instruction included an increase in students' ICT skills, competence in searching websites, and inquiry-based learning skills.

The purpose of the 2nd study was to explore the effectiveness of WebQuest on the higher-order thinking, learning motivation, and English achievement of elementary school students. The participants were 105 sixth-grade students in three classes enrolled at a large elementary school in Tainan. The independent variable was instructional strategy with three levels: traditional instruction (the comparison group), WebQuest with resources (treatment I), and WebQuest with resources and then without resources (treatment II). The dependent variables were problem-solving skills, learning motivation, and English achievement. The results indicated: 1) There were no statistically significant differences among these three classes in learning motivation. 2) For problem solving skills, students who participated in treatments I and II performed significantly better than those who participated in the comparison group. 3) For English achievement, students who participated in treatment II performed significantly better than those who participated in the comparison group and treatment I.

7.4 Interview

According to the frequency and length of time they surfed PBL.NET, four teachers were chosen to take part in the interviews. These four teachers included two LFs, one coach, and one influenced teacher. In addition, we also randomly selected six boys and six girls for interviews who had teachers that had implemented WebQuest for school teaching and student learning.

Teachers gained knowledge sharing and ease of teaching from PBL.NET. Teachers were inspired to organize their teaching materials and display them systematically. Also, they were encouraged to design attractive teaching activities. WebQuest enriches students' vocabulary and develops their innovation and creativity, and teachers experienced greater achievement. In addition, teachers' suggestions about PBL.NET are to design an interface with personalized features, to set up real-time interactive functions for PBL.NET, and to increase the number of files that can be uploaded. There were five reasons given by students about the benefits of WebQuest: increased ICT skills, improved data coordination, enhanced webpage searching ability, improved inquiry skills in the network, and increased student interest in "learning."

7.5 Summary for Evaluation Results

Our evaluation of this project included four surveys, an empirical analysis of the research results, and interviews. Based on the results from the Post-Unit Survey, our LFs have a greater understanding of the training content. From the results of the Feedback Survey for Peer Coaching Training, we realized that more practice time should be included in the training workshop, and standard operation handbooks and handouts should be provided for the LFs in training their coaches. These requests have been processed by modifying our training schedule and providing training handbook, handouts, and PowerPoint slides for LFs to download on our PBL.NET website. According to the Skills and Practice survey, teachers possessing high ICT skills do not necessarily make effective use of them during their instruction. We, thus, need to further encourage teachers to integrate their ICT skills into their teaching in the third year. In addition, the results of the Local Facilitators' Attitude Survey showed that teachers are pleased to participate in the promotion of coaches' training if bonuses, certificates and some practical assistance are provided. Furthermore, the results of the empirical research indicated that students' problem solving skills and academic achievement were significantly enhanced after WebQuest instruction. Although critical thinking and learning motivation were not improved during the one-semester experiment, we will continue to track and observe this progress during the next academic year. Finally, the results of the interviews demonstrated that both teachers and students have learned new teaching and learning skills from this Peer Coaching project. Students also increased their ICT skills, and website-searching competence, as well as gained satisfaction in learning accomplishments.

8 Conclusions

Due to the development of the Internet and the ICT skills, teachers have more opportunities to learn from each other to promote students' better learning results. Under the guidance of coaches, many teachers are adopting new strategies that appear to be resulting in improved student learning (Bogner, 2002; Guiney, 2001; Wong & Nicotera, 2003). Hence, the Peer Coaching Program is one of the best ways for teachers to do cooperative learning. In the planning of the program, there are many factors that need to be considered. In order to make the program work more efficiently and successfully, reflection and modification are very important processes. In addition, government support and policies will affect the success of the promotion of the program. Therefore, it is important to help the government understand the purpose of peer coaching so that we can have more government support.

As to the planning of the program, we suggest that it should be designed as a three-year program. In this way, not only will the training scale be enlarged, but more importantly with such non-stop promotion, we can keep modifying the training process to make the training program more effective. Also, to promote the program, the most important elements are budget, resources, and specialists. Only with the cooperation of industry, government, and academia can the national teaching environment and quality be improved. Consequently, the training program will be implemented more efficiently and successfully so that peer coaching can play an effective role in helping teachers integrate technology into their classrooms in ways that encourage active learning by their students. It is our hope that as more teachers are involved in this program, the program can reach more teachers to develop standards-based instruction through engaged learning and technology integration. In conclusion, with our continuous endeavor in the third year, this project, we believe, will inspire more creative ICT-integrated teaching and learning to provide a better quality of K-12 instruction.

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eKnowledge Repositories in eLearning 2.0: UNITE - a European-Wide Network of Schools

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Abstract. The upcoming Web 2.0 technologies change the aspects of eLearning fundamentally. The traditional paradigm of classroom teaching and homework learning will develop further towards sharing experiences and knowledge in word-wide social communities. Moreover, knowledge capturing in ambient environments gains more and more importance. These aspects characterize the so-called eLearning 2.0. This paper describes a prototype of an eLearning 2.0 system covering the different aspects such as platform, pedagogy and scenarios. The concepts presented here have been applied in the EU-project UNITE. The implementation of this system in the setting of a European network of fourteen schools is presented as an iterative four stage process, covering scenario planning and implementation, validation in addition to platform and process improvement. Achieved intermediate results from the first iteration of the implementation process are discussed and future work is presented.

Keywords: Web 2.0, eLearning 2.0, eKnowledge repositories, knowledge processing, eLearning standards, e/mLearning.

1 Introduction

Nowadays eLearning solutions are mostly based on the Web 1.0 paradigm. Web 1.0 can be characterized as single user and data-download centred. With the upcoming features of Web 2.0, this situation changes completely. Support of communities and folksonomies, as well as communicating and collaborating user groups become prevalent. Moreover, these user groups also upload data to the web and, herewith, the Web becomes a medium for group-based interaction. Consequently, application fields like eLearning will change and develop further. Different aspects of this paradigm shift are presented and the EU-project UNITE [1] as an application case offered.

The paper is structured as follows. Section 2 introduces state-of-the-art along with challenges of eLearning 2.0 and the UNITE project. Section 3 concentrates on the technical aspects of the design and implementation of eLearning 2.0 platforms whereas section 4 focuses on enhanced eKnowledge repositories. Section 5 describes the implementation of the e/mLearning platform in Spinut School. Finally, Section 6 concludes the paper and brings future plans.

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2 Background

2.1 State of the Art and Challenges

eLearning systems consist of platforms, pedagogy and scenarios in application domains. Nowadays platforms Moodle [2], Blackboard [3], Ilias [4] are based on client/server architecture. eContent is stored on server side management systems and delivered to learners on the client side. Courses themselves consist of sequences of pages and atomic assets. To support searching and classification, content can be annotated with standardized meta-data (LOM). Today's eLearning pedagogy principles follow the traditional model of classroom learning and homework. Application domains are pre-defined by eLearning providers and delivered as pre-fabricated pieces of learning material.

The state of the art in eLearning environments is defined by computers with Internet-connection. This technology of web-based trainings (WBTs) is well known and conceptually mature. However, with the upcoming Web 2.0, the usage of mobiles as devices for both downloading content as for uploading results or input (see Flickr [5]) becomes more and more prevalent. With this trend the challenge arises of the development of eLearning solutions taking the integration of mobile learning into consideration.

Considering the amount of eLearning platforms, the traditional classroom-metaphor of learning is still prevalent. Contents are delivered to the students, and the students can download the materials from the platform. Interaction among students and the teachers is rather rare. Innovative Web 2.0 technologies for cooperative and collaborative work, such as voice and video over IP, and mLearning play only a marginal role, although the benefits through the possibilities of collaborative learning with these tools are promising.

Informal learning today becomes the dominant form of learning [6]. The principles of the Web 2.0, like the ability to connect people, to distribute information world wide and discussing ideas with people form all over the world, have similarities to modern educational theories [7]. Constructivist Perspectives [8] and Activity Theory [9] emphasise the importance of learning active, with methods like cooperative learning [10, 11, 12] and problem-based learning [13] in real-world contexts (situated learning) [14] as well as learning through games and entertainment [15, 16] becomes more and more popular. On the contrary, eLearning systems are still frequently used in a teacher centred way (transmissive learning) and less for self-regulated [17] learning, reflection, social and communication skills, problem solving capacities [18]. With these new approaches, the role of teacher shift to facilitator, while the learners leave their former passive role and start to embrace an active involvement in the learning process.

Traditional eLearning scenarios focus on enhancing the learning process in the classroom or support learning at home. Blended learning for example tries to combine eLearning with the learning of people, who are in one place present. Scenarios in which the learners are learning outside the school-like environment are not the focus of these approaches. With mLearning groups of learners can go participate in real life, while getting guidance through their mobile by solving problem-based scenarios. Another problem of the traditional scenarios is the non-standardisation of the scenarios. Standardisation makes the principles of the scenario explicit and therefore accessible for evaluation. A comparison of different scenarios is possible and hence best practice approaches can be identified. A propos, standardisation is sometimes confounded with inflexibility. This may result from a narrow understanding of the term standardisation. Standardisation, as we see it, is a way of making teaching process explicit. The standardisation can be general enough to embrace nearly all teaching processes. For new teaching approaches new standards will derived using abstract meta-scenarios. Another advance is the reusability of standardised scenarios for new learning projects.

To sum up, next generation eLearning will extend all the aspects above. Scenarios will take into account the collaboration of heterogeneous groups. The classical roles of teacher, tutor and learner will disappear and will be further developed towards situated skill sharing with dynamic roles of *skill providers* and *skill consumers*. This leads to requirements new eKnowledge repositories have to deal with.

2.2 UNITE - a European-Wide Next Generation Network of Schools

UNITE (Unified eLearning environment for the school) is a thirty-month project partially supported by the European Community under the Information Society Technologies (IST) priority of the 6th Framework Programme for R&D (www.unite-ist.org). Project is aiming to provide novel services in education for young Europeans by combining different state-of-the-art technologies in e/mLearning, also taking into consideration innovation in technology and pedagogy.

The main goal of UNITE is "… to contribute to the improvement of Europe-wide education in secondary schools based on common, innovative principles in technology, pedagogy and in learning scenarios, tested by a well-defined validation framework" [19]. In order to achieve this goal, a number of key objectives were set up: (i) the *pedagogical framework*, designed and implemented in the first phase, initiates daily use of the UNITE platform in classrooms and provide pedagogical concepts for the e-Learning scenarios; (ii) the *technical platform* with its communication and co-operation functionalities supports wide-spread learning along with other learning concepts of the designed pedagogical framework; (iii) the *learning scenarios* use full potential of the platform and developed pedagogical concepts so as to motivate learners and deliver innovation in the classroom.

It is important to note that other objectives concern the establishment of a *Network of Schools*, the development of a Europe-wide repository of *re-usable m/eLearning content*, the development of an adequate *validation framework*, detailed *socio-economic evaluation* of UNITE as well as a carefully designed *exploitation plan*. Teaching and learning process implies the usage of fundamental material delivered not only in English, but also on partners' mother tongue: (i) *eLearning scenario template* along with more than 20 different scenario examples [20], (ii) *Content development handbook* [21] and (iii) *Teachers' handbook* conveying the pedagogical principles of UNITE [22].

3 eLearning 2.0 Technical Platforms

3.1 Functional Design

A Web 2.0 eLearning platform seamlessly integrates three distinct technologies including their diverse functionalities into usable and effective e/mLearning environment [23]: (i) an *eLearning portal*, supporting the learning process and specifically, group-oriented learning in classes of pupils, (ii) an *eKnowledge repository*, containing traditional eLearning material (like assets, pages and courses), but also images shot during "learning at excursions", knowledge sharing sessions and best practices, and (iii), a *mobile learning component*, that allows to contact both other learners as well as the school-server and to communicate taking in mobile learning scenarios.

3.2 System Architecture

From a system design point of view, modularity and re-usability are key point. Modern Web-based systems are therefore based on a so-called Webservice-oriented architecture (SOA). This supports the configuration and integration of systems based on the functionality of services avoiding any implementation detail.

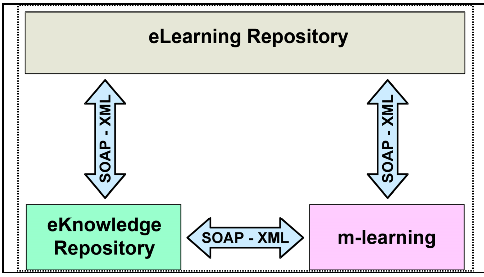

Fig. 1. eLearning 2.0 platform: System archi-tectture

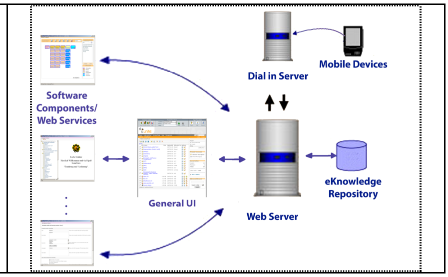

Fig. 2. eLearning 2.0 platform: Functional design

3.3 The UNITE Platform

The UNITE platform implements the concepts explained above. The provided functionality covers an eLearning portal, an eKnowledge repository, and a mobile learning component. The system architecture integrates three already existing components. The portal is based on *Microcosmos* [24], the enhanced eKnowledge repository comes from eLearning repository *Infopool* [25] and mobile learning is implemented using the *mediaBoard* built by [26]. The communication between these components is realized using *web services* (see Fig. 1). This technology supports both the integration of already existing modules (as in UNITE) as well as the later integration/extension of new modules.

The UNITE platform has two access points: (i) the learning portal and the learning management system are directly accessed via a web server (http://pilot.unite-ist.org), while (ii) the mobile devices are connected to the platform via a dial-in server. The knowledge repository is a background service behind the web server (see Fig. 2).

3.4 The Platform Validation

In order to verify the validity of technological and pedagogical developments, the validation of the UNITE platform and its e/mLearning scenarios was performed. The validation results show the appropriateness, meaningfulness and usefulness of both the system and the scenarios [27]. In the following we refer to the procedure and end-results of the platform evaluation. Iterative user-centred design of the UNITE system comprised an evaluation methodology [28], by means of which the relevant platform characteristics were quantified, validated and weaknesses identified. Both low-fidelity (paper-based) and high fidelity (computer-based or interactive) prototypes were tested by UNITE users. A total of 62 teachers and 131 pupils (ranging between 11 and 18 years of age) involved in the project along with 28 partner members and observers participated in two iterations of the evaluation. In addition, 5 double experts from the usability and e-learning field were employed also.

The evaluation procedure of the UNITE system comprised (i) *heuristic evaluation* and (ii) *scenario-based usability testing*, including pre-experiment multi-choice questionnaire, task-based user testing, memory test, usability satisfaction questionnaire and semi-structured interview. In order to make a decision regarding whether or not there is sufficient evidence that the platform has met its objectives, several goals were set up. For example, *accuracy of task completion*, as objective performance measurement of effectiveness, for students was 78,3% and for teachers 70,59%, while *task completion time*, as objective performance measurement of efficiency, for students was 14,75 minutes and for teachers 24 minutes (our goal was to make it under 20 and 30 min respectively). The overall conclusion is that UNITE is a good system but would benefit from some alterations (*ibid.*).

4 Enhanced eKnowledge Repositories

As already mentioned above, there is a fundamental further development from traditional eLearning content towards Web 2.0 material. Web 2.0 is much more focused on the knowledge sharing between heterogeneous communities. Because Internet technologies are used, the term "eKnowledge" (similar to eLearning) will be used in the following.

4.1 eKnowledge Domains

In eLearning 2.0, content includes not only traditional SCORM-compliant eLearning content (assets, pages and complete courses), but, in addition, mLearning content (images shot using mobiles or handhelds), information about groups and results of collaborative learning. All information can be tagged with meta-data and, herewith, can be searched using terms like keywords, authors and the like. Keywords can be assigned either individually, or based on commonly agreed glossary. This allows the uniform categorization of data and, herewith, the re-use on a European-wide scale.

On top of the meta-data, *eKnowledge domains* or *eLearning contexts* are defined. An eKnowledge domain is, using semantic web terminology, defined as a ontology, consisting of topics and associations between them. The topics consist of categories of meta-data, while the associations describe the relations between them. An eKnowledge domain forms a semantic space, in which the meta-data as well as the data have a context-specific meaning. Correspondingly, the same data and meta-data may have different meaning in different knowledge domains. In UNITE, eLearning contexts are defined as *reference scenarios*. Consequently, topics, associations and meta-data have a context-specific meaning.

To manage eKnowledge content, an eKnowledge repository must handle all the content types above as first class entities. In UNITE, the eKnowledge repository is based on a traditional eLearning repository, extended by the features to deal with content produced by mobile devices, the management of uniform meta-data spaces across different items and of complex ontologies for both users as well as content.

4.2 Content Patterns

Re-usability and *uniform layout* are key requirements in eLearning. Because content production is very expensive the re-use of whole courses or at least parts is essential. eLearning content has often to follow a certain CI, what makes adaptability necessary. In eLearning 2.0, re-usability and uniform layout become even more crucial, because of the large and heterogeneous groups of content producers and consumers. A solution for these requirements is the usage of *patterns*, as well known from software design. While there may be numerous kinds and types of patterns, UNITE has concentrated on two of them: *page-patterns* and *course-patterns*. Page patterns define the types of pages (like introduction, presentation, quiz, test) as well as their layout (text page, page with graphics/animation, single choice / multiple choice tests and the like). These page patterns are described in UNITE's teachers' handbook and form a general guideline for the production of content.

Course-patterns are a new concept, first introduced in UNITE. A course is a learning unit that can be executed and navigated. Currently, simple sequencing, the standardized way of navigation, is implemented. A course consists of different types of course elements (such as modules, questions), which reference locations and meta-data in the repository. Because there are just references, content can easily be shared among different courses. Courses themselves are treated as first class elements of the eKnowledge repository. They have specific meta-data that can serve as search criteria. Courses can be re-used "as-is" or can be modified with "copy & paste". Moreover, abstract course templates can be modelled and stored as *course patterns*. These patterns define only a navigation structure through different course elements, but have no content yet. They can be *instantiated* with specific content in the same or in different contexts.

The combination of both, page patterns and course patterns, allows the creation of courses with the same look and feel for different pedagogic situations, a prerequisite for a wide network of schools with different knowledge domains.

4.3 eKnowledge Management Tools

UNITE provides tools for the management of the eKnowledge repository: a meta-data editor and a course editor. The web-based meta-data editor is based on the international standard LOM (learning objects meta-data), and can be configured to cover just the necessary data for a specific knowledge domain, and, herewith, allows annotation with minimal efforts and maximal confidence, because only the formally correct key word dictionary is provided. Key words are stored in a dictionary and a search engine is integrated in the editor.

The platform also provides an interactive *course editor*, a web-based application managing courses as XML files. Courses can be created by drag&drop of course elements; different course elements can be distinguished by different colors. A meta-data search engine is integrated, so that content can be searched for during the course creation process. Fig. 3 shows screenshots from different graphical elements of the platform. Apparently, UNITE serves as an enhanced eKnowledge repository with special focus on collaborative and explorative learning along reference scenarios.

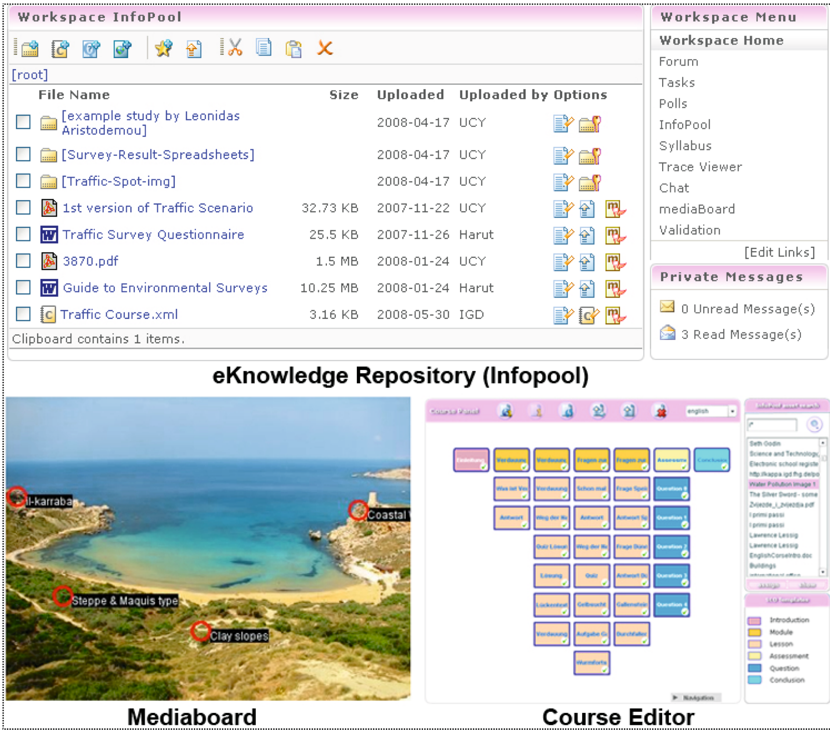

Fig. 3. The UNITE platform

5 The Implementation of UNITE in School Settings

In previous sections the platform's numerous possibilities for successful knowledge delivery and acquisition are pointed out. It is up to teachers and schools how they will make use of them. Consequently, the e/mLearning implementation phase comprises joint work of project partners and partner schools related to setting up the infrastructure, planning, creation and delivery of new and/or customised scenarios as well as validation of performed activities in the network of 14 European schools.

This section presents a case study of the e/mLearning implementation of theories and practices in one elementary school, the Spinut School. A team of five people was formed, consisting of the school's headmaster, the pedagogue and three subject teachers. Support in terms of organizational and technical assistance was provided by University of Split (UoS), one of 13 project partners. In the first two scenario implementations approximately 50 students took part (mostly 13 and 14 year-olds).

As any other good-practice project, UNITE has followed a certain process in order to implement its theories and practices in schools. It somehow matches the idea behind Deming's iterative four-step problem-solving *Plan-Do-Check-Act* (PDCA) or *Plan-Do-Study-Act* (PDSA) process [29]. Aligning with the PDSA cycle, UNITE's implementation process advances through four major phases including (i) scenario planning, (ii) scenario implementation, (iii) validation and (iv) platform and process improvement respectively (see Fig. 4).

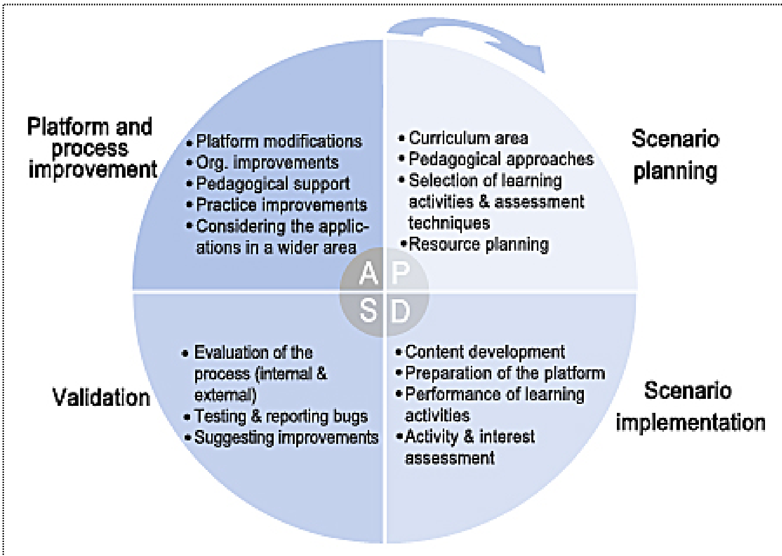

Fig. 4. The launch of UNITE in the school

A fundamental principle of this process is iteration: once our assumptions are confirmed or negated in the validation phase, we execute the cycle once again with the intention of extending the knowledge further. Below we present the results from the first iteration, the one that took place in Spinut School (Feb 2007 - Jun 2008).

5.1 Scenario Planning

The objective of the *scenario planning phase* was the delivery of two innovative scenarios: (i) the custom scenario, planned and written using the scenario template and (ii) the adapted scenario, an adjusted scenario sample in order to fit the curriculum. The UNITE scenario template consists of two parts, one related to the curriculum area and the second one to the pedagogical activities planned to take place during the scenario implementation (where every activity is matched to its learning objective, the tools/resources the intended assessment technique and its time span [20]. The outcome of this phase was a paper-based version of the two scenarios developed according to the teachers' understanding of pedagogical and technological considerations.

5.2 Scenario Implementation

The *scenario implementation phase* encompassed the development of e/mLearning content, the preparation of the UNITE platform along with the performance of learning activities from the scenario using the platform and mobile devices. This phase can be perceived as testing the scenario against the platform. The most relevant material (tools and resources) collected by teachers were subsequently employed in the course preparation, hence being available for those who wanted to know more about related subject matter (for this purpose modules *Course Editor* and *Course Viewer* were used) [30]. Six groups of approximately equal numbers of students aged 13 and 14 were formed.

Student assignments were placed within the system (module *Tasks*) and appropriate instructions were provided. Students consulted their online textbooks, Internet sources and their teachers in order to find material related to the problem defined in their assignment. Most relevant resources they found were placed in the platform using mobiles, PDAs, laptops and PCs (modules *InfoPool* and *mediaBoard*). Moreover, by means of *Metadata editor* related metadata was attached as well.

UoS provided support to students as technical expert/advisor throughout few workshops and the whole time via the platform (using *my Messages*, *Chat* and *Forum*). Activities undertaken enabled students to express their own competence and knowledge about the various aspects of related matter and eventually about system.

5.3 Validation

The objective of the *validation phase* was to monitor and evaluate the process and achieved results against the goals, reporting the outcome in *case record* format. This phase also included testing and reporting bugs via forum or e-mail, suggesting platform improvements, introducing and organizing diverse validation activities in the school (e.g. filling subjective satisfaction questionnaires).

The most valuable validation feedback came from case records. One form was completed by every teacher, while most of the students completed the questionnaire as well, either as individual or group exercise. Teachers were concerned about how to assign additional specific tasks to students not actually contributing to a group work in any way. While teachers were very satisfied with students' interest in these new ways of communication and teaching, students did not share their opinion. Students stated that they mostly communicated with their teacher in the classroom and not online. The possibility to communicate with students from other European schools was in students' opinion a great advantage of such kind of shared platform.

Students pointed out a problem related to mLearning. They found it extremely useful and fun to use their mobile phones for learning, but were worried about the cost of using their devices for this purpose. Nevertheless, *mediaBoard* zones were populated enough with relevant resources. The use of phones was very effective because it was used as a different way of collecting data related to subject matter, but also as a very familiar way for students, helping to steer their interest and motivate them for platform usage. According to students' comments and our personal attitude, they were very pleased with the platform, eLearning and mLearning in general.

5.4 Platform and Process Improvement

The *improvement phase* enabled revision and modification/enhancement of the previous phases, just before the start of next iteration. Based on timely validation information from the *Network of Schools* and earlier planning, there are already several platform improvements available, categorized mostly in four main areas: stability, user interface, functionality and performance. To exemplify, one of recently introduced functionalities is *MyLearning author for Pocket PC*, an authoring tool that allows teachers to create learning materials for Pocket PCs and Smart Phones.

Apart platform improvements, there are additional modifications in terms of organizational nature (e.g. platform will be used as a tool during the whole semester for all lessons from one subject and not only for the selected ones) and pedagogical support (e.g. new portal for teachers is available).

6 Concluding Remarks and Future Work

Currently four major cycle phases, including scenario planning and implementation, validation as well as platform and process improvement, are being reviewed and the next iteration planned (started in October of 2007). Having in mind that, opposite to so-called "classical" methods, peer-to-peer and problem-based learning in real-world contexts as well as learning throughout entertainment is becoming increasingly popular, there are some initiatives in Spinut School to approach younger students (11 to 15 years old) and to particularly stimulate their interest in science and technology.

Current trends in the EU are showing that innovative experiments on science teaching or inquiry learning [31] are proving benefits for education [32]. Within the next implementation phase an elective course entitled "Wonderful world of inventions" for talented students will be developed in order to encourage students' desire to learn and to give a playful dimension to the knowledge acquisition through the new learning scenario. Within its framework and parallel to the activities performed within the school environment, ones taking place in more informal contexts like field trips, museums, institute laboratories and a like will be undertaken.

According to the diverse areas/stages of the course, different pedagogical approaches will be implemented, such as a project work where students will be encouraged to take more active role, the role of researchers and to come up with their own sketches and designs (of either a parachute, a plane or similar). Subsequently, students will try-out their designs in practice and will actually learn-by-doing. There will be a lot of exploratory learning, with elements of cooperative learning in groups, along with some couple-work. Students will be taught how to work/learn individually. The teacher will act mostly as students' mentor and not as a "classical" teacher. Field work, numerous visits and workshops will be a great value-add to this scenario and an opportunity for students to learn astrology, robotics and science in general in a real-life environment(s). These new methods make science teaching more exciting.

UNITE will be/is already used as a repository of the learning material and problem-based tasks (either provided by the mentor or collected by students as a part of their research assignment) as well as an irreplaceable communication platform. Both synchronous and asynchronous communication and collaboration functionalities are important since the course is attended by a heterogeneous student groups at different times of day; coming from different classes and a like. Furthermore, mobile learning capabilities, notes, journals and similar functionalities of the UNITE system will be of great importance since students will be able to track their progress, update their portfolio, reflect, explore and discuss. In this way, every student is provided with the opportunity to express her/himself, to experiment and to learn.

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The Research on the Case Learning Activity Sustained by a Web-Based Case Assisted Study Environment —Take the Introduction of Industry System Course for Example*

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Abstract. This article aims to introduce the study process and outcome of case learning activity sustained by a web-based case assisted study environment (or WebCASE for short), including the choosing of learning object, the implementing of study proposal and the discussion of initial conclusion. Our research mainly concerns problems from two levels: one is how to organize case study activities; the other is how to design effective on-line study environment to support case study activities. We exactly follow the design-based research pattern to improving our research result and conclusion, so we develop two sections of research work, as follows: prototype implementing section, practice research section. In prototype implementing section, we study the current situations of popular case databases all over the world and the requirement for online case study environment of users by literature review, questionnaire statistics, and personal interviews. Based on the initial requirement, we design and implement a prototype system of Web-based Case Assisted Study Environment, WebCASE. Research work and results of prototype system implementation can be found in. In practice research section, we study the case study activities supported by WebCASE prototype system, with the course "Industry System Introduction" provided by Professor Darong Lu as our reference. In this paper, we mainly concern problems in four aspects: first is the study environment, studying overall teaching effectiveness and main functions of WebCASE; second is learning object, studying how original cases developing in WebCASE systems; third is study process, how to organize case studies under the support by WebCASE; finally is study evaluation, how to generally and effectively evaluate students' performance in case study activities.

Keywords: design-base research, web-base case assisted study environment, case-based learning activity, learning object, learning evaluation.

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1 Introduction

With the fund of Ministry of Education 10th-five-year Programming Project - "About Network Education Mode and its cross-subject development" from 2003-2006[1], we study the Web-based Case Assisted Study Environment (or WebCASE for short） and its supporting case study activities for a period of two years. Our research mainly concerns problems from two levels: one is how to organize case study activities; the other is how to design effective on-line study environment to support case study activities.

In the purpose of continuously improving our research result and conclusion, we exactly follow the design-based research pattern which is an emerging technique all over the world. Quantitative research and Qualitative research are two basic types which social science researchers often use, and both of them have been used widely in educational science researches. Although these two research patterns differ in philosophy basis, applicable conditions, and operating methods, both of them aim at describing and illustrating learning and objective phenomena, basic relationship or rules in education area, not directly focus on how to improve human's study and education [2]. In 1990th, some researchers (Brown, 1992; Collins, 1992) reconsidered the problems of orientation, thinking and methods, and then put forward the concept of "design-based research" [3]. Design-based research aims at verifying and improving principle-and -pre-study-based education design through forming study process. Design-based research use" improve by steps" to put initial design into reality to see its effectiveness, then improve application basing on the feedback of practice, till all the biases are fixed. Hence, a more reliable and effective design is formed [4]. Following this pattern of design-based research, we develop two sections of research work, as follows:

In prototype implementing section, we study requirement for online case study environment of users by literature review, questionnaire statistics, and personal interviews. Based on the initial requirement, we design and implement a prototype system of Web-based Case Assisted Study Environment, WebCASE. Research work and results of prototype system implementation can be found in.

In practice research section, we study the case study activities supported by WebCASE prototype system, with the course "Industry System Introduction" provided by Professor Darong Lu as our reference. In this paper, we mainly concern problems in four levels: first is the study environment, studying overall teaching effectiveness and main functions of WebCASE; second is learning object, studying how original cases developing in WebCASE systems; third is study process, how to organize case studies under the support by WebCASE; finally is study evaluation, how to generally and effectively evaluate students' performance in case study activities.

Research on WebCASE prototype system based case study activities in system applying section is the emphasis of this paper, and we will introduce research and results of system improvement section in another paper later.

2 Learning Object Selection

"Industry System Introduction" is started as a basic course for the requirement of integration of High Education Courses, as a compulsory undergraduate course of College of Economy Management, and also an elective course for all engineering majors, this course aims at developing engineering diathesis and economy concept. Teaching should be open, innovative, and encouraging students to study by themselves and collaborate. In 2005 summer, 2005 autumn, 2006 spring, 2006 summer and 2007 spring, teachers organize students with case study activities based on WebCASE and student-summer social practice activities in collaborate study mode. Basic practice mode is Web-Enhanced Instruction, i.e., teachers are still organizing normal classes, and case resources and online study environment are used to help students finish study load to enhance the study effectiveness of this course.

In order to be in line with research progress, we select "Industry System Introduction" in 2007 Spring Semester as research area, and take case study activities supported by WebCASE as learning Objects. 22 undergraduates from different departments and grades are enrolled in this course, and 10 cases are given to students at the beginning of the semester, as shown in Table 1.

Table 1. Case List of "Industry System Introduction" in 2007 Spring Semester

Case Index	Case Title	Corresponding Section
C1	2002-2004 Lack of Electricity all over China	S1 Energy Sources Industry
C2	Switchback of Steel Price in 2004 Jan-Jun	S2 Metallurgy Industry
C3	Troubles in GMP Identification of Pharmacy	S3 Chemistry Industry
C4	Tsinghua Mechanism Factory ERP Applicability Analysis	S4 Mechanism Industry
C5	DaQing Railway Heavy-load transportation	S5 Car Industry
C6	Natianal CPU "LongXing" development and future	S6 Information Industry
C7	China Milk Product Indutry Report	S7 Light Industry
C8	Beijing CBD now and tomorrow	S8 Construction Industry
C9	China Agriculture and Solutions	S9 Agriculture
C10	Comparison and Analysis of Beijing 3-biggest Newspaper Group	S10 Third Industry

Above ten cases are related with ten major industries in Civil Economy, students are required to select cases and group according to their interests, and they need to submit a case analysis report at the end of semester, one report each group. At last, C1, C2, C3, C5 and C8 are chosen by students, 10 of them select C1, 3 of them select

Table 2. Group List of course “Industry System Introduction” in 2007 Spring Semester

Group ID	**Case ID**	**Case Title**	**Index**	**Case Analysis Report**
G1	C1	2002-2004 Lack of Electricity all over China	R1	Lack of Electricity allover China-Reason, Effect, and Solutions
G2	C1	2002-2004 Lack of Electricity all over China	R2	East China Eletricity Supply Analysis in 2003-2004
G3	C2	Switchback of Steel Price in 2004 Jan-Jun	R3	China Steel Problem - From view of Steel Price
G4	C3	Troubles in GMP Identification of Phamacy	R4	GMP Identifiction and the future of China Pharmacy
G5	C5	DaQing Railway Heavy-load transporta-tion	R5	Case Study: DaQing Railway Heavy-load transportation
G6	C8	Beijing CBD now and tomorrow	R6	Beijing CBD Dvelop-ment Plan and current status

C2, 4 of them select C3, 3 of them select C5, and 2 of them select C8. Considering the capacity of each group, students who select C1 are divided into two sub groups, five students each group. So finally, 6 groups (G1-G6) are formed up. This paper takes the case study activities of these 6 groups as learning Objects. Their Group IDs, numbers of students, selected cases, and case analysis reports are listed in Table 2.

3 Research Plan and Implementation

To solve the problems of study environment, learning Object, study activity and study evaluation in case study activities, we have done researches in 4 following sections.

Scene Observing Section During the semester of 2007 Spring, we have been participated the course as teaching assistant of “Industry System Introduction”, and we also maintain the WebCASE system as a system administrator. We can observe progress and result of each group either online or offline.

Evaluation Design Section At the end semester, we design the case study activity rubric for course “Industry System Introduction” so that teachers can evaluate students, group members can evaluate each other, and students can evaluate themselves. After the first round of usage, we modified some of evaluation guide lines.

Questionnaire Investigation Section Before the end of semester, we design the questionnaire of “WebCASE usage”, and investigate 22 students from different majors who are enrolled in course “Industry System Introduction” about the teaching function and case study activity of WebCASE.

Conclusion and Analysis Section After summer vacation in 2006, we began to analyze the 5 original cases which students selected, 6 case analysis reports, and 5 case teaching packages which teachers make after the course, we also collect statistics information according to returned questionnaires.

4 Results and Discussion

4.1 About Study Environment

The Study Environment in this paper means the online WebCASE prototype system. Through analysis of questionnaire feedback by 22 students in 6 groups, we find that when asking the question “Are you satisfied with the teaching effect of WebCASE”?, one student chooses extremely satisfied, 15 students choose satisfied, 5 choose not satisfied, and one student choose extremely not satisfied. A total of 16 students, which is 72.7 in all, agree with the good effect Which WebCASE brings, this result shows WebCASE prototype system can satisfy most of investigated persons.

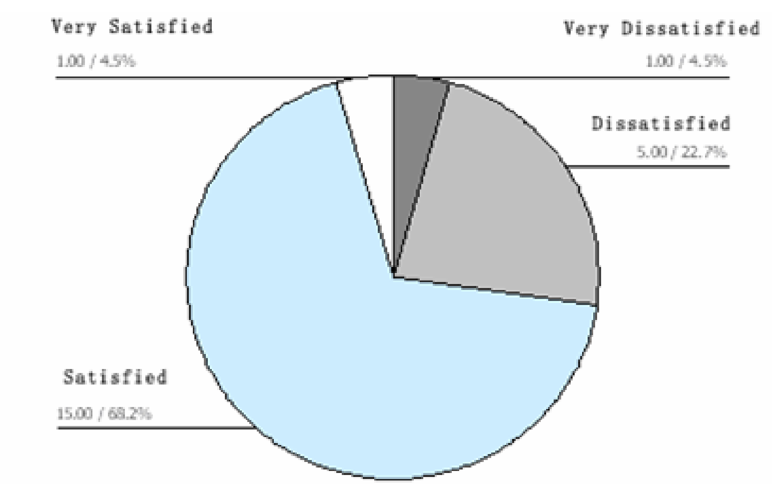

Fig. 1. Satisfaction Distribution of WebCASE

During the requirement analysis section, we have found that investigated persons’ requirements focus on the functions of Case Index, Discuss Board, Case Report Writing Format Form, and Electronic Documents. In order to verify the effectiveness of functions provided by WebCASE, we design and verify 9 questions in the questionnaire of “WebCASE usage”.

Table 3. WebCASE function usage statistical information

ID	Question	Choices and Selected Numbers			
		Extreme Not Compatible	Not Compatible	Compatible	Very Compatible
1	Check Cases in Case Database Often	1(4.5%)	5(22.7%)	13(59.1%)	3(13.6%)
2	Check Case Report of Case Report Database Often	1(4.5%)	8(36.4%)	12(54.5%)	1(4.5%)
3	Write Case Analysis Report Often	1(4.5%)	13(59.1%)	8(36.4%)	0
4	Use case discuss board and discuss often	0	6(27.3%)	15(68.2%)	1(4.5%)
5	Use class discuss board often, and discuss with teachers and classmates	0	13(59.1%)	9(40.9%)	0
6	Use Group Discuss Board and discuss cases of-ten	0	8(36.4%)	12(54.5%)	2(9.1%)
7	Conclude study process often and write study notes	0	2(9.1%)	14(63.6%)	6(27.3%)
8	Often clean up materials during study process	0	6(27.3%)	13(59.1%)	3(13.6%)
9	Often view other students' study note	1(4.5%)	11(50%)	9(40.9%)	1(4.5%)

Through the analysis of Table 3, we find that 16 (72.7% in all) investigated persons can often read cases in case database; 13 (59% in all) investigated persons can often read reports from report database; 16 (72.7 in all) can often participate into discussion in the discussing board; 14 (63.6% in all) often participate group discussion; 20 (90.9% in all) often write notes; 16 (72.7% in all) often pack up study materials during study period. These data reflect the high usage of Case Database, Case Report Database, Case Discuss Boards, Group Discuss Board, Study Notes and Personal Files in WebCASE from users' point of view.

From Table 3, we also note that the frequency of writing case analysis reports, participating class discussion, view other students' study note is very low, which indicates a low usage of corresponding functions provided by WebCASE. Through talking to investigated persons, we find this problem comes from two main aspects: one is study mechanism such as formal case analysis reports are only submitted by group leader; the other is there are some system problems with WebCASE in operating and stableness.

Through comparison on case discuss board, class discuss board, and group discuss board, we find investigated persons tend to participate case discuss area with clear topics (16 persons, 72.7% in all) and group discuss area (14 persons, 63.6% in all), but not often participate class discuss area with unclear topics (9 persons, 40.9% in all).

4.2 About Learning Object

Here learning Object means the original cases published in WebCASE. They mentioned the appearance which WebCASE exceeds traditional case database is supporting case developing. To verify this concept, we compare and analyze the 5 original cases, 6 case analysis report submitted by students, and 5 case teaching packages, and then we find that: in form aspect, original case implements the evolvement from case to case analysis report, and from case and case analysis report to case teaching package; in content aspect, from case to case analysis report, and from case to case teaching package, questions related are becoming more tiny and deep; in resource aspect, additional extended resources are enlarging from case to case teaching packages. This result shows original cases in WebCASE are developing during the teaching exchange process.

In our research, we also find that although WebCASE can support case development with same topic, but it does not support interactions of cases, case reports and case teaching packages with different topics, so such resources can't be used by each other. Even for the same topic, case resources, case, case analysis reports and case teaching package can only have single-direction reference. When learners enter into case, case analysis report or case teaching package, they can only see the basis and reference of this object. Actually, as development record, when entering case, case analysis report, or case teaching package, learners should not only see the basis and reference of current object, but also should see which objects have referenced current object, and which objects are developed on base of current object.

4.3 About Study Process

After live observation and analyzing the answers to the question "Please list the process of case study analysis report work in your own group" in the questionnaire, we find group case study activities in 2005 autumn semester commonly will be divided into 6 sections:

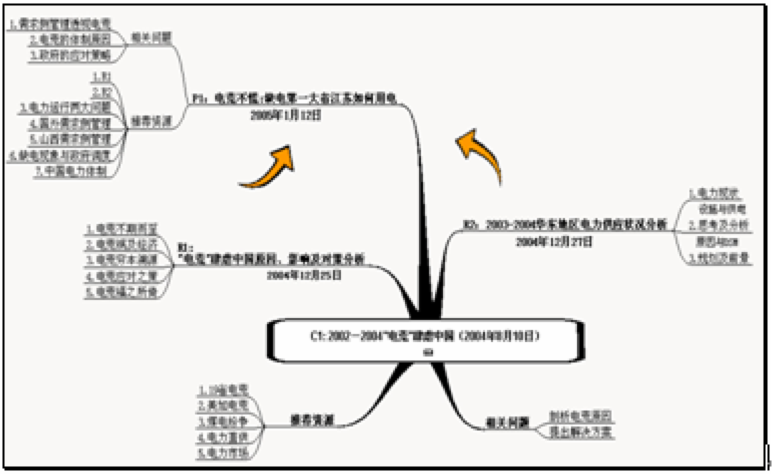

Fig. 2. Case Development of "2002-2004 Lack of electricity all over China"

Section 1 Case Selection and grouping. In this section, students initially read published cases and recommended resources in WebCASE case database, then selecting cases, grouping and voting for group leaders.

Section 2 Initial discussion and distribution of work. In this section, students will read the case to be studied, and via group discussion, research topics are initially established, and work is distributed.

Section 3 Material collecting and communicating. In this section, group members will collect topic-related materials, and materials are shared in several means such as face-to-face talking, email, sharing resources database.

Section 4 Establish title and syllabus. In this section, group members tempt to find the disagreement place in collected materials which are firstly personally analyzed and then discussed in group, hence title of case analysis report and syllabus will be clearly defined.

Section 5 Case Analysis report writing and publishing. In this section, each group member will afford part of the work in case analysis report according to personal opinions, interests and abilities. Group leader will conclude the analysis report on base of all group members' work. Initial analysis report will be discussed first within group, then after some revise and improvement, then submitted to WebCASE by group leader.

Section 6 Case report meeting and Studying evaluation. In this section, one student from each group will give a presentation which is organized by teachers, and results of each group will communicate in report meeting. Self-evaluating, group-evaluating, and teacher-evaluating will be used together to evaluate students' performance in case study activities.

As an online study environment, the effect of WebCASE in different case study sections can be concluded with aspects such as class management, case deploy, sharing resources, discuss and communicate, study review, and result present.

4.4 About Study Evaluation

Study Evaluation, which judges study effectiveness by collecting information from various ways, is one of the most import part in study procedure. Through literature review, we find that both case written by teachers and case analysis report written by students have certain evaluation guide lines, however, we lack of the evaluation guide line for students' performance in case study activities.

In teaching practice, teachers often evaluate by the case analysis report, rather than evaluate on students' case study activities. Although simplified evaluation is more effective, the objectivity, veracity and maturity of such evaluation is doubtful, as teachers can not participate into case study procedure of each group and what they get is only final case study result.

分类	考察项	自评（30%）	组评（30%）	教师评（40%）	说明
量化统计	出勤次数（10）				初始成绩为10，课堂、参观或小组讨论缺席一次-1，迟到一次-0.5,减到0为止。
	登陆次数（10）				初始成绩为0，登陆一次+1，直到10为止。
	发帖次数（10）				初始成绩为0，每贴+0.5，进入精华区每贴+1，同一贴只加分一次，加到10为止。
	资源个数（10）				初始成绩为0，每共享一个资源+0.5,加到10为止。
	周志次数（10）				初始成绩为0，没写一次周志+1，加到10为止。
质性分析	讨论质量（10）				几乎不参与小组讨论+2，参与讨论，但较少发言+4，能及时提出自己的意见和看法+6，能积极提出新观点+8，能积极提出新观点，并被大家认可+10。
	报告质量（25）				很差+5，比较差+10，一般+15，比较好+20，非常好+25。此项的自评成绩是小组内部给出的成绩，而组评成绩是其他小组给出的成绩。
	资源质量（5）				几乎没有上传+1。上传了几个，但主题相关程度不大+2。提交了5个以上，与主题有一定相关性+3。提交了5个以上，与主题有很大相关性，并且描述比较详细+4。提交了10个以上，与主题非常相关，并且描述非常详细+5。
	周志质量（10）				几乎没有写学习周志+1。写学习日志的周数不少于4次+4。写学习日志的周数不少于6次，但反思不够深刻+6。写学习日志的周数不少于8次，反思比较深刻+8，写学习日志的周数不少于10次，反思非常深刻、全面+10。

Fig. 3. Initial Rubric of Case Study Evaluation

个人信息	评分规则							
姓名:	1、出勤情况：满分10，课堂、参观、小组活动缺席一次 －1分，迟到一次－0.5分，直到0分为止。							
学号:	2、登陆次数：满分5，采用李克特五级记分法。 A、几乎每天都登陆 +5 B、一般两三天就会登陆一次 +4 C、一周登陆一次 +3							
组别:	D、两周登陆一次 +2 E、一月登陆一次 +1 F、总登陆次数不超过3 +0							
自评成绩:	3、发贴数量：满分10，每发一篇帖子+0.5，每有一篇帖子被置顶或加入文摘＋1，直到10分为止。							
组评成绩:	4、上传文件：满分5，每上传一个同研究主题相关、名称直观且描述详细的文件+1，直到5分为止。							
师评成绩:	5、学习日志：满分20， A、没写过学习日志＋0 B、写学习日志的次数>=3 ＋5 C、写学习日志的次数>=5 ＋10							
最终成绩:	D、写学习日记的次数>=10,但反思不够深入。＋15 E、写学习日志的次数>=10,反思比较深刻、全面 ＋20							
	6、小组讨论：满分20， A、几乎不参小组与讨论 +0 B、参加讨论，但很少发言 +5 C、能及时提出自己的意见和看法 +10							
	D、能积极提出新观点 +15 E、能积极提出新的观点，并得到大家的认可 +20。							
	7、报告质量：满分30， A、很差＋10 B、比较差＋15 C、一般＋20 D、比较好＋25 E、非常好＋30							
	8、个人最终成绩=自评成绩X３０％＋组评成绩X４０％＋师评成绩X３０％							
评自己	出勤情况（10）	登陆次数（5）	发贴数量(10)	上传文件(5)	学习日志(20)	小组讨论（20）	报告质量（30）	总成绩（100）
评组员	出勤情况（10）	登陆次数（5）	发贴数量(10)	上传文件(5)	学习日志(20)	小组讨论（20）	报告质量（30）	总成绩（100）
评报告	一组	二组	三组	四组	五组	六组		

Fig. 4. Case Study Evaluation Rubric in Due Form

To reveal the objectivity and veracity, current study research and evaluation often use rubric evaluation methods. In case study of course “Industry System Introduction” in 2007 spring semester, we design case study evaluation rubric to evaluate students' performance in case study activities according to case study rubric. According to case study rubric, students' final scores are composed of self-evaluating score, group-evaluating score, and teacher-evaluating score. All these three parts consider both quantitative and qualitative analysis when evaluating students' performance in case study procedure.

At the beginning of semester, we delivered the initial rubric for “case study evaluation rubric”. According to feedback by teachers and students, we make a “case study rubric” in due form facing students at the end of semester. As a real evaluation tool, rubric is not only a suite of standard for evaluating students' study performance, but also a bridge to study-self-examination and study-communication. After a trial round, the equality and generality of this rubric is widely accepted by both teachers and students.

5 Conclusions

This paper introduces the research procedure and result of WebCASE-based case studies, including: selection of learning Object, implementation of study proposal, and discussion on study results. The case study activities of 6 groups in course “Industry System Introduction” shows: in study environment aspect, the teaching effectiveness of WebCASE is accepted by 72.7% investigated persons, further analysis shows a high usage rate of functions like case database, case report database, case discuss board, group discuss board, study notes and personal files in system. In studying object aspect, the concept of case developing has been implemented in certain level—in form level, original case implements the deduction from case to case analysis report, from case and case analysis report to case teaching package; in content level, questions related with the process from case to case analysis report, from case to case teaching package are studying further and more detailed; in resource level, resource recommended to students from case to case teaching package are being enlarged; in studying procedure, there are six sections for each group case study activity, as follows: case selection and group, initial discuss and work distributing, material collecting and communicating, making title and syllabus, case analysis report writing and delivering, and case report meeting and study evaluating. In study evaluation, we design the case study rubric to evaluate students' performance in case study activities according to the principle of multiple evaluated objects, quantitative and qualitative evaluating guide lines.

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An Artificial Intelligence Course Used to Investigate Students' Learning Style

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Abstract. This paper introduces a course module in the domain of Artificial Intelligence, implemented in a web-based educational system called WELSA. The course is specifically tailored to capture the learning style of the students, while they browse through the module. The way of organizing and indexing the constituent educational resources is briefly introduced and then illustrated with a course fragment. In order to validate the proposed approach, a selection of learners' behavioural patterns are analyzed and interpreted, being subsequently correlated with the learning preferences of the students.

1 Introduction

Identifying the learning style of the students is a challenging task for today's e-learning systems. Given their importance in educational psychology, learning styles have become an important constituent of the learner model, together with the knowledge level, interests and goals.

According to [10], learning style designates a combination of cognitive, affective and other psychological characteristics that serve as relatively stable indicators of the way a learner perceives, interacts with and responds to the learning environment. During the past two decades, educational psychologists have proposed numerous learning style models, which differ in the learning theories they are based on, the number and the description of the dimensions they include.

There are two methods that have been proposed for learning style diagnosis in educational hypermedia systems: i) an explicit one, by having the students fill in a dedicated psychological questionnaire and ii) an implicit one, by analyzing and interpreting students' interaction with the system. Examples of educational systems that apply one or the other of the above methods include:

- CS383 [3] - is based on 3 constructs of the Felder-Silverman model [6] (sensing/intuitive, visual/verbal, sequential/global), which are assessed by means of applying the Felder-Solomon's dedicated questionnaire [19].
- AES-CS [21] - is based on Witkin's [23] field dependence/field independence characteristic, which is assessed by means of applying a Group Embedded Figures Test questionnaire at the beginning of the course.

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- INSPIRE [12] - is based on Honey and Mumford learning style model [9]. The prevalence of the Activist, Pragmatist, Reflector or Theorist dimension is identified either by applying a dedicated questionnaire or by student's self-diagnosis (students can directly manipulate and modify the learner model).
- Heritage Alive Learning System [4] - is based on Felder-Silverman learning style model. Learning preferences are diagnosed implicitly, by analyzing behavioural patterns on the interface of the learning system using Decision Tree and Hidden Markov Model approaches.
- [1] deals with the sequential/global dimension of the Felder-Silverman learning style model. Students are explicitly diagnosed by applying the Felder-Soloman Index of Learning Styles Questionnaire and are subsequently presented with the course content in a specific layout, corresponding to the identified preference.
- TANGOW [13] - is based on two dimensions of the Felder-Silverman learning style model: sensing/intuitive and sequential/global. Learners are asked to fill in the Index of Learning Styles Questionnaire when they log into the system for the first time and the student model is initialized correspondingly. Subsequently, the student actions are monitored by the system and if they are contrary to the behaviour expected for that learning preference, then the model is updated. The student observed behaviour is restricted to 4 patterns, each corresponding to one of the four possible learning preferences.
- [20] - is based on Biggs' surface vs. deep student approach to learning and studying [2]. The student diagnosis is done by means of a neural network implementation for a fuzzy logic-based model. The system learns from a teacher's diagnostic knowledge, which can be available either in the form of rules or examples. The neuro-fuzzy approach successfully manages the inherent uncertainty of the diagnostic process, dealing with both structured and non-structured teachers' knowledge.
- EDUCE [11] - is based not on a learning style model but on Gardner's theory of multiple intelligences (MI), using 4 types: logical/mathematical, verbal/linguistic, visual/spatial, musical/rhythmic [7]. The student diagnosis is done both dynamically (by analyzing the student's interaction with MI differentiated material and using a naive Bayes classification algorithm) and statically (by applying a Shearer's MI inventory [18]).

As can be seen, most of today's educational systems that deal with learning styles are based on a single learning style model. We take a different approach, by using a unified learning style model (ULSM) [15], which includes characteristics from several models proposed in the literature. An overview of this ULSM together with the educational system that we have developed based on it is presented in the following section. Subsequently, section 3 details the way of organizing and indexing the educational resources in order to serve our learning style diagnosing purpose. The approach is illustrated in section 4 with a chapter from an Artificial Intelligence course. Some behavioural patterns are then extracted and validated by an experimental study involving 71 undergraduate students, briefly reported in section 5. Finally, in section 6 we draw some conclusions, pointing towards future research directions.

2 System Overview

In [15] we introduced an implicit, dynamic learner modelling method, based on monitoring the students' interaction with the system and analyzing their behaviour. The novelty of our approach lies in the use of a unified learning style model, which integrates characteristics from several models proposed in the literature. Moreover, it includes e-learning specific aspects (technology related preferences) and it is stored as a set of learning characteristics, not as a stereotyping model. More specifically, ULSM integrates learning preferences related to: perception modality (visual vs. verbal), field dependence/field independence, processing information (abstract concepts and generalizations vs. concrete, practical examples; serial vs. holistic; active experimentation vs. reflective observation, careful vs. not careful with details), reasoning (deductive vs. inductive), organizing information (synthesis vs. analysis), motivation (intrinsic vs. extrinsic; deep vs. surface vs. strategic vs. resistant approach), persistence (high vs. low), pacing (concentrate on one task at a time vs. alternate tasks and subjects), social aspects (individual work vs. team work; introversion vs. extraversion; competitive vs. collaborative), study organization (formal vs. informal), coordinating instance (affectivity vs. thinking).

More formally, let L be a learner and let $Pref(L)$ be the set of learning preferences identified for learner L by analyzing her/his behavioural indicators. Obviously, $Pref(L) \subset Pref\_ULSM$, where $Pref\_ULSM$ is the set of learning preferences included in our ULSM. Specifically, $Pref\_ULSM = \{p\_visual$, p_verbal, $p\_fieldDependence$, $p\_fieldIndependence$, $p\_abstract$,$p\_concrete$,p_serial,$p\_holistic$, $p\_activeExperimentation$, $p\_reflectiveObservation$, $p\_carefulDetails$, $p\_notCarefulDetails$, $p\_deductive$, $p\_inductive$, $p\_synthesis$, $p\_analysis$, $p\_intrinsic$, $p\_extrinsic$, p_deep, $p\_strategic$, $p\_surface$, $p\_resistant$, $p\_highPersistence$, $p\_lowPersistence$, $p\_oneTask$,$p\_alternateTasks$,$p\_individual$,p_team,$p\_extraversion$, $p\_introversion$, $p\_competitive$, $p\_collaborative$, p_formal, $p\_informal$, $p\_affectivity$, $p\_thinking\}$ (meaning of each preference obviously results from its name).

The advantages of this approach include: i) it solves the problems related to the multitude of learning style models, the concept overlapping and the correlations between learning style dimensions; ii) it removes the limitation imposed by traditional learning in the number of learning style dimensions that can be taken into consideration in face-to-face instruction; iii) it provides a simplified and more accurate student categorization (characteristic-level modelling) which in turn allows for a finer granularity of adaptation actions. Evidently, this characteristic-level modelling does not exclude the use of traditional learning style models. Indeed, starting from the identified learning preferences on one hand and the description of the desired learning style model on the other hand, the system can easily infer the specific categorization of the student. Our approach thus provides the additional advantage of not being tied to a particular learning style model.

Based on the above approach we have developed an educational hypermedia system called WELSA, which offers the following functionalities:

- an authoring tool for the teachers, allowing them to create courses conforming to the internal WELSA format (that will be introduced in the next section)
- a course player for the students, enhanced with a learner tracking functionality (monitoring the student interaction with the system)

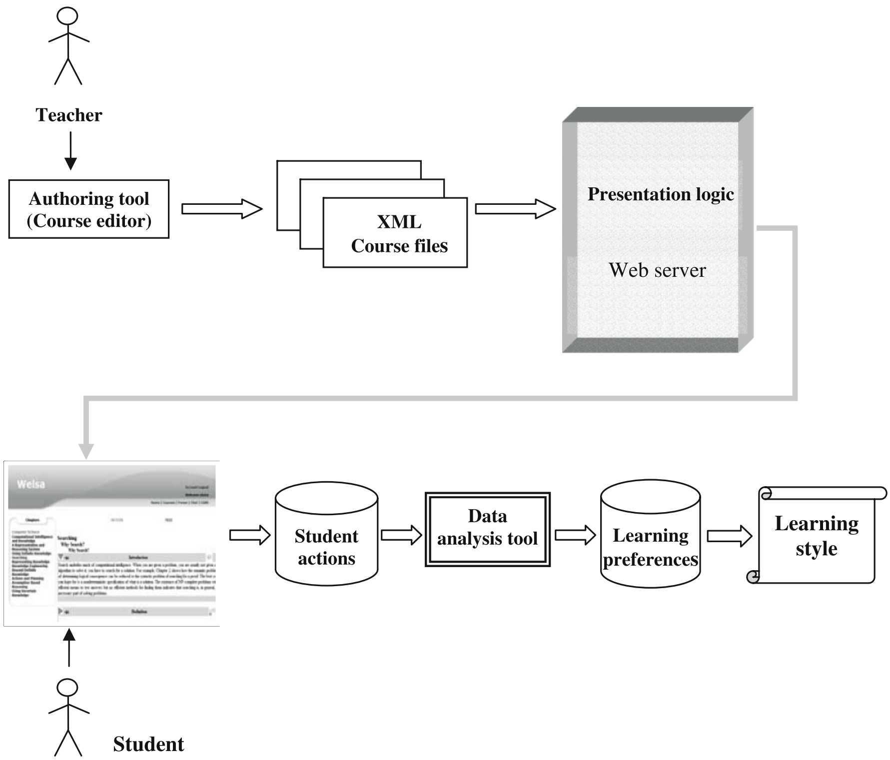

Fig. 1. WELSA - schematic architecture

– an analysis tool allowing the researcher to interpret the behaviour of the students and identify the corresponding learning styles.

A schematic representation of the system architecture is illustrated in Fig. 1.

3 Learning Objects Indexing and Organization

Our choice for organizing and annotating the educational material has been detailed in [16]. Basically, we have conceptualized the learning material using a hierarchical organization: each course consists of several chapters, and each chapter can contain several sections and subsections. The lowest level subsection contains the actual educational resources. Each such elementary learning object (LO) corresponds to a physical file and has a metadata file associated to it.

Based on our teaching experience, this is the natural and most common way a teacher is usually organizing his or her teaching materials. Additionally, this hierarchical approach presents several advantages, facilitating:

– good reuse of the educational resources
– detailed learner tracking (since we know all the information about the learning resource that is accessed by the learner at a particular moment).

As far as the educational metadata is concerned, one possible approach (which is used in [8]) would be to associate to each learning object the learning style that it is most suitable for. One of the disadvantages is that this approach is tied to a particular learning style. Moreover, the teacher must create different learning objects for each learning style dimension and label them as such. This implies an increase in the workload of the teacher, and also the necessity that she/he possesses knowledge in the learning style theory. Furthermore, this approach does not support dynamic learner modelling, since accessing a learning object does not offer sufficient information regarding the student (a learning object can be associated with several learning styles).

Instead, we proposed in [16] a set of metadata that describe the learning object from the point of view of instructional role, media type, level of abstractness and formality, type of competence etc. These metadata were created by enhancing core parts of Dublin Core [5] and Ullrich's instructional ontology [22] with some specific extensions to cover the requirements of WELSA. Thus some of the descriptors of a learning object are:

– title (the name given to the resource) → *dc:title*
– identifier (a reference to the actual resource, such as its URL) → *dc:identifier*
– type (the nature of the content of the resource, such as text, image, animation, sound, video) → *dc:type*
– format (the physical or digital manifestation of the resource, such as the media type or dimensions of the resource) → *dc:format*
– instructional role, either i) fundamental: definition, fact, law (law of nature, theorem) and process (policy, procedure) or ii) auxiliary: evidence (demonstration, proof), explanation (introduction, conclusion, remark, synthesis, objectives, additional information), illustration (example, counter example, case study) and interactivity (exercise, exploration, invitation, real-world problem) → *LoType1, LoType2, LoType3, LoType4*
– related learning objects: i) *isFor / inverseIsFor* (relating an auxiliary learning object to the fundamental learning object it completes); ii) *requires / isRequiredBy* (relating a learning object to its prerequisites); iii) *isA / inverseIsA* (relating a learning object to its parent concept); iv) *isAnalogous* (relating two learning objects with similar content, but differing in media type or level of formality).

Obviously, these descriptors are independent of any learning style. However, by analyzing the interaction between the student and the learning objects described by these metadata (time spent on each learning object, order of access, frequency of accesses), the system can infer a particular learning preference of the student.

4 AI Course Description

In order to validate our approach, we implemented a course module in the domain of Artificial Intelligence, based on the chapter dedicated to search strategies and solving problems by search, from the classic textbook of Poole, Mackworth and Goebel [14]. The module consists of 4 sections and 9 subsections, including a total of 46 LOs. The distribution of LOs from the point of view of media type and instructional role is summarized in Table 1.

Table 1. Number of LOs composing the AI chapter

LoType1="Fundamental"	12	LoType1="Auxiliary"	34	dc:type="Text"	35
LoType2="Definition"	5	LoType3="AdditionalInfo"	4	dc:type="StillImage"	1
LoType4="Policy"	7	LoType4="Demonstration"	1	dc:type="MovingImage"	7
		LoType3="Example"	14	dc:type="InteractiveResource"	3
		LoType3="Exercise"	5		
		LoType3="Exploration"	3		
		LoType3="Introduction"	5		
		LoType3="Objectives"	1		
		LoType3="Remark"	1		

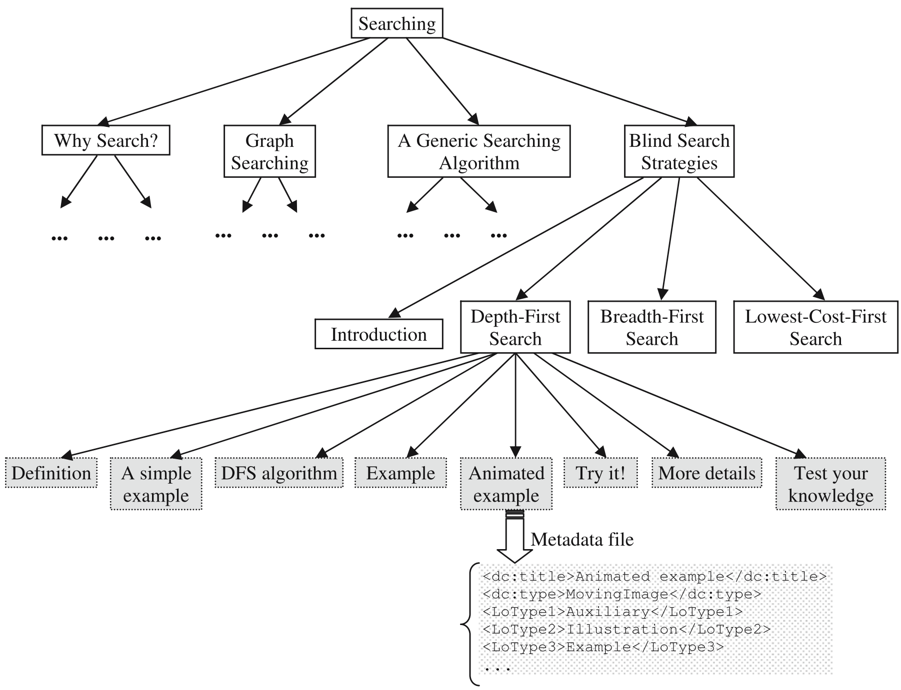

Fig. 2. AI chapter hierarchical organization (white boxes designate sections and subsections, while grey boxes designate LOs)

The structure of the course chapter is illustrated in Fig. 2, with a focus on the "Depth-First Search Strategy" subsection.

Initially, only the first LO on each page is expanded, the rest being shown in a strech-text format, including only the resource title and some visual cues such as icons for the instructional role and the media type. However, the student has the possibility to expand any LOs on the page and "lock" them in the expanded format. She/he can thus choose between having several LOs available at the same time or concentrating on only one LO at a time.

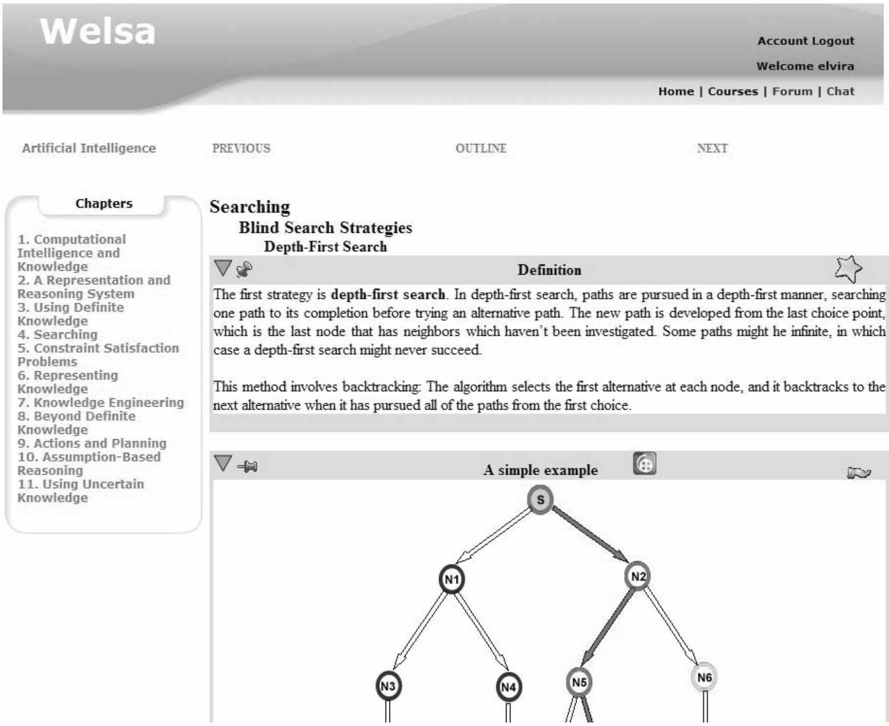

Fig. 3. WELSA course player view - a fragment of the AI course

The course also includes access to two communication tools, one synchronous (chat) and one asynchronous (forum) and offers two navigation choices - either by means of the *Next* and *Previous* buttons, or by means of the *Outline*.

Figure 3 shows a part of the "Depth-First Search Strategy" subsection, as it is visualized by the end-user (the student), including one LO with $LOType2 = "Definition"$ and $dc : type = "Text"$ and one LO with $LOType3 = "Example"$ and $dc : type = "MovingImage"$, both in an expanded state.

5 Behavioural Patterns

The course introduced in the previous section was conceived so as to provide a beneficial educational experience for the students but at the same time to help gather useful information from the learners' studying behaviour, as we have shown in [17]. The learner tracking functionality incorporated in WELSA ensures that all student actions are monitored and recorded by the system. Examples of such actions include: *login, logout, home, jumpToCourse, jumpToChapter, jumpToPage, nextButton, prevButton, outline, accessLO*, each with its associated time stamp. Furthermore, for each visited LO we have access to all the information regarding its instructional role, media type, relations to other LOs etc, by consulting the associated educational metadata (as described in section 3).

The main behavioural patterns that we take into account in our analysis refer to:

- Educational resources (i.e. learning objects) that compose the course: time spent on each LO, number of accesses to an LO, number of skipped LOs, order of visiting the LOs
- Navigation choices: either by means of the *Next* and *Previous* buttons or by means of the course *Outline*
- Communication tools: time, number of visits, number of messages posted in forum/chat.

In what follows we provide some examples of correlations that can be made between a subset of the ULSM preferences (introduced in section 2) and the behavioural patterns extracted from students' interaction with the AI course (described in section 4):

- *p_verbal* / *p_visual* → the time spent on LOs with $dc : type$ = "*Text*" versus the time spent on LOs with $dc : type \in \{$ "*StillImage*", "*MovingImage*", "*InteractiveResource*" $\}$ (*t_mediaType*[1]); the number of hits on each type of LO (*h_mediaType*); the level of activity in communication channels (*t_chat, n_chat_msg, t_forum, n_forum_msg*)
- *p_abstract* / *p_concrete* → the time spent on LOs with $LoType1$ = "*Fundamental*" versus the time spent on LOs with $LoType2$ = "*Illustration*" (*t_instructionalType*); the time spent on LOs with $hasAbstractness$ = "*abstract*" versus the time spent on LOs with $hasAbstractness$ = "*concrete*"; the number of hits on the above types of LOs (*h_instructionalType*); the order of access of LOs (*sequence_abstract_first, sequence_fundamental_before_illustration*)
- *p_serial* / *p_holistic* → frequent use of *Next* button versus *Outline* visits, jumps between pages and *Previous* button clicks (*n_navigationAction*, e.g. *n_nextButton, n_prevButton, n_outline, n_jump*); time and number of hits on LOs with $LoType3 \in$ $\{$ "*Introduction*", "*Objectives*", "*AdditionalInfo*" $\}$ (*t_instructionalType, h_instructionalType*); number of skipped LOs (*n_skipped_LO*), number of returns to LOs (n_returns_LO)
- *p_activeExperimentation* / *p_reflectiveObservation* → time and number of hits on LOs with $LoType3 \in \{$ "*Exercise*", "*Exploration*" $\}$ versus $LoType1$ = "*Fundamental*" (*t_instructionalType, h_instructionalType*); order of access of LOs (*sequence_interactivity_before_fundamental, sequence_interactivity_before_ illustration*)
- *p_carefulDetails* / *p_notCarefulDetails* → time and number of hits on LOs with $LoType3 \in \{$ "*Remark*", "*Demonstration*", "*AdditionalInfo*" $\}$ (*t_instructional Type, h_instructionalType*)
- *p_individual* / *p_team* → level of activity in communication channels (*t_chat, t_ forum, n_chat_msg, n_forum_msg*).

The above relations between students' learning preferences and their behavioural patterns were empirically confirmed by means of an experiment involving 71 undergraduate students in the field of Computer Science from the University of Craiova, Romania. Due to space constraints we only present here the conclusions of this study. The

[1] Note the meaning of prefixes in the names of the behavioural patterns: *n* stands for *number*, *t* stands for *time* and *h* stands for *hits*.

experiment lasted for 4 hours: 2 hours were reserved for course studying, and 2 hours for discussions and filling-in some questionnaires. For the first part of the experiment, the students accessed the AI course module in WELSA and all of their interactions with the system were recorded. Afterwards, the students were asked to self-assess their ULSM learning preferences, using a dedicated questionnaire. Next, the relation between the students' self-diagnosis of the learning preferences and the patterns of behaviour recorded by the system were analyzed. The whole process is automatically performed by the WELSA Analysis Tool (see Fig. 1), including a pre-processing step, in which the duration of each student action is computed, eliminating erroneous values. Next, we applied statistical analysis tests to identify significant differences in the patterns of behaviour exhibited by students with different ULSM preferences, as well as correlations between the two variables. The results were found to be in agreement with the intensional definitions of the ULSM preferences, validating the above correspondences between behavioural patterns and learning preferences.

6 Conclusions

In this note we presented an AI course module implemented in a dedicated educational hypermedia system (WELSA), which was used for investigating the learning preferences of the students who interacted with it. An experimental study involving 71 undergraduate students was performed in order to validate the proposed approach.

As future work we plan to use WELSA for authoring and deploying more courses from various domains, in order to prove the usability of the Course Editor Tool and the generality of our approach.

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Modeling Units of Assessment for Sharing Assessment Process Information: Towards an Assessment Process Specification

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Abstract. IMS Question and Test Interoperability (QTI) is an e-learning standard supporting interoperability and reusability of assessment tests/items. However, it has insufficient expressiveness to specify various assessment processes, especially, the new forms of assessment. In order to capture current educational practices in online assessment from the perspectives of assessment process management, we extend QTI and IMS Learning Design (LD) with an additional layer that describes assessment processes in an interoperable, abstract, and efficient way. Our aim is an assessment process specification that can be used to model both classic and new forms of assessment, and to align assessment with learning and teaching activities. In this paper, the development of the assessment process specification and its benefits and requirements are described. A conceptual model, the core of the assessment process specification is presented. The proposed conceptual model has been subject to a first validation, which is also described.

Keywords: e-learning standard, IMS QTI, IMS LD, assessment process specification, and new forms of assessment.

1 Introduction

IMS Question and Test Interoperability (QTI) [20] is an open technical e-learning standard which was developed to support the interoperability of systems and reusability of assessment resources. QTI addresses those assessment types for which an unambiguous definition in technical terms can be specified such as multiple-choice and filling-in-blank. In addition, QTI provides sufficient flexibility to grow into the advanced constructed-response items and interactive tasks we envisage as the future of assessment [1]. Recently, many QTI-compatible systems and assessment items have been developed (e.g., APIS [2], AQuRate [3], QuestionMark [21], and R2Q2 [22]). The development and application of QTI-compatible systems will promote and accelerate the exchange and sharing of assessment resources across platforms.

However, QTI provides no means to support the design and management of assessment processes. Specifically, it ignores who will be involved and what roles they will play, what kinds of activities should be performed by whom and in which sequence, what assessment resources will be produced and used in an assessment process, and

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what dynamic changes may happen and under which conditions. In short, it provides insufficient support for the representation and execution of an assessment plan. Furthermore, QTI does not sufficiently emphasize the support for 1) the integration of assessment with learning, and 2) competence assessment.

Integration of assessment with learning: according to Biggs [4], teaching, learning and assessment interact in modern learning, and this requires that curriculum objectives, teaching and learning activities and assessment tasks are aligned. Many researchers (e.g., Boud [6], Bransford et. al. [8], Brown & Knight, [10]) have emphasized the importance of formative assessment in student learning. As Black and Wiliam [5] pointed out, formative assessment that precisely indicates student strengths and weaknesses and provides frequent constructive and individualized feedback leads to significant learning gains if compared to a traditional summative assessment. However, QTI is just a specification about question definitions and response processing, and has nothing to do with teaching and learning activities. Conversely, IMS Learning Design (LD) [16] is used to support teaching-learning processes, but cannot explicitly support assessment.

Competence assessment: there is a marked tendency to place ever more emphasis on general competences in education and, therefore, in assessment too. Information gathering for the assessment of competences is increasingly based on qualitative, descriptive and narrative information, in addition to quantitative, numerical data. Such qualitative information cannot be judged against a simple, pre-set standard. Although classic forms of assessment still can be used for competence assessment, they do not suffice. Competence assessment relies mainly on new forms of assessment. Examples of new forms of assessment are self- and peer assessment, 360 degree feedback, progress testing, and portfolio assessment. These innovative forms of assessment address complex traits of students and foster deep learning [7], [13], [25]. However, these innovative forms of assessment are process-based and involve multiple persons in multiple roles. As already argued, they cannot be expressed using QTI alone.

Several software tools that support various forms of assessment have been developed, such as SPARK [11], Peer Grader [12], and eSPRAT [17]. However, these tools cannot support interoperability, reusability, and integration with learning activities, because each tool has its own data structure. In order to orchestrate various assessment-relevant activities performed by multiple roles/participants and, in particular, to address the problems described above, we have set out to extend QTI and LD with an additional layer that describes assessment processes in an interoperable, abstract, and efficient way. The aim is an assessment process specification (APS) that should facilitate experts and practitioners to share assessment process information. It is expected that APS can provide the means for defining assessment processes, as an internal part of the design process of a unit of learning (UoL), by combining new types of assessment with the ones already included in QTI specification [24]. As a first step towards APS, we developed a conceptual model, the core of APS. In this paper, we identify the requirements for the APS. Then we present the conceptual model, which represents the main concepts and their relations. This conceptual model has been validated by using literature and case studies. We conclude the paper with some indications of future work.

2 Objectives, Approach, Benefits, and Requirements

In practice, there are many different assessment process models (sometimes described as assessment plans and scenarios) and new models will be developed at all time. In order to support online assessment planning and execution, developing a software tool for each separate assessment process model would be inefficient. Based on our experience with the development of the IMS Learning Design specification (LD), a standard educational modeling language used to specify a wide range of pedagogical approaches/strategies, we set out to develop an abstract notation based on various assessment process models. We expect that the abstract notation can be used to specify a wide range of assessment approaches/strategies if not all. In a way analogous to extending IMS Meta-Data and IMS Content Package (CP) to LD, we extended QTI by applying the framework of LD to APS: from a content-based specification to an activity-centric and process-oriented specification. And similar to the term learning design in LD, the term assessment design refers to the formal description of an assessment approach/strategy. Also, similar to the unit of learning (UoL) in LD, a unit of assessment (UoA) in APS is a package of an assessment design and associated assessment resources (e.g., QTI assessment items/tests) using IMS CP.

As proposed in [18], an assessment process can be formally modeled through a combined use of LD and QTI. However, by adopting this approach, the user has to model assessment-specific concepts (e.g., trait, responding, and comment) using generic concepts (e.g., outcome variable, learning-activity, and property). The user must deal with all the complexity of integrating QTI resources into LD, binding LD properties to QTI outcome variables, and so on. In comparison with typical software development approaches, such a process modeling and execution approach is efficient and flexible for technical experts. However, for practitioners it is very difficult if not impossible to work at this abstraction level [18]. Therefore, APS should be abstracted at an appropriate level. For APS to be useful, on the one hand, the notation should be sufficiently general to represent various characteristics found in different assessment process models. On the other hand, it should be sufficiently specific to have expressiveness for modeling assessment processes stronger than provided by LD and QTI. To achieve this goal, we applied a domain-specific modeling approach with the intent to raise the level of abstraction beyond QTI and LD; we did so by choosing the vocabularies used in the domain of assessment. These vocabularies provide natural concepts that describe assessment in ways that practitioners already understand. They do not need to think of solutions in coding terms or/and generic concepts [19]. Once practitioners have specified a solution in terms of the vocabularies, an interpreter will automatically transform the solution represented in the high-level process modeling language into a formal model represented in LD and QTI. That is, a UoA will be translated into a UoL with QTI resources, which then can be instantiated and executed in existing integrated LD and QTI compatible run-time environments.

Based on APS, it is possible that practitioners can develop UoAs. The benefits of the UoA are:

1. A UoA, as a description of a use case represented in a standard language, can facilitate understanding, communication, and reuse of a variety of assessment practices.

2. A UoA provides a base for analyzing and evaluating an assessment plan by using formal techniques (e.g., validation and simulation) for a deeper understanding, comparison, and improvement.
3. An executing UoA can scaffold learners, tutors, and other stakeholders to perform the tasks suggested by providing guidance and awareness information, such as current status, suggested next steps, available resources, and decisions (e.g., terminating activities and initiating a service).
4. An executing UoA can enforce learner, tutors, and other stakeholders to strictly follow a plan by configuring a workspace for carrying out prescriptive tasks (e.g., doing an examination with a QTI tool and demonstrating skills with a simulator), by controlling and changing the sequence of activities based on the execution state and circumstantial information, and by orchestrating the efforts made by different roles/participants.

For all these benefits to materialize, APS has to match the following requirements (derived from [14, 15]):

1. Completeness: The APS must be able to fully describe the whole assessment process, which consists of various types of activities performed by various roles that use a variety of assessment resources.
2. Flexibility: The APS must be able to express the assessment meaning and the functionality of the different data elements within the context of a UoA. It must be sufficiently flexible to describe a wide range of assessment strategies/approaches.
3. Adaptability: The APS must be able to describe adaptation aspects within a UoA, so that the assessment resources and assessment activities within a UoA can be adapted to the preferences, portfolio, educational needs, performances, assessment results and situational circumstances of users.
4. Compatibility: The APS must be able to match and integrate available standards and specifications, such as the IMS (imsglobal.org) and IEEE LTSC (ltsc.ieee.org). In particular, it should be compatible with existing relevant standards such as QTI and LD.

APS, following common IMS practice, should consist of: (a) a conceptual model, (b) an information model, (c) XML Schemas binding, (d) a Best Practices and Implementation Guide. Among these, the conceptual model is the core of the specification. This paper focuses on the conceptual model. Admittedly, reusability, formalization, and reproducibility are also requirements of a specification. Because these requirements deal with technical issues in respect to the formal representation and run-time execution, they will not be discussed in this paper.

3 The Conceptual Model of APS

The conceptual model of the APS represents main concepts and their relations. In this section, we will express it as a semantic aggregation model, a conceptual structure model, and a process structure model.

3.1 Semantic Aggregation Model

Fig. 1 represents the conceptual model of the semantic aggregation levels in APS. The model shows the levels of semantic aggregation. The semantically highest level is *assessment design*, which aggregates a collection of *components* and a *method*. A *component* can be one of five types: *role, artifact, service facility, information resource,* and *property*. More detailed categories of each component are also depicted in Fig. 1. They will be familiar to those who know LD, as will be several aspects to be discussed subsequently. A *method* consists of one or more assessment *scenarios* and a set of *rules*. An assessment *scenario* consists of several sequential *stages*. Each *stage* consists of a set of *activities* and/or *activity-structures*. Each *activity-structure* consists of a set of sequential, selectable, concurrent, or alternative activities/activity-structures. A *rule* consists of a set of *conditional expressions* and a set of *actions* in a structured if-then-else/else-if format. The sub-types of each concept are illustrated in Fig. 1 as well. Because of the limited space available, this paper only briefly describes the semantics of the important vocabularies and attributes.

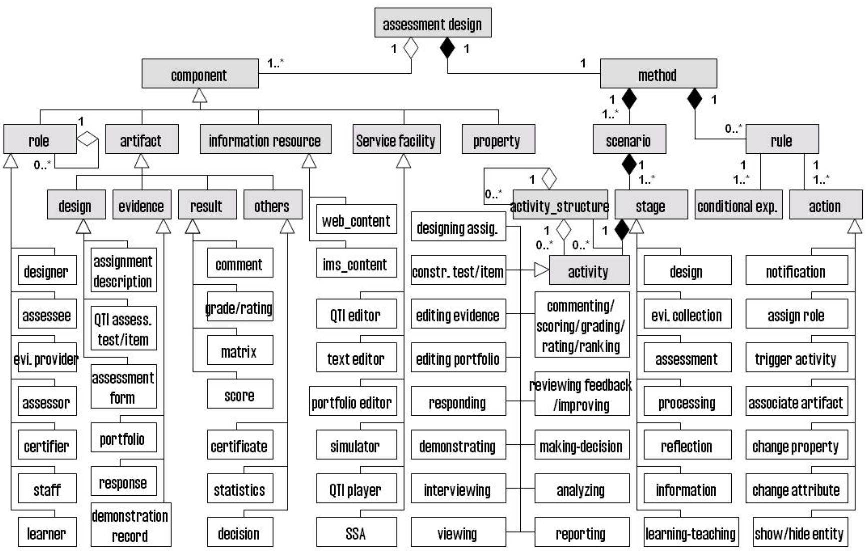

Fig. 1. Semantics Aggregation Model

Assessment design is a description of an assessment method that yields the appropriate evidence of assessees' competences and produces assessment results through following some rules. It has attributes such as *identifier, title, description, assessment objectives, assessment types*, etc. The *identifier, title,* and *description* are trivial attributes for presenting semantics and will not be mentioned any more when presenting other vocabularies. *Assessment-objective* is used to describe the intended outcome of the assessment in terms of information resources or competence proficiencies. *Assessment-type* is used to define a way to yield and evaluate evidence. The possible choices are *classic test, self-/peer assessment, portfolio assessment, 360 degree feedback,* etc.

Each choice will provide additional restrictions to the conceptual model. For example, in a peer assessment many concepts will be excluded. A detailed example of a peer assessment is given in [19].

Role is used to distinguish different types of participants in an assessment process. Several roles have been pre-defined such as *designer, assessee, evidence provider, assessor, certifier, learner,* and *staff.* Each role can be refined or customized further, for example, *candidate* and *assessment-taker* to *assessee* and *reviewer, rater,* and *evaluator* to *assessor*. Note that a user may be able to have several roles at the same time and that many users can play the same role. Two important attributes of a role are *role-property* and *role-member-property*. A declaration of a *role-property* is just instantiated once in an execution to present a characteristic and a state of the whole role, for instance, whether all assessors have finished commenting. A declaration of a *role-member-property* will be instantiated for every user who has this role, for instance, a *trait* is a pre-defined *role-member-property* for *assessee*. A *role-member-property* of the root role can be declared locally or globally.

Stage is used to distinguish different focuses within the whole assessment process, and *activity* is a logical unit of task performed individually or collaboratively within a *stage*. As shown in Fig. 1, APS has seven pre-defined types of stages and fourteen types of activities, which have more assessment-specific semantics than the generic terms such as act and activity in LD. However, the constraints about the aggregation relations between the stage types and activity types have not been illustrated in Fig. 1 for reasons of readability. In fact, in each type of stage only some types of activities are allowed. For example, *constructing QTI items/test* and *designing demonstration assignment* can only been specified in the design stage. In the *evidence collection stage* only *responding QTI test/item, editing portfolio, editing evidence,* and *demonstrating* are allowed. Note that *learning-activity* and *support-activity* (not shown in Fig. 1) are defined to be similar to those in LD; they can be performed in the learning-teaching stage. In addition, more than one activity can be performed within the same stage. A set of *activities* can be grouped as an *activity-structure*. Four types of activity-structures are specified: *sequence-structure* (all activities will be performed in a prescribed sequence), *selection-structure* (a given number of activities selected from a set of candidate activities will be performed in any order), *concurrent-structure* (a set of activities are performed concurrently), and *alternative-structure* (one or more activities selected from a set of candidate activities according to prescribed conditional expressions will be performed). A *stage,* an *activity-structure,* and an *activity* have common attributes such as *completion-condition* (e.g., user-choice, time-over, artifact-submitted, and even user-defined conditions) and *post-completion-actions* (e.g., show/hide information/activity).

Artifact is used to represent the information object created, introduced, and shared within and/or across activities as an intermediate product and/or a final outcome. As Fig. 1 shows, a particular type of artifact will fall into one of four categories: *design, evidence, assessment result,* and *others*. Each type of concrete *artifact* has a specific data-type and will be handled using appropriate *services*. For example, a *comment* is an information object created by using a QTI player as a response to an extended-text-interaction or an output of a text editor. Some attributes of an artifact can be used to capture generic information such as *status, size,* and *media-type* (e.g., a MIME-type). For example, an *evidence* or *demonstration* may be in the form of Text, XML, URL, an image, or a video. Other attributes are used to describe association information such as *source-activity, destination-activities,* and *default-service-type*. *Information resource* differs from *artifact* because it is available and keeps unchanged during the whole assessment process.

Service is used to specify the type of "service" for handling certain types of *artifacts* (e.g., QTI player and portfolio editor) or/and for facilitating communication and collaboration (discussion forum and text editor). As shown in Fig. 1, the APS extends LD built-in services by including several assessment-specific services and some general-purpose services which can be used for assessment. It is allowed to introduce new types of services when modeling and executing a UoA.

Property is designed for capturing any information relevant to the process or to certain roles. The role relevant property has been discussed above. A process relevant property will be instantiated once for each execution of a UoA or for all executions, depending on whether it is declared by the user as a local property or a global one. Examples of the process relevant properties are a process status, a decision, etc.

Rule consists of *conditional expressions* and a set of *actions* and/or embedded rules in a form of If (conditional expression) Then (actions) Else (actions/rules). A *conditional expression* is a logical expression on the attributes (e.g., assessment-type, activity-status, user-in-role, role-in-activity, artifact-default-service, and etc.) and properties. An *action* is an operation performed by the system. As shown in Fig. 1, exemplar actions are *change attribute* (assigning a value to an attribute), *associating artifact* (assigning an artifact as an input/output of an activity), and *show/hide entity* (making a scenario/activity/information visible for the user), etc. Thus, a *rule* can be used to model dynamic features and support adaptive assessment.

3.2 Conceptual Structure Model

Fig. 2 illustrates the main structural relations between the concepts. By design, APS is an activity-centric model. The core idea is: following certain *rules* people with various *roles* perform *activities/activity-structures* allocated to them; they do so in *stages* using *service facilities* and *information resources* in order to consume and produce *artifacts*. When presenting the semantics of each concept above, we have mentioned some structural relations. In this sub-section, we focus on discussing the structural relations around the activity.

The important attributes of an *activity* are *roles involved, input and output artifacts, services needed, information resources referred to, completion-conditions,* and *post-completion-actions*. For each particular type of activity, APS specifies a few particular structural relations with certain types of roles, artifacts, and services. For example, a *responding* activity is associated with an *assessee,* a *QTI test/item,* a *QTI player,* and a *response*. The structural relations between these components are pre-defined in APS. Therefore, in design-time, after an activity with a certain type has been created, the associated components (e.g., roles involved, input and out artifacts, and services needed) will be created automatically and the values of some attributes of these components (for specifying types and association relations) can be assigned automatically. Another example is *improving* activity, which can be specified according to the definition of the activity specified in the *evidence collection* stage. For instance, if the type of activity arranged in the *evidence collection* is *responding* (e.g., answering a list of multiple-choice questions or writing an essay), the *improving* activity will be configured in such a way that it associates the *improving* activity with a *QTI player*, the original *QTI test/item*, and the *response* of the user. Obviously, we cannot detail here all pre-defined structural relations between all types of roles, activities, artifact, and services. Please note, though, that a user-defined *rule* can be used to specify and change the pre-defined structural relations by the user. For example, the type of the input artifact used for the *commenting* activity is pre-defined in APS as an extended text interaction of QTI. The user can change the definition of a given *commenting* activity by assigning a value (e.g., Text) of the input artifact type. Then the default service (a text editor in this case) for handling this artifact type will be arranged accordingly. Thus, the structural relation specified in the rule can help the run-time system pass the text-based document as an input artifact of the activity when invoking a text editor.

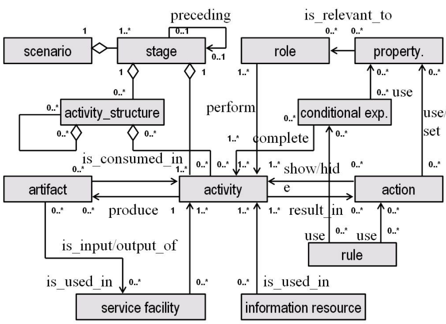

Fig. 2. Conceptual Structure Model

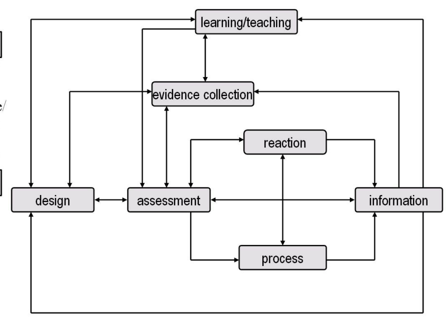

Fig. 3. Process Structure Model

3.3 Process Structure Model

Fig. 3 illustrates the process structure relations between the seven stages (cf. Fig. 1). Usually both the start point and end point of an integrated learning and assessment scenario are the *learning/teaching stage*. A complete process may consist of all types of stages in a sequence of *learning/teaching, design, evidence collection, assessment, reflection, process, information,* and *learning/teaching*. Sometimes one or more stages can be excluded. For example, the *design stage* may be excluded if the method for collecting evidence and the assessment form/criterion have been designed before the start of the execution and will be available during the execution. In a particular case, a teacher may grade students based on memory and then an *evidence collection stage* can be excluded. In contrast, some stages may be repeated several times. For example, further evidence may need to be gathered after an initial assessment; and even a *design stage* may be needed for creating additional assessment items according to the user's response at run-time. Sometimes a peer assessment can be designed in a way that enables the *assessee* to review the feedback and request for elaboration. The assessor may provide further comments and detailed explanations. In some complicated cases, multiple loops may be defined within a scenario. Therefore, many concrete assessment process models can be derived from this generic process structure model. In particular, these concrete assessment process models can be designed differently at the component (e.g., role, activity, artifact, and service) level.

4 An Initial Validation of the Conceptual Model

Validation studies have been conducted to test if the conceptual model would meet the requirements described in section 2. In this section, we present the results of these initial validation studies.

Completeness: The OUNL/CITO model [9] is an extensible educational model for assessment, which provides a broad basis for interoperability specifications for the whole assessment process from design to decision-making. The OUNL/CITO model was validated against Stiggins' [23] guidelines for performance assessments and the four-process framework of Almond et al. [1]. In addition, the model's expressiveness was investigated through describing a performance assessment in teacher education using OUNL/CITO model terminologies. Brinke et. al. [9] reported that the OUNL/CITO model met the requirement of completeness. This paper bases the APS validation study of completeness on the OUNL/CITO model. Indeed, the conceptual model of APS is based on the OUNL/CITO model. However, like QTI, the OUNL/CITO model is a document-centric one. The concepts of stage and corresponding activities are not explicitly included in the model although they are conceptually used to develop and organize the model. As a consequence, an assessment description based on the OUNL/CITO model cannot be executed by a process enactment service, because important information about control flow and artifact flow from one activity/role to another is missing in the OUNL/CITO model. Nevertheless, APS extracts almost all concepts represented explicitly and implicitly in the OUNL/CITO model. We reformulated these concepts from a perspective of process support. APS explicitly formalizes concepts such as stage, activity, artifact, service, and rule, and re-organizes them around the activity. As already mentioned, like LD, APS is an activity-centric and process-based model. We removed some run-time concepts such as *assessment-take* and *assessment-session* from the OUNL/CITO model, because they are related to the execution of the model. Moreover, because some concepts such as *assessment policy*, *assessment population*, and *assessment function* are complicated for ordinary teachers and instruction designers, APS does not explicitly include them. If need be, the attribute *description of the assessment design* in APS can be used to represent these concepts implicitly. In addition, terms such as *assessment plan* and *decision rule* are replaced by other terms such as *UoA* (in fact, an instance of a UoA) and *rule*, which are expressed in a technically operational manner. We conclude that all concepts in the OUNL/CITO model can be mapped to APS. Furthermore, in order to model formative assessments, APS integrates the *learning/teaching stage* and the activities specified in LD. Thus APS meets the basic requirements of completeness.

Flexibility: As mentioned when we presented the process structure model in section 3.3, APS enables users to specify various assessment process models by tailoring the generic process structure model and by making different detailed designs at the component (e.g., role, activity, artifact, and service) level. We tested the flexibility by conducting several case studies. In order to explain how to model a case based on APS, we present a simple peer assessment model. As shown in Fig. 4, this three-stage model involves two learners. In the first stage, each learner writes a different article and sends it to the peer learner. Then each learner reviews the article received and sends a comment with a grade back to the peer learner. Finally, each learner reads the received feedback. In the same way, we have tested three more complicated peer assessment models, a 360 degree feedback model, and a programmed instruction model. For lack of the space, a detailed description of these case studies is omitted. All validation studies, however, reveal that APS is sufficiently expressive to describe these various forms of assessment. Thus APS supports flexibility to at least some extent.

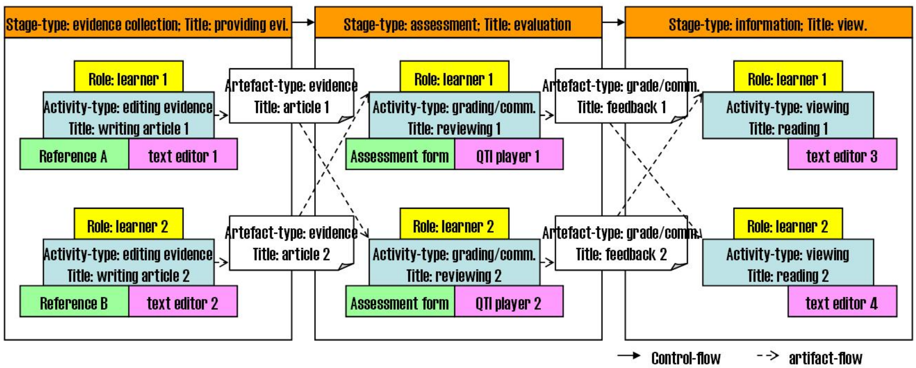

Fig. 4. A Simple Peer Assessment Model

Adaptability: Adaptation can be supported in APS at two levels. The first is at the assessment task level. As we know, QTI can support adaptation by adjusting assessment item/test (e.g., questions, choices, and feedback) to the responses of the user. APS, however, supports adaptation at task level much more broadly. According to an assessee's personal characteristics, learning goals/needs, response/performance, and circumstantial information, an assessment-specific activity can be adapted by adjusting the input/output artifact, service needed, completion-condition, post-completion-actions, and even the attributes of these associated components. For example, a rule could be: if (learning_goal:competenceA.proficiency_level >= 5) then (a test with a simulator) else (a test with a questionnaire). The second level is the assessment process level. APS supports adaptation of assessment strategies and approaches by changing the process structure through showing/hiding scenarios, changing the sequence of stages, showing/hiding activities/activity-structure. The adaptation is expressed as rules in APS. An example of such a rule is: if (learning within a group) then (peer assessment) else (interview with a teacher).

Compatibility: The domain of application of APS overlaps with those of both LD and QTI. However, they operate at different levels of abstraction. LD and QTI provide a wealth of capabilities for modeling assessment process models, but the code can become lengthy and complex. For this reason, we developed APS at a higher level of abstraction by providing assessment-specific concepts. These built-in constructs provide shortcuts for many of the tasks that are time-consuming if one uses LD and QTI to model them. However, APS is built on the top of LD and QTI, and the assessment-specific concepts are specializations of the generic concepts in LD and QTI. For example, concepts such as *constructing assessment item* and *commenting* in APS are specializations of the generic concept *support-activity* in LD. An assessment process model based on APS can be transformed into an executable model represented in LD and QTI. Thus, we should be able to use an integrated LD and QTI run-time environment to execute various forms of assessment based on APS. In addition, APS will be organized using the IMS Content Package specification. It can use IEEE Learning Object Metadata (LOM) to describe the meta-data of elements in APS. Moreover, the IMS Reusable Definition of Competency or Educational Objectives can be used to specify traits and assessment objectives. The IMS ePortfolio can be used to model portfolios (coupled with artifacts in APS) and integrate a portfolio editor. The IMS Learner Information Profile can be used to import global properties from a run-time environment and export them to it. IMS Enterprise can be used for mapping roles when instantiating a UoA. Therefore, APS is compatible with most existing, relevant e-learning technical specifications.

5 Conclusions and Future Work

This paper addressed the problems one faces when attempting to use QTI and LD to support the management of assessment processes, in particular, formative assessment and competence assessment. In order to support the sharing of assessment process information in an interoperable, abstract, and efficient way, we developed APS as a high-level assessment-specific process modeling language. We have developed the conceptual model of APS by adopting a domain-specific modeling approach. The conceptual model has been described through detailing the semantics aggregation model, the conceptual structure model, and the process structure model. The first validation study has been conducted through investigating whether the conceptual model of APS meets the requirements of completeness, flexibility, adaptability, and compatibility. The results suggest that the model does indeed do so.

APS should meet additional requirements (e.g., reproducibility, formalization, and reusability), which we intend to investigate after the development of the information model and XML Schemas binding. In order to enable practitioners to easily design and customize their own assessment process models, an authoring tool for modeling assessment processes with APS will be developed in the near future. In order to execute an instantiated model in existing LD and QTI compatible run-time environments, transformation functions have to be developed as well. Then we will carry out experiments to investigate the feasibility and usability of APS and the corresponding authoring tool. Finally, we will propose APS as a candidate, new open e-learning technical standard.

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A Method to Find Learner's Key Characteristic in Wed-Based Learning

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Abstract. One of the challenges in personalized e-learning research field is how to meet the unique learning strategies according to a learner's personality characteristic. But a learner's characteristic may have many attributes, and some of them have not equal value for personalized e-learning. This paper exploits the aspect to evaluate the important attributes, puts forward the concept of key personality characteristic and an improved algorithm basing on rough set theory to find the key attributes. Systematic experiments and their results are reported and shows the dimensions of personality characteristic can be decreased to below one-quarter.

1 Introduction

Because of its flexibility and cost-effectiveness, e-learning has become a vital complement to the traditional classroom learning. The research of personalized e-learning is an important topic in education and computer science fields. Some fundamental learning theories show that learning strategies are vital aspects of personalized learning [1] and the study in educational psychology shows that learning strategies are greatly affected by the learner's personality characteristic [1][2].

Personality characteristic refer to somebody's relatively stable traces that are revealed internally or externally. Physiologically, these characteristic include physical signs and human senses etc. Psychologically, these characteristic include intellectual types, personal interests, motivation, emotion and will etc.

However, the relative importance of these attributes does not have equal weights to learning strategies. Some attributes are even redundant. If we consider all attributes in personalized e-learning, then when the number of learners in a study group is large in quantity, we may encounter the problem of "dimension disaster". One example will be an e-learning university where thousands of students are enrolled and each of them needs hundreds of attributes to describe his/her characteristic and finding appropriate strategies for each student quickly are a hard problem in the situation. Therefore, it is an important research problem to reduce the number of attributes so that only key attributes are identified and used in the search for appropriate learning strategies in personalized e-learning environment. This article presents the results of a research project that sought to explore learner's key characteristic attributes and determine the relative weight of each attribute.

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The experiments and analysis, in Section 5, showed that the concept of key personality characteristic and the analysis method, we put forward in the paper, are efficient to solve the problems of dimension disaster and huge data volume in personalized e-learning environment. For the sample data set, the initial personality characteristic have 28 dimensions and, after processed, the dimensions of key personality characteristic attributes can be decreased to below one-forth and the reduction rate of data volume can mostly be about 50%.

2 Related Work

Nowadays there are some studies on the relationship among learner's characteristic and the learning strategies. Most of them are from the perspective of educational psychology. The methods used by them are correlate analysis, regression analysis and discriminator function [7][8]. These only focus on the correlation study, but which attributes are key and which are redundant (i.e., they are the target for reduction) still involved human experts to determine and the process is subjective and wastes time.

Furthermore, most researches simply study the relation between the single attribute and learning strategies and did not considerate the whole influence of the combination of attributes to the strategies. Moreover, some method, such as regression analysis, can not be applied when the attributes have interrelation each other. While, traditional statistical methods are employed to handle massive data set in e-learning.

Rough set is a relatively new mathematically method to handle imprecise, non-deterministic and incomplete data. In recently years, it has been applied to areas like machine learning, knowledge discovery, data mining and decision support [4][6]. The inference process of the rough set naturally simulates the self-adaptive behaviors and characteristic existed in human beings. The key advantage of the rough set approach over other ones is that there is no need for prior knowledge. It is able to reveal the natural relationship through data itself [5].

In the paper, a new approach was presented to study how to fine the learner's key attributes influencing the learning strategies. The method first constructed information system for learners' personality characteristic, then applied an improved algorithm basing on rough set theory, which directly built core set and non-core set and calculated the reducts basing on the logical calculation to obtain the attribute reducts, and, at last, analyzed and compared the results, and found the learner's key characteristic attributes and obtained their weights.

3 Concepts and Definitions

Many educational psychology researches and practices show that personality factors, learning styles and learning conceptions have influences on the learning strategies[2], so in this paper, personality characteristic include these. Personality factors are representative of the affective and cognitive aspects of individual traits. Recent decade's research results in psychology field show that investigating personality factors help predict a person's learning patterns and strategies[2]. Learning styles denote cognitive styles observed specifically in a learning context. Cognitive styles are tendencies that are consistently displayed by individuals to adopt a particular type of information processing strategy. Learning conceptions are a person's conceptions and ideas about what learning is. It is believed to have a strong impact on learning strategy use[2].

There is still a debate among about the definition of learning strategy in education and educational psychology. Our understanding of the learning strategy is mainly based on the experiences gathered through the study of foreign language (main English) at Xi'an Jiaotong University, China. In Chinese universities, College English is a required course for almost all students. Here, to make the study more effective and not be too general to be valuable, we take English language learning into account, and accordingly, personality characteristic include personality factors, language learning styles and language conceptions, and learning strategies include metacognitive strategy, affective strategy, form-focused strategy, meaning-focused strategy, compensation and social strategy[3].

To make expatiate smoothly and avoid different comprehension in meanings, some definitions are explained in details as following.

Definition 1. Personality characteristic

A learner's personality characteristic is the relatively stable traces that are revealed internally or externally. As the above, in this paper, personality characteristic include personality factors, language learning styles and language conceptions and it can be represented as C = {PF, LS, LC}. C is the whole attribute set for personality characteristic. PF is the attribute subset for describing personality factors and one example is 16 PF identified by Raymond B. Cattell in the 1940s. LS is the attribute subset for describing the language learning styles, such as visual, audio or experimental types. LC is the attribute subset for describing the language conception such as self-management in a learning environment. The details are showed in Appendix. In the case, personality characteristic have 28 dimensions at least.

Definition 2. Learning strategies

As the above, taken English language learning into account, learning strategies can be described in the following five aspects: metacognitive strategy, affective strategy, form-focused strategy, meaning-focused strategy, compensation and social strategy[3].

Metacognitive strategy refers to plan the organization of one's learning, such as establishing the goal for learning, making a schedule, etc. Affective strategy refers to control one's affection during learning, such as encourage oneself when feeling depressed. Form-focused strategy refers to the concrete approach to mastering the knowledge, such as memorizing the words by reciting. Meaning-focused strategy refers to practice the ability of reading, speaking, listening, etc., such as improving listening ability by listening to the foreign language radio. Compensation and social strategy refers to methods during one's communication with others, such as gesturing when one can not express any words.

Learning strategies can be described as $D = \{mcs, afs, ffs, mfs, css\}$, where *mcs* is the abbreviation for metacognitive strategy, *asf* is for affective strategy, *ffs* is for form-focused strategy, *mfs* is for meaning-focused strategy and *css* is for compensation and social strategy.

Definition 3. Information system for learners' personality characteristic （SLPC） The construction of an information system for learners' personality characteristic is the foundation for analyzing key characteristic attributes. The information system is the set of learners. The set can be represented as $S=(U,C\cup D,V,f)$. U is the non-empty finite set for all the learners. C is the non-empty finite set for personality characteristic attributes of learners. D is the non-empty finite set for the learning strategies, such as metacognitive strategy, and affective strategy etc. $C\cap D=\varnothing$, $C\cup D=A$, $V=\bigcup_{a\in A}V_a$, V_a is the value domain for $a\in A$ $f:U\times A\to V$ is a single mapping function such that there is a unique value in V for all $a\in A$.

Definitions 4. Reducts of the set of personality characteristic Reducts of the set of personality characteristic are the results of the approach, applied in this paper, and the reduction is the process through which characteristic attributes, that have little influence on the learning strategies, are eliminated, according to the implicit relationship among characteristic attributes and the learning strategies.

In rough set theory, suppose $R\subseteq C,\ X\subseteq U$, $\underline{R}X=\left\{x\in U\mid [x]_{ind(R)}\subseteq X\right\}$ is the R-Lower approximation of X. Suppose $pos_R(D)=\bigcup_{X\in U/D}(\underline{R}X)$ is R-positive region of D. It is essentially the union set of all objects of U, which can be classified into U/D using the learners' personality characteristic subset R. If $\alpha\in R$, $pos_R(D)=pos_{R-\{a\}}(D)$, then α is redundant in R. Otherwise, α is necessary in R. If every α in R is necessary, R is independent of D. That is to say, for given information system of learners' personality characteristic S, the rough set $C^{'}$ is a non-empty subset of C such that (1) $pos_{C^{'}}(D)=pos_C(D)$, (2) If $C^{'}$ is the C-independent subset of D, $C^{'}$ is the C-relative independent rough set of D. $red_D(C)$ represents the set of all reductions. The core of C is defined as the intersection of all reductions of C: $core_D(C)=\cap red_D(C)$.

Definition 5. Key attributes of personality characteristic Key attributes of personality characteristic are the ones that have relatively importance value related to the learning strategies. If $\alpha\in C^{'}$, The influence factor of α is defined as

$$SGF(a,C^{'},D)=(\mid pos_{C^{'}}(D)\mid-\mid pos_{C^{'}-\{\alpha\}}(D)\mid)/\mid U\mid.$$

If $SGF(a,C^{'},D)$ is $\geq 97\%$, α is the key attribute. Otherwise, α is not.

Definition 6. Discernibility function If $a_i\in C$, $x,y\in U$ and belong to different equivalent sets of $d_i\in D$, $a(x,y)=\{a_1,a_2,\ldots,a_k\}$ represents the subset of C and $a_i\in C$ can differentiate x and y in U (the learner's domain). $\sum a(x,y) = a_1 \vee a_2 \vee \cdots \vee a_k$. If $a(x,y) = \varnothing$, then let $\sum a(x,y) = 1$. Discernibility function is defined as: $\Delta = \prod_{(x,y)\in U\times U} \sum a(x,y)$.

Theorem 1: The minimal disjunctive normal form of the discernibility function Δ corresponds to the all reduction set of S.

Definition 7. Reduction efficiency
The data volume of the information system before the reduction is defined as: $E_S = |C| * |U|$ and after the reduction is defined as: $E_S^{'} = |C^{'}| * |U|$. The reduction efficiency is: $E = 1 - E_S^{'} / E_S$.

4 Find the Key Personality Characteristic Attributes

Under the background of College English learning in Xi'an Jiaotong University, China, the concrete personality characteristic, learning strategies, etc., are defined as above, then finding the key personality characteristic attributes can be applied as following.

To obtain the reducts, the improved method is used to analyze ISLPC. Here, personality characteristic, defined as C, are the conditional attributes and learning strategies are the decision attributes. Once the reduced set is available, we order the attributes based on the value of SGF , defined in Section 3, and, at last, find the key personality attributes.

Since the huge volume of e-learners and high dimension attributes of personality characteristic, the traditional reduction methods are generally not suitable. This paper proposes a method that directly builds *core set* and *non-core set* and calculates the reducts based on the logical calculation. In the method, discernibility matrix[9][10], that costs huge space, can not be generated and, moreover, an optimal strategy is applied, in which, the attributes in *nocore* set can be absorbed in advance to reduce the value of calculation. In worst situation that the number of the attributes is the cardinality of C , the time complex is $O(N^2 * C)$.

Core is the set of the attributes only by which any two learners can be distinguished in the domain. It is defined as:

$$core = \{c \in C : \exists c,\ \text{such that}\ \forall c^* \in C,\ c^* \neq c, \text{having}\ f(x_i,c^*) = f(x_j,c^*)\ \text{and}\ f(x_i,c) \neq f(x_j,c)\}$$

$nocore$ set includes the attributes that are not in *core*, but can still be used to distiguish any two learners in the domain. We have:

$$nocore = \{a \in C : a \not\subset core, \text{having}\ f(x_i,a) \neq f(x_j,a)\}\ .$$

The following condition must met: $core \subseteq C$, $nocore \subseteq C$, $core \cap nocore = \varnothing$.

The following is the detailed description of the algorithm:

Input: Information system $S = (U, C \cup D, V, f)$, including the learners' personality characteristic.

Output: The reduct red and the set of key personality characteristic K.

Steps:

Step 1: Let $red = \varnothing$; $nocore = \varnothing$; $core = \varnothing$; flag = 0; $attr = \varnothing$;

Step 2: Compare subjects in the domain one by one, calculate *core* set and *nocore* set. The following is the detail:

```
For ( i = N; i > 0; i--)            //N is the number of learner subjects in U
  {For ( j = i-1; j >0; j--)
        {
if f(i,d) ≠ f(j,d)          //d ∈ D , refer to definition 2, f(i,d) is
                            //described in definition 3
 { for ( k = 1; k <= FN; FN++)      //FN is the cardinality of the
                                     //personality characteristic set C ,
                                     //refer to definition 1
    if i[k] ≠ j[k]
      {  attr = attr ∪ i[k] ;  //record the names of the personality
                               //characteristic attributes that have
                               //unequal values
 if (attr ∩ core ≠ ∅)
   { attr = ∅ ;  got to step 2; } // apply optimal
                              //strategy, that is to say, if
                              // attr and core have
                              //common attributes, then
                              //the attributes was absorbed
                              //in advance and need not be
                              // compared continually.

else
flag++;  //flag marks the number of personality
         //characteristic attributes that have unequal
           //values
      }
  }
if flag>1 { nocore = nocore ∪ attr ;} // the attribute in attr
                                      //is not core
if flag = 1
 { core = core ∪ attr ;    //the attribute in attr is core
   if (attr ∩ nocore ≠ ∅)
       nocore = nocore \ attr ;
}
```

```
            flag=0;
            attr = ∅;
              }
     }
```

Step 3: $red = \min\{|\alpha|, \alpha \in core \times nocore\}$;

Step 4: Convert $S = (U, C \cup D, V, f)$ to $S^{'} = (U, red \cup D, V, f)$;

Step 5: Calculate SGF;

Step 6: Order the SGF value from the large to the small, calculate the key personality characteristic set K.

According to the above algorithm, when comparing subject 1 and 2, we can obtain $core = \{a\}$; when comparing subject 3 and 4, first obtained $attr = \{a\}$ and then applied the optimal strategy. Since $attr \cap core \neq \varnothing$, we need not calculate attributes a, b continually. If we calculate continually, we will obtain {a, b} and according to the logic absorb principle, {a, b} will be absorbed to {a} ultimately. So we applied the strategy and cut down the compared attributes to the best advantage. The effect is prominent because there are high dimension attributes in ISLPC. Specially, we carefully investigated the data of the e-learners and drew the conclusion that the values of most attributes are equal among e-learners. Such situation can get the most out of the strategy and dramatically decrease the cost of comparing the attributes.

5 Experiments and Analysis

The above method is illustrated by an example as follows. More than 300 students in several colleges of Xi'an Jiaotong University, China, have used the personalized English e-Learning system to improve their English skills. We have collected 157 valid samples from these students. In the situation, personality characteristic of each sample have 28 dimensions and, according to the definition 7 in Section 3, the value of E_S is 4396. As showed in the following, after the above method processes the samples, the dimensions of key personality characteristic attributes can be decreased to below one-forth and the reduction rate E can mostly be about 50%. If the method will be applied to the realistic e-learning university, that there are thousands of students, the function will be more remarkable.

As described in definition 2, learning strategies set $D = \{mcs, afs, ffs, mfs, css\}$ includes multiple attributes. In order to simplify the calculation, according to the pedagogic theory, these five learning strategies can be separately implemented to speed the process of finding the optimal learning strategies. So, we decomposed $S = (U, C \cup D, V, f)$ into five different subsystems $\{S_1, S_2, S_3, S_4, S_5\}$, where $S_i = \{U, R_i, V, f)$, $R_i = C \cup \{d_i\}, d_i$ $(1 \le i \le 5)$ represents the *i*th elements in the set $D = \{mcs, afs, ffs, mfs, css\}$.

We have applied the reduction algorithm described in Section 4 for $S_i = \{U, R_i, V, f)$, $(1 \le i \le 5)$, respectively. The results are showed in table 1.

Table 1. Reducts for 5 learning strategies

Learning Strategy	*Reducts{Personality Characteristic Attribute Name}*
mcs	{C, E, H, I, M, N, O, Q2, Q4, GROUP1, GROUP3, GROUP4, MYYLLEVEL, XXXZLEVEL, XXCLLEVEL}
afs	{B, E, G, H, I, N, O, Q2, Q3, Q4, GROUP2, GROUP3, GYLEVEL, XXXZLEVEL, XXCLLEVEL}
ffs	{E, I, Q2, GROUP4, ZWXNLEVEL}
mfs	{A, C, G, H, N, O, Q2, Q3, Q4, GROUP1, GROUP3, GROUP6, MYYLLEVEL, ZWXNLEVEL, GYLEVEL}
css	{A, C, F, G, I, M, O, Q4, GROUP1, GROUP2, GROUP3, GROUP4, GROUP5, GYLEVEL, XXXZLEVEL, XXCLLEVEL}

We found that personality characteristic attributes included in each learning strategy varies significantly. No single characteristic attribute is related to all 5 strategies. Sensitity(I),apprehension(O), self-reliance(Q2), tension(Q4), group|individual lity(GROUP3) are attributes that affect 4 learning strategies. Therefore these attributes are key ones. Brilliance(B), excitement(F), systematic/random(GROUP5), spontaneity/thoughtfulness(GROUP6) are attributes that only affect one learning strategy. These personality characteristic are less important ones and can be eliminable if needed.

According to the definition 5 in Section 3, we can calculate the value of SGF for every attribute in each reduct and the detail is illustrated from table 2 to table 6. Then, it is clear, in table 2, that visual|auditory|experimental(GROUP1), shrewdness(N),

Table 2. The value of SGF for *mfs*

Characteristic Attributes (for *mfs*)	Attribute Name	SGF
Visual|Auditory|Experimental	GROUP1	0.1146
Shrewdness	N	0.0764
Social boldness	H	0.0701
Dependence on mother tongue	MYYLLEVEL	0.0637
Language learning conception	XXXZLEVEL	0.0510
Sensitivity	I	0.0382
Group|Individuality	GROUP3	0.0382
Apprehension	O	0.0255
Self-reliance	Q2	0.0255
Tension	Q4	0.0255
Emotional stability	C	0.0127
Dominance	E	0.0127
Learning strategy conception	XXCLLEVEL	0.0127
Imagination	M	0.0009
Analytical|Synthesis	GROUP4	0.0009

social boldness(H), dependence on mother tongue(MYYLLEVEL), language learning conception(XXXZLEVEL), sensitivity(I) and group|individuality(GROUP3) are key attributes for $mcs \in D$.

Similarly, ascribing conception(GYLEVEL), sensitivity(I), independence|dependence(GROUP2), social boldness(H), tension(Q4), persistence(G), self-reliance (Q2) are key attributes for $afs \in D$ in table 3.

Table 3. The value of SGF for *afs*

Characteristic Attributes (for *afs*)	Attribute Name	SGF
Ascribing conception	GYLEVEL	0.0701
Sensitivity	I	0.0510
Independence|Dependence	GROUP2	0.0510
Social boldness	H	0.0446
Tension	Q4	0.0446
Persistence	G	0.0382
Self-reliance	Q2	0.0318
Apprehension	O	0.0255
Self-discipline	Q3	0.0191
Learning strategy conception	XXCLLEVEL	0.0191
Language learning conception	XXXZLEVEL	0.0127
Brilliance	B	0.0008
Dominance	E	0.0008
Shrewdness	N	0.0008
Group|Individuality	GROUP3	0.0008

Dominance(E), analytical|synthesis(GROUP4), self-efficacy conception(ZWXNLEVEL), sensitivity(I) and self-reliance(Q2) are key attributes for $ffs \in D$ in table 4.

Table 4. The value of SGF for *ffs*

Characteristic Attributes (for *ffs*)	Attribute Name	SGF
Dominance	E	0.2803
Analytical|Synthesis	GROUP4	0.0828
Self-efficacy conception	ZWXNLEVEL	0.0764
Sensitivity	I	0.0318
Self-reliance	Q2	0.0318

Table 5. The value of SGF for *mfs*

Personality Characteristic (for *mfs*)	Attribute Name	SGF
Social boldness	H	0.0382
Apprehension	O	0.0318
Warmth	A	0.0255
Emotional Stability	C	0.0255
Tension	Q4	0.0255
Ascribing Conception	GYLEVEL	0.0255
Persistence	G	0.0127
Self-Reliance	Q2	0.0127
Self-discipline	Q3	0.0127
Visual|Auditory|Experimental	GROUP1	0.0127
Dependence on mother tongue	MYYLLEVEL	0.0127
Self-efficacy Conception	ZWXNLEVEL	0.0127
Shrewdness	N	0.0009
Group|Individuality	GROUP3	0.0009
spontaneity / thoughtfulness	GROUP6	0.0009

Social boldness(H) and Apprehension(O) are key attributes for $mfs \in D$ in table 5. Sensitivity(I) and visual|auditory|experimental(GROUP1) are key attributes for $css \in D$ in table 6.

Table 6. The value of SGF for *css*

Personality Characteristic (for *css*)	Attribute Name	SGF
Sensitivity	I	0.0446
Visual|Auditory|Experimental	GROUP1	0.0382
Warmth	A	0.0255
Persistence	G	0.0255
Imagination	M	0.0255
Emotional stability	C	0.0127
Excitement	F	0.0127
Apprehension	O	0.0127
Tension	Q4	0.0127
Independence|Dependence	GROUP2	0.0127
Ascribing conception	GYLEVEL	0.0127
Language learning conception	XXXZLEVEL	0.0127
Learning strategy conception	XXCLLEVEL	0.0127
Group|Individuality	GROUP3	0.0007
Analytical|Systhesis	GROUP4	0.0007
Systematic|Random	GROUP5	0.0007

Now, we obtained the key personality characteristic attributes and during the development of personalized e-learning, these attributes have important influence to learning strategies and should be considered top-priority.

According to the definition 7 in Section 3, before using the reduction algorithm, the value of E_S for S_1 is 4396. After the reduction, the value of $E_S^{'}$ is 2355. The reducetion rates E for S_1, S_2 and S_4 are 46% respectively. The reduction rate E for S_3 is 82%. The reduction rate E for S_5 is 43%.

6 Conclusion

This paper investigated the problem of key personality attributes that influence the personalized learning strategies in e- learning and proposed an algorithm to effectively identify key personality attributes. The algorithm is based on the rough set theory and does not require any prior knowledge. An extensive experiment has been conducted in a major Chinese research university to validate the method and drew the initial results. In the future, the results will be used to instruct the construction of personalized e-learning system.

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Computer-Aided Generation of Item Banks Based on Ontology and Bloom's Taxonomy

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Abstract. Online learning and testing are important topics in information education. Students can take online tests to assess their achievement of learning goals. However, the test results should assign student scores and assess their achievement of knowledge and cognition levels. Teachers currently need to spend considerable time on producing and maintaining on-line testing items. This study applied ontology, Chinese semantic database, artificial intelligence and Bloom's taxonomy to propose a CAGIS E-learning system architecture to assist teachers in creating test items. As the result, the computer assisted teachers in producing a large number of test items quickly. These test items covered three types of knowledge and five dimensions of cognitive skills. The test items could meaningfully assess learning level meaningfully.

Keywords: Online Test, Test Item Bank, Bloom's Taxonomy, Ontology, Semantic Web.

1 Introduction and Related Works

Online learning and subsequent testing have been important topics in information education. Because education is intended to change students behaviors, teachers must use tests well to assess student achievements. Computer-based testing has numerous benefits, including data-rich test results, immediate test feedback, convenient test times and locations, and so on. [1].

In designing test items, teaching goals should be considered when designing test items. According to education testing theory, educational goals can be classified into three different levels: cognition field, emotional field and movement ability [2]. Types of instruction assessment can be grounded in types of knowledge. Three distinct knowledge types require assessment: declarative (knowing what/knowing about), procedural (knowing how), and conditional (knowing why and when) [3]. Bloom identified six levels within the cognitive domain, including knowledge, comprehension, application, analysis, synthesis and evaluation [4]. Anderson and Krathwohl [5] revised the original taxonomy of Bloom by combining both the cognitive process and knowledge dimensions. The revised Bloom's taxonomy comprises a two-dimensional table. One dimension identifies the knowledge (the kind of knowledge to be learned), while the other identifies the cognitive process (the process used to learn). The knowledge dimension comprises four levels: factual, conceptual, procedural, and

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meta-cognitive. The cognitive process dimension comprises six levels: remember, understand, apply, analyze, evaluate, and create. This new expanded taxonomy can help instructional designers and teachers set meaningful learning objective, and provide the measurement tool for thinking.

Creating and maintaining the item bank is a time-consuming. When the item bank contains an insufficient number of items, the exposure frequencies of items may be too high and students may directly recall the answers [6]. Therefore, how to prepare sufficient items in the bank and efficiently generate items have become important research issues [7].

Deveszic [8] proposed developing Web-based educational applications with more theory and content-oriented intelligence. To increase the effectiveness of the testing system, numerous researchers have applied artificial intelligence, fuzzy theory and other techniques. If information techniques can be properly applied, numerous omplex issues can be solved, such as test item selection, item generation, scoring, explanation, and test feedback to enhance education and learning [9-15].

This study claims that computers can assist in aiding item generation in e-learning environments, if the material can be first stored based on knowledge ontological structure and semantic relation. An intelligent online learning system has been proposed to resolve the above problems.

2 Proposed System Architecture

To propose a system architecture for computer-aided tem bank generation, this study followed the following steps: (1) Conducting a pilot study to explore the difficulty faced by teachers in manually creating items, and analyzing the item types; (2) Developing course material knowledge and item structure ontologies, involving concept of Bloom's taxonomy; (3) Creating a knowledge base related to online course materials; (4) Developing a prototype for computer-aided generation of item system (CAGIS).

2.1 A Pilot Study Exploring the Difficulty of Manual Item Creation

Fifteen university teachers from 11 different universities - who had taught "management information system" courses, participated in the pilot study. These teachers were given two weeks to create test items from specific chapters of a textbook. It was required that the test items should include four types: true-false, multiple-choice, multiple-response, and fill-in-the-blank. No upper limited constrained the quantity of test items. Finally, the teachers produced 440 items manually, with the average time taken to complete the task being 4.3 hours. After deleting the duplicate items, there are 386 items left and shown in Table 1. The knowledge types of those items included "factual, conceptual, procedural" knowledge, and their cognitive levels included: "remember, understand, analyze, and evaluate". The specific chapters are no suitable knowledge content to generate the item of "apply" level. Some teachers indicated that it would be very difficult to generate the "create" level items using true-false, multiple-choice, multiple-response, and fill-in-the-blank question type.

Table 1. Number of Items with Bloom's Taxonomy Produced by Teachers Manually

Knowledge Dimensions	Cognitive Process Dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Total
Factual	192 (49.7%)	25 (6.5%)		56 (14.5%)	3 (0.8%)	276 (71.5%)
Conceptual	59 (15.3%)	27 (7.0%)		12 (3.1%)	0 (0%)	98 (25.4%)
Procedural	9 (2.3%)	0 (0%)		3 (0.8%)	0 (0%)	12 (3.1%)
Total	260 (67.3%)	52 (13.5%)	0 (0%)	73 (18.4%)	3 (0.8%)	386 (100%)

2.2 Course Material Knowledge Ontology

Since the meta-cognitive knowledge of Bloom's Taxonomy is not included in the regular teaching material or test [5,16], it was not considered in this study. To store knowledge content of course materials, and to consider the dimensions of Bloom's factual, conceptual, and procedural knowledge, this study developed a knowledge ontology, as shown in Fig. 1. This knowledge ontology was developed by content analysis of specific chapters from the above textbook, and includes the concepts of WordNet, revised Bloom's Taxonomy, Dublin Core, Semantic Header, and so on.

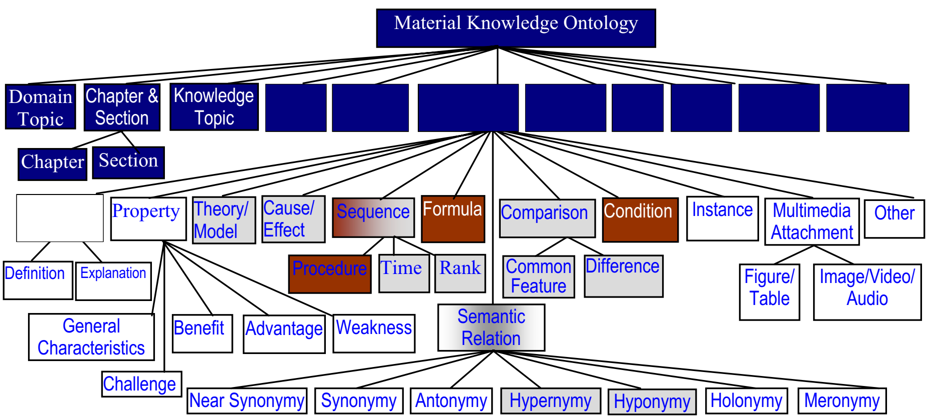

Fig. 1. Course Material Knowledge Ontology

Figure 1 uses the “Knowledge Content” to store the real course material content, and comprises 12 subclasses of knowledge, which are used to store knowledge concepts such as “What”, “Why”, “When” and “How”. For example, sequence relation knowledge includes procedure (the procedural step, used to express the concept of “How”), time (the time sequence), rank (specific attribute rank). Hypernymy knowledge records a relation similar to generalization, is-a relation, is-a-kind-of. Meronymy knowledge records a relation similar to component-of.

The proposed course material knowledge ontology covers the knowledge dimension of Taxonomy of Bloom, as detailed below.

- **Factual Knowledge:**
  - Knowledge of terminology including technical vocabulary and musical symbols. In Fig. 1, such type of knowledge is stored through "Description" and "Multimedia Attachment".
  - Knowledge of specific details and elements: major natural resources and reliable sources of information. In Fig. 1, such type of knowledge is stored through "Description", "Property", "Instance", "Holonymy", "Meronymy", "Near Synonymy", "Synonymy", and "Antonymy".

- **Conceptual Knowledge:**
  - Knowledge of classifications and categories: geological time periods. In Fig. 1, it would be stored through "Hypernymy", "Hyponymy", "Time", and "Rank".
  - Knowledge of principles and generalizations: In Fig. 1, it would be stored through "Hypernymy", "Hyponymy", "Comparison", and "Multimedia Attachment".
  - Knowledge of theories, models and structures: In Fig. 1, it would be stored through "Theory/Model", "Cause/Effect", and "Multimedia Attachment".

- **Procedural Knowledge:**
  - Knowledge of subject-specific skills and algorithms: In Fig. 1, it would be stored through "Formula".
  - Knowledge of subject-specific techniques and methods: In Fig. 1, it would be stored through "Procedure".
  - Knowledge of criteria for determining when to use appropriate procedures: In Fig. 1, it will be stored through "Condition".

2.3 Test Item Structure Ontology

The test item structure ontology includes an intelligent online test scoring mechanism [28], which includes various parameters for dealing with fill-in-the-blank tests. In Fig. 2, the item structure ontology includes four question types: true-false, multiple-choice, multiple-response, and fill-in-the-blank. The ontology also includes original and variable item types. The question steam of original items can be generated based on primitive online material knowledge, in which case the structure of the question steam does not require any special changes. The original item is primarily used to assess the "remember" level of the cognition process. The structure of the question steam of variable items differs from that for online material knowledge. Furthermore, the variable item is used to assess the "understand, apply, analyze, and evaluate" levels of the cognition process. The variable items are divided into structure variable items and operands variable items. The structure variable items are generated by changing the structure, words of material knowledge. Moreover, the operands variable items are generated by calculation or formula inference module.

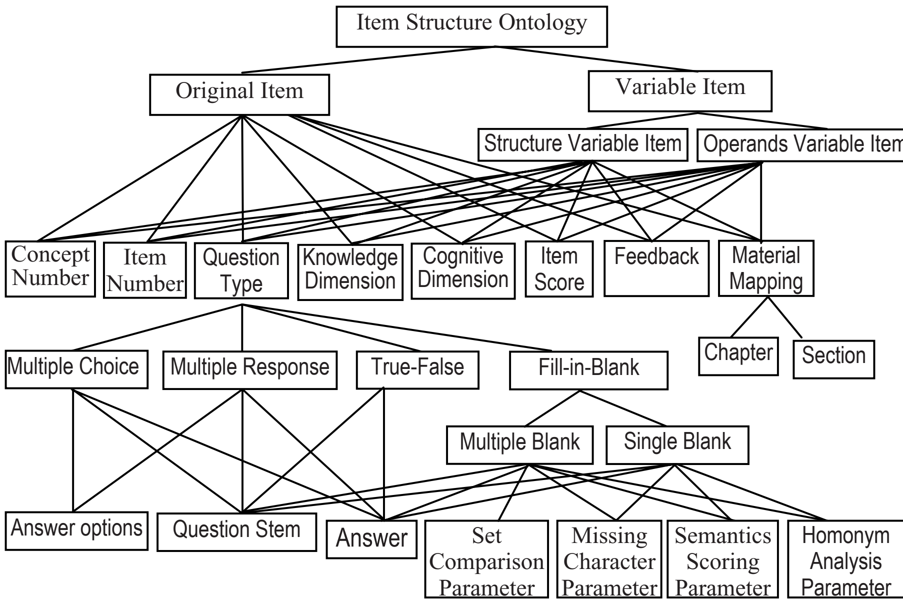

Fig. 2. Test Item Structure Ontology

2.4 CAGIS System Architecture

This study designed a computer-aided generation of items prototype system (CAGIS) in a three-tier Client/Server architecture. The back-end database server was Microsoft SQL Server 2000, which was used to implement trigger procedures and store the items, material, student data, scores, and so on. The web server was the Internet Information Server in Windows 2003. ASP language was adopted in the server-side. The architecture of the CAGIS E-learning system is shown in Fig. 3. The components are briefly described below.

This structure includes two user interfaces, five subsystems and 18 relevant databases. They are briefly described below. The Word Segment Process Subsystem segments the Chinese words in the primitive knowledge article, and stores the segmented results in the Expertise WS Knowledge Base. The Computer-Aided Generation of Material & Presentation Subsystem retrieves the segmented material knowledge from Expertise WS Knowledge and uses it to generate an online material knowledge, and stores it in the Material Knowledge Base. It can also dynamically generate teaching material pages that students can learn online. The Computer-Aided Generation of Item Subsystem, the focus of this study, can analyze the content of the Material Knowledge Base, generates various item types by referring to Item Structure Ontology and rules of item generation, and stores these items and standard answers in the Item Bank. The Online Test & Intelligent Scoring Subsystem manages testing and scoring. The Assisting Learning Tool Subsystem provides tools to assist learner leaning.

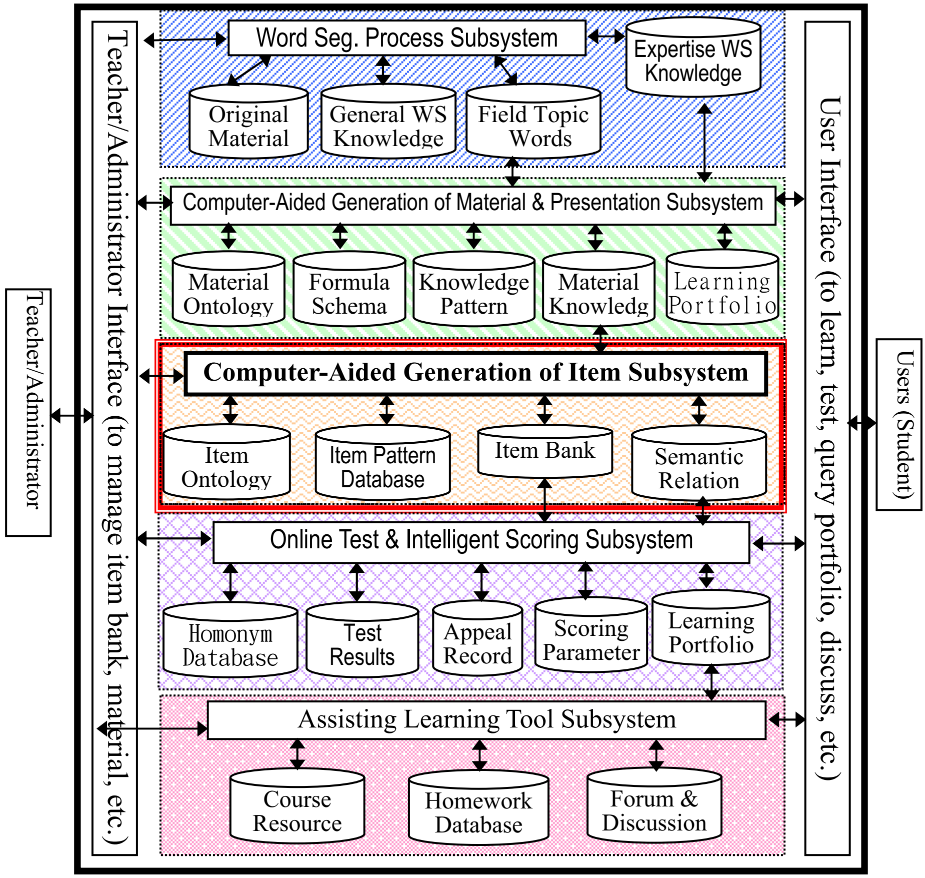

Fig. 3. CAGIS E-learning System Architecture

2.5 Computer-Aided Generation of Item Subsystem

Figure 4 shows he architecture of the Computer-Aided Item Generation Subsystem. From a 3*5 table of Bloom's taxonomy ("factual, conceptual, procedural" knowledge, and cognitive levels of "remember, understand, apply, analyze, evaluate"), teachers could assign numbers of four types of automatically generated test items: true-false, multiple-choice, multiple-response, and fill-in-the-blank. The components are presented below:

- **Formula Schema Database:** Storing the knowledge rule of mathematical formulae, logic operations, or equations.
- **Knowledge Pattern Database:** Storing the regular rules of Chinese grammar structure, semantic relations between words, and notation of word segments corresponding to Chinese sentences in general textbooks.
- **Material Knowledge Database:** Storing the knowledge content of the material. The knowledge was stored based on Material Knowledge Ontology. Relevant

knowledge can be linked by semantic relations. It is a knowledge source for generating online material in the Computer-Aided Generation of Material Subsystem and generating items for the Computer-Aided Generation of Item Subsystem.

- **Module of Item Pattern:** It provides a function for managing and maintaining the rules (characteristics) of item patterns, semantic relations, and question types for item generation.
- **Item Pattern Database:** Storing the rules (characteristics) of item patterns, semantic relation, and question type.
- **Module of Item Ontology:** This module provides a function for managing the item structure ontology.
- **Item Ontology Database:** Storing the item structure ontology.
- **Computer-Aided Generation of Item Module:** It executes the tasks involved in item generation. The module takes the knowledge content newly entered from the Material Knowledge Base, seeks other correlated existing knowledge concepts and checks the rules governing the item pattern. If the check is passed, the computer automatically generates the item and stores it in the item bank.
- **Item Bank:** Storing the items generated by Computer-Aided Generation of the Item Module. Alternatively, items created manually by teachers can also be stored if necessary.
- **Semantic Relation Database:** Storing the semantic relationships among words, including semantic words, correlation types (Near Synonymy, Synonymy, antonymy, etc.), and correlation ratios.

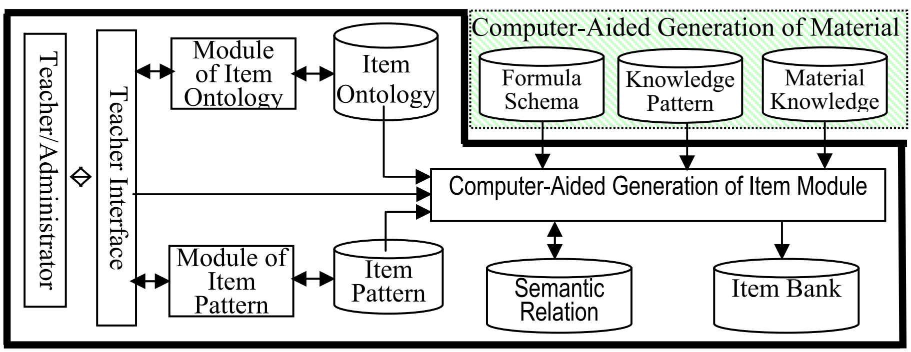

Fig. 4. Architecture of Computer-Aided Generation of Item Subsystem

2.6 Structure Rules of Knowledge Type and Item Generation Method

The Computer-Aided Generation of Item subsystem generates ten types of knowledge, Description, Property, Theory/Model, Cause/Effect, Sequence, Semantic Relation, Comparison, Formula, and Instance, and Others. The Formula Knowledge was created based on the formula schema set by teachers, the other nine knowledge types have their structure rules. These rules identify the knowledge type of original article contents, and store material knowledge that has been segmented to corresponding relation tables of the database. For illustration, some item generation methods are briefly described below.

- **Original Items:** The question steam structure refers to the same structure as the material knowledge base. For true-false questions, the answers are all true, which can be used to assess the ability of the "remember" process. The original items can generate items of other question types, e.g., fill-in-the-blank items, which can be used to "recall" ability.
- **Opposite Items:** If certain words in the question steam have the antonym sets in the Semantic Relation Database, the computer replaces them to produce the opposite items, which can assess the ability of confirmation in "remember" process level.
- **Grammar Inverting Items:** The material knowledge includes positive and negative concept sentences. If the computer exchanges and inverts the knowledge grammar structure of sentences, the sentences become the grammar inverting items. The grammar inverting items can be used to assess the ability of "understand" process.
- **Combined Same Subclass Knowledge of Single Concept Items:** These items were generated by the computer and combined with a lot of the same subclass (or sub-subclass) knowledge content from the single topic concept of materials. These items could be used to assess the confirmation ability in "understand" and "analysis" process levels. For example, since the concept "Expert System" has the following some characteristics: "Inference ability", "Explanation ability", etc. in the sub-subclass knowledge "General Characteristics", an item about "Expert System" concept can combine numerous "General Characteristics" knowledge.
- **Combined Same Subclass Knowledge of Multiple Concept Items:** These items were generated by the computer and used to combine a lot of the same subclass knowledge content from the multiple meaning-related topic knowledge contents of materials. For example, the concepts "Decision Support System" and "Expert System" could be compared with the "General Characteristics".
- **Combined Different Subclass Knowledge of Single Concept Items:** These items were generated by the computer and used to combine a lot of the different subclass knowledge contents from a single topic concept. For example, since the concept "Expert System" involves some knowledge in "General Characteristics", "Definition", "Condition", and "Meronymy", an item about "Expert System" concept could combine a lot of different subclass knowledge.
- **Combined Original Items of Same Concept:** These items were generated by the computer and combined a lot of original items of true-false of same topic knowledge from existing item bank. These original items could be combined to generate multiple-choice or multiple-response items.

3 Evaluation of System Effectiveness

This study compares computer-aided generation and manual item generation by teachers. The CAGIS used the same materials as the teachers used in a pilot study for item generation. Counting the different forms of the question stems and contents, CAGIS generated 18621 items, as shown in Table 3. However, certain items involve the same item concepts and meanings, because they were generated by procedure of combination and permutation in CAGIS. As a result, the CAGIS generated 1567 item groups with different assessment meanings (as listed in Table 4), which originated from 279 knowledge concepts of course materials. Each item thus can be replaced with an average of 11.466 (18621/1567) different forms of items. This study thus could solve the problems of shortages problem and excessive exposures of test items. In the pilot study, 15 teachers create 386 items in total. This CAGIS is more efficient than teachers on the quantity of items.

Furthermore, this study compares the effectiveness as follows. (1) The items produced by CAGIS include the assessment information of the knowledge and cognitive process dimensions. Such information can be used to provide learning suggestions for learners, and can also be used for teaching. (2) Teachers have difficulty creating the item of higher cognitive process level. In CAGIS, the items cover three types of knowledge and five dimensions of cognitive skills. (3) Regarding the degree of objectivity in selecting and generating items, teachers usually have personal subjectivity. However GAGIS follows the standard generation rules to select and produce items. (4) Regarding the effort spent on production and the quantity of items produced, 15 teachers produced 440 items manually and the average consuming-time of the teachers was 4.3 hours; CAGIS spent just 5 minutes producing the 1567 item group, and 18621 items. (6) Finally, because not all teachers underwent instructional strategy training, some items violated educational principles. However, these rules of preparing items are built into the Module of Item Pattern of CAGIS.

Table 3. Question Type of Items Generated by CAGIS

Question Type	True-False	Multiple Choice	Multiple Response	Fill-in-Blank	Total
Different Question stem and Answer Options	6.19% (1153)	35.51% (6612)	57.24% (10659)	1.06% (197)	100% (18621)
Different Assessment Meaning (Item Group)	32.04% (502)	20.49% (321)	37.97% (595)	9.51% (149)	100% (1567)

Table 4. Distribution of Items in Bloom's Taxonomy by CAGIS

Knowledge Dimensions	Cognitive Process Dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Total
Factual	555 (35.42%)	0 (0%)		245(15.63%)	0 (0%)	809(51.05%)
Conceptual	137 (8.74%)	28 (1.79%)		108(6.89%)	0 (0%)	273(17.42%)
Procedural	17 (1.08%)	0 (0%)	2 (0.13%)	457(29.16%)	18 (1.15%)	494(31.53%)
Total	709(45.25%)	28 (1.79%)	2 (0.13%)	810(51.69%)	18 (1.15%)	1567(100%)

4 Conclusions and Future Research

Instructional designers and teachers have adopted Bloom’s taxonomy involved in all levels of education. This study applied ontology, Chinese semantic database, artificial intelligence, and Bloom's taxonomy, to propose a CAGIS E-learning system architecture to assist teachers in creating test items.

Based on the results of this study, we recommend the following: (1) applying machine learning techniques and revising the item pattern rules to generate items for supporting higher level cognitive processes, (2) exploring the item difficulty and item discrimination indexes, (3) executing empirical research to explore the learning effects of CAGIS.

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Motivating Students through On-Line Competition: An Analysis of Satisfaction and Learning Styles

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Abstract. The Bologna model pursues to improve the quality of Higher Education and, in turn, human resources across Europe. One of the action lines of the Bologna Process is the promotion of the attractiveness of the European Higher Education Area (EHEA). In this context, motivated students are a key element. Motivation can be reached in a number of different ways, one of which is explored in this paper, and consists in the use of active e-learning methodologies to force students to compete among themselves during their learning process. The relationship between motivation and competition is analysed through a number of hypotheses focusing on elements such as the level of satisfaction of students with different learning styles (competitive, collaborative…) when using the competitive active e-learning tool called QUESTournament. This system has been used in several University courses belonging to different degrees and diplomas taught at the University of Valladolid (Spain). Data collected from these experiences are analysed and discussed.

Keywords: Active learning, Competitive learning, E-learning, European Higher Education Area (EHEA), Learning styles, Students' satisfaction.

1 Introduction

The response to the challenge of improving the quality of Higher Education and, in turn, human resources across Europe, is widely known as the Bologna Process. Higher education institutions and students themselves have an important role to play in the Bologna Process and Ministers have called upon them to become involved in forming a diverse and adaptable European Higher Education Area (EHEA).

Involving students in the learning organization and the learning process itself is a recent approach. Traditional education has historically been dominated by a teacher-centred learning approach which entails the assumption that learning takes place passively. However, at the present time, a focus on student-centred learning or active learning is promoted. Teachers become guides rather than dispensers of knowledge and the students engage in the learning process.

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In order to involve students in an effective way, they should be motivated to participate and improve the learning process. Motivation can be reached in a number of different ways. Nowadays, many of the applied motivation strategies are related to active methodologies and make use of Information and Communication Technology (ICT). ICT provides a valuable flexibility and allow institutions to offer remote or blended courses synchronously and asynchronously through collaborative e-learning spaces [1]. Moreover, the role of the teacher can be easily adapted to a new model according to which students must actively lead their learning process.

This paper describes, analyses and discusses the use of an ICT-based active learning methodology as a strategy to motivate different type of students and to improve their learning process. The described method focuses on a competitive approach, which is combined with collaborative and individualistic approaches in order to cover different learning styles.

The remaining of this paper is organized as follows: the subsequent section reviews the relevant literature in order to provide the theoretical background about learning styles and competitive learning technologies. The following section describes the QUESTournament system, a tool for active and competitive learning. Next, the hypotheses guiding this research are reviewed including the methodology used and data collection. The analysis and results of the study are presented subsequently. Finally, in the last section, conclusions and future research directions are discussed.

2 Learning Styles and Competitive Learning

Literature on active learning shows significant improvement both in students' skills (such as responsiveness, long term retention, degree of understanding… [2] [3]) and in their level of achievement [4] [5]. All of these studies take the advantages of ICT as a technological tool to implement different active learning methodologies.

On the other hand, teachers have perceived that some students prefer certain methods of learning more than others. Grasha [6] define learning styles as, "personal qualities that influence a student's ability to acquire information, to interact with peers and the teacher, and otherwise participate in learning experiences" (p. 41). Thus, once the technology and tools are available, the main emphasis has to be made on designing instructional methodologies to fit the learning style of the student.

Numerous categorizations of learning styles are found in the literature such as those proposed by Kolb [7] and Felder and Silverman [8]. One of the most frequent classifications [9] is the one established by Kolb [7], who identifies four learning styles according to how information is received (from concrete experiences to abstract concepts) and how it is processed (from active experimentation to reflective observation): diverging, converging, assimilating and accommodating. Unlike the Kolb's and most learning style models, which classify learners in few groups, Felder-Silverman learning style model (FSLSM) is more detailed and distinguish between preferences on five dimensions: Perception (sensing/intuitive), Processing (active/reflective), Input (visual/verbal), Organization (inductive/deductive), and Understanding (sequential/global), where the two first dimensions replicate aspects of the Kolb's model. According to different authors [10] [11], the FSLSM is most appropriate and feasible learning style theory in respect to e-learning design and development.

In another line, Kim and Sonnenwald [12] use the scale of learning preferences of Owens and Barnes to identify three learning styles: cooperative, competitive and individualized. The cooperative learning style indicates a preference for achieving individual goals while working in group; students work together to maximize their own and each other's learning. The competitive learning style indicates a preference for learning in competition with others, often achieving individual goals; students work against each other to achieve a good grade and only some of them succeed. Lastly, the individualized learning style indicates a preference for "working by oneself to ensure that one's own learning meets a present criterion independently from the efforts of the other students" [13]. Moreover, Grasha and Riechmann have developed the Student Learning Styles Scale to measure the preferences of students in interacting with teachers and other students where they determine six categories: participative, avoidant, collaborative, competitive, independent and dependent [14].

It would seem logical to think that, for example, competitive and independent students feel more motivated through competition than through collaborative learning. The idea of competition is usually linked to gaming, and games are often pleasing for any kind of student, In fact, the intention of incorporating gaming elements into learning has received increasing attention recently [15] [16]. So, for example, Siddiqui, Khan and Katar [17] present a case of application of simulation games. They tested a supply chain simulator and observed a higher sense of competition amongst students. In addition, their results clearly showed a significant increase in students' motivation.

Games have a number of characteristics that make them attractive from a pedagogic and instructional point of view. Therefore, there are some systems that implement games as an effective method to capture student interest, encourage active learning and increase motivation [18] as well as fun and learning [19]. Fasli and Michalakopoulos [20] stay that "the nature of the game itself and the competitive element involved, act as an incentive for all students to put in more effort and even weaker students persist with playing the game".

Moreover, there are also studies that analyse possible negative factors of competition and compare different competition approaches: anonymous, of known authorship, face-to-face, etc. Yu, Chang, Liu and Chan [21] examine students' preferences towards different kinds of competition and their satisfaction with regard to the learning experience. Their results show that students prefer anonymous rather than face-to-face competition, since the former is more likely to reduce stress and other similar negative emotions. In fact, results from studies conducted in traditional classroom have showed negative effects of competition on interpersonal relationships and emotional states. However, those studies involved face-to-face situations, where, without the use of networking technologies, the identity of the participants could not be hidden.

ICT could mitigate the negative effects of face-to-face competition by hiding the identity of students if necessary. An example of the success of this possibility is the QUESTournament system, where networking provides the support of anonymity that allows teachers to design learning strategies adapted to the anonymous competition mode. Moreover, QUESTournament allows team competitions which combine the better of competitive learning with the better of the collaborative learning (as explained below).

Finally, it is important to show that there is not an overabundance of research in the area of learning styles and e-learning. Most of the studies focus on the discovery of relationships between learning styles and specific student achievement outcomes (drop rate, completion rate, attitudes about learning…) [14] [22] and between learning styles and the learning environment [23].

Knowledge of student learning preferences could provide a bridge to course success. It is important that an individual's learning style is examined for compatibility with the educational learning environment.

3 The QUESTournament System

The QUESTournament system - previously called QUEST (*Quest Environment for Self-managed Training*) system - is an innovative tool for active ICT-based learning, whose aim is the development of cooperative and competitive workshops supported by telematics. This system pursues the development of student inquiry, documentation and critical analysis skills, while raising the level of involvement and communication between students and teachers.

QUESTournament is accessible from every computer with Internet access and a Web browser and has been implemented as a module integrated into the e-learning platform Moodle in order to offer a new type of activity for the courses delivered through that platform.

The QUESTournament system presents both individual and group work environments in which teachers and students propose "challenges" that must be solved in a time-constrained way.

The answers to the proposed challenges can be of any type of those most usual within the current assessment tests. Therefore, each and every type of question (essay, tests, short answer…) can be included. Besides, files in different formats can be attached to the answers. Once submitted, these ones are rewarded by means of a variable scoring system.

QUESTournament has been designed to motivate students through competitiveness and collaboration. Hence, work sessions are presented as a contest that involves several tasks or challenges. The contest ranking is based on the scores for each challenge and it is dynamically updated every time that a student's answer is scored.

Students are allowed and encouraged to submit their own challenges related to the course and to evaluate the corresponding answers. Their work will be rewarded depending on the quality of the proposed challenge as well as the accuracy of the assessments and the feedback offered to other contestants. In this way students get more involved and collaborate to enrich the learning process.

As seen in Fig. 1, the QUESTournament system displays a permanently updated top ranking with a link to a detailed scoreboard. There are both individual and team rankings. Besides, all the challenges proposed by teachers or students are shown in the main area of the screen. The challenges proposed by students must be previously approved and scored by a teacher, although it is also possible to set up the system to allow automatic approvals. In fact, one key design point of QUESTournament is flexibility. There are many ways in which teachers can use the system; they can change the maximum and minimum values for the scoring function, the number of answers to be accepted, etc.

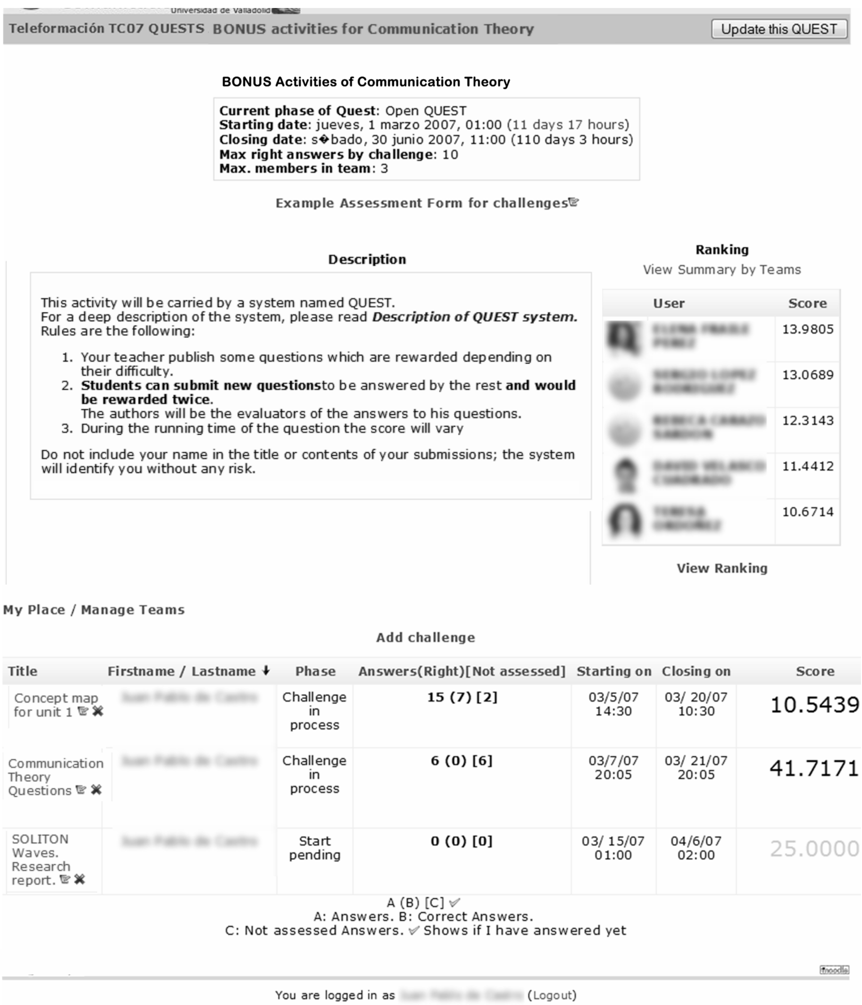

Fig. 1. Main screen of the QUESTournament system

Each challenge has a set of assessment criteria to be used by the author for evaluating the answers that is known by every participant beforehand. There is also a general set of criteria to evaluate the challenges proposed by the students.

To sum up, QUESTournament encourages students to actively participate and generate contents in a dynamic and changing environment. Students' submissions are anonymous but accessible to everyone, providing competitive but also reciprocal learning. A more completed description of QUESTournament can be found in [24].

4 Research Methodology

Several studies [25] [26] suggest that students' satisfaction and motivation are important factors in measuring the success or effectiveness of the e-learning process. Consequently, this study proposes to measure students' satisfaction with QUESTournament in order to find out the effect of competitive e-learning on higher education students and to analyse it according to the different students' learning styles.

4.1 Hypotheses

It has been proposed that there are many factors that promote or hinder the success of students. Among these factors, motivation and satisfaction have been linked to student attrition and performance [27] [28]. Moreover, student satisfaction is associated with student achievement [29] and it is also a key indicator of educational quality [30]. So, this study proposes the following set of hypotheses related to the students' satisfaction and motivation according to their learning styles:

H1. The level of satisfaction of competitive students will be higher than that of non-competitive students when using a competitive active learning tool.
H2. The level of satisfaction of participative students will be higher than that of non-participative students when using a competitive active learning tool.
H3. The level of satisfaction of non-collaborative students will be higher than that of collaborative students when using a competitive active learning tool.

4.2 Methodology and Instruments

One instrument has been used in this study with two parts. The first one is a ten-item survey based on the method developed by [25], which measures students' satisfaction and motivation in e-learning environments. It provides students with a five-score Likert-type scale, which ranges from ''Strongly Disagree'' to ''Strongly Agree''. Students' satisfaction total score, generated by summing up all the scores, can range from a minimum of 10 (very low satisfaction level) to a maximum of 50 (very high satisfaction level). According to previous literature [31] [32], items relating to student interaction, collaboration and active learning have been included in the students' satisfaction survey.

The second part is a questionnaire with several questions about the students' learning style based on three of the categories of the Grasha-Reichmann Learning Style Scales (GRSLSS): participative, competitive and collaborative.

4.3 Data Collection

Data were collected on line, using the instruments described above, during June 2006. The survey was set to collect responses using the "phpEsp" survey system. Data submission was anonymous with no link between a submission and its author.

QUESTournament is currently being applied in different university courses in both Arts and Science degrees. Specifically, during the academic year 2005 – 2006, the system was used in 10 courses in different degrees and diplomas taught at the University of Valladolid: Degree in Telecommunications Engineering, Diploma in Telecommunications Engineering (several specialities) and Degree in Translation and Interpreting with a total of 522 enrolled students. Enrolment on most of these courses was below 50 students and most of them were taught by only one teacher. However, there were some courses with over 100 students enrolled and courses which were taught by more than one teacher (specifically, by two teachers). Therefore, the test environment counted with a sufficiently varied course spectrum.

5 Analysis and Results

The collected data have been analysed for group comparison using Student T-Test for students' satisfaction. This statistic assesses whether the means of two groups are statistically different from each other in order to be able to compare them.

5.1 Analysis of Students' Satisfaction and Motivation

In order to know if the system was successful, it is important to analyse the level of students' satisfaction from the survey data. About 30% students completed the survey (129 of the 447 students who used QUESTournament). The collected sample was provided online via the Web-based survey system. Additionally, the collected sample had similar demographics characteristics as the university students' population, thus appearing representative: boys and girls of arts and science with an average age of 21.8 years and a medium computer skills level.

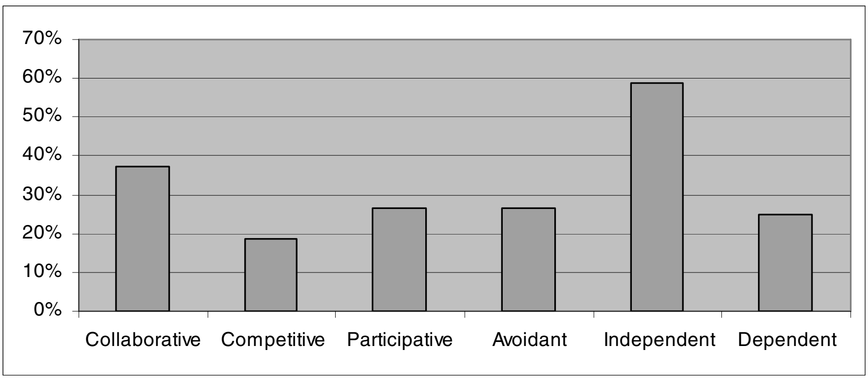

Fig. 2. Learning Styles

In general terms, the experience has been positively evaluated by students (with an average sum score of 29.01). However, it is interesting to examine the effect of competitive active learning on students' satisfaction in order to identify those students who benefit most from competitive learning. Then, the students' learning style is examined in Fig. 2. It shows that most of them are non-participative and non-competitive, feel more comfortable with individual work and prefer group work only for special tasks, even though many students admit the advantages of working in group.

Next, it is important to analyse the relationship between the dependent variable, student satisfaction, and the three following variables: number of competitive students, number of participative students and number of collaborative students. Results from the analysis of T-Test for satisfaction according to students' competitiveness are presented in Table 1. These data show that students' satisfaction was not found significantly different between the two groups: competitive and non-competitive students. This indicates that the hypothesis H1 is not supported as, although the level of students' satisfaction with QUESTournament is higher for competitive students than for non-competitive students, this difference is not significant. In addition and in spite of the fact that QUESTournament is a competitive tool, only 19% of students defined themselves as competitive.

A similar analysis has been done for the second hypothesis. Results are presented in Table 2. In this case, students' satisfaction was found non-significantly different between the two groups: participative and non-participative students. Thus, the hypothesis H2 is not supported as the level of satisfaction of participative students is not significantly different from that of non-participative students.

Table 1. Group comparison – Competitive and non-competitive students

	Competitive (n = 24)		Non-competitive (n = 105)		T-Test
	M	SD	M	SD	p
Satisfaction	31.46	7.342	28.45	7.726	0.085

Table 2. Group comparison – Participative and non-participative students

	Participative (n = 32)		Non-participative (n = 97)		T-Test
	M	SD	M	SD	p
Satisfaction	28.50	6.248	29.18	8.168	0.670

Table 3. Group comparison – Collaborative and non- collaborative students

	Collaborative (n = 48)		Non-collaborative (n = 81)		T-Test
	M	SD	M	SD	p
Satisfaction	28.92	8.520	29.06	7.257	0.918

Finally, the third hypothesis (H3) is connected with the collaborative character of students and indicates that the satisfaction of collaborative and non-collaborative students is found to be not significantly different with regard to QUESTournament (see Table 3).

6 Conclusion

First of all, the following results and contributions have been obtained with regard to the QUESTournament system, an innovative competitive e-learning tool:

- Experiences and results show that QUESTournament could be an important tool in order to adapt the current university curriculum to the new educational model of the EHEA. Some students have commented that they feel more motivated to think for themselves and try to apply the concepts studied.
- A new teaching-learning methodology and the corresponding adapted assessment method have been defined. It is based on competitive active methodologies, working groups and independent student learning. It aims to allow students to acquire the characteristics required by new professional profiles, for example becoming active, independent, strategic, reflective, cooperative and responsible.
- Innovative strategies, such as those related to the partial assessment of students carried out by their classmates, have been proved to be very useful if the teacher instructs students properly in this assessment task.
- The assessment phase has been integrated into the learning process together with documentation, tutorship, communication tools, etc.

However, the students have also highlighted some negative aspects, like an excess of competitiveness and an increase of work volume. The teachers also have reported an when students dare to submit their own challenges In this sense, QUESTournament can be configured for automatic approvals of students' challenges and assessments, according to their autonomy or the teacher's confidence.

On the other hand, the students' level of satisfaction with regard to a competitive active e-learning tool, such as QUESTournament, has been high. In addition, in spite of the fact that this system is a competitive active tool, the students' level of satisfaction has not been significantly different for the different learning styles. That is, the level of satisfaction with QUESTournament has not depended on how students defined themselves (participative, competitive or collaborative).

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Collaborative Learning Tool Applying to C Programming Language

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Abstract. Collaborative learning, which includes activities of interaction between learners, share knowledge each other, and cooperate in finishing some tasks, is a popular research topic in the past decades. The essence of collaborative learning is that active participation is significant in the learning process and that learners share the valuable knowledge to the other learners in traditional classroom. Nowadays, computers and information technology (IT) become a general component on a lot of aspects of education. The combination of collaborative learning and information technology is commonly called "Computer Supported Collaborative Learning" (CSCL), and that is currently having much attention. Therefore, we have developed a friendly server / client tool, which embedded voice and text chat communication to support collaborative learning via internet. Learner can study from group's collaborative learning, find and solve the problem of C programming language designing through communicating and discussing. Besides, it makes users gained the experience and knowledge of program designing efficiently.

1 Introduction

The traditional way of learning C programming language [1], students' individual learning is the main method. In traditional learning, students are stipulated to complete the teacher's designated homework after class. In individual learning, every student must proceeds at their own pace to accomplish the study goal without other classmates' help. But in these processes, the students may encounter a lot of problems, for example, they may have some trouble in designing the structure of program, or they make some errors and cannot solve the problem in the process of compile and debug. These problems will make learners lose the interest of C programming language, and they may give up to studying.

Collaborative learning has offered a chance to learners working together to reach a common goal. And collaborative learning uses a way of group-learning, with classmates learning together to increase their own and other classmates' awareness [2, 3]. Learners' co-operation and teamwork always support collaborative learning. Through enhancing information sharing and supporting the group process, effective collaborative learning might be reached. Improving the learner's participation and ameliorating join actively in knowledge construction by assisting creation, exchange, and analysis of information during learning group interactions, it will be made possible to increase

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the effectiveness of collaborative learning [4, 5 and 6]. During the collaborative learning process, all teammates will benefit from each other [7]. The approach to education that is more suitable to the educational environment through group collaborative learning. In this paper, we introduce the system architecture which we have developed, that include audio and text information communication to support co-operation and teamwork, and it has program co-editor interface [8].

The rest of this paper is organized as follows: Section 2 presents related work about our research. Section 3 introduces the main research of the system architecture implementation. Section 4 we will discuss with the difference of other collaborative software and our tool. Section 5 concludes this paper and discusses the future works.

2 Related Work

In this section, we are going to introduce the related work about this paper. First, we will present the theoretical background about collaborative learning. Collaboration defined "working together to complete the shared goals" [9]. Collaborative learning allows students to share their knowledge and information each other within the problem-solving process [10]. Second, we present the ways of teaching / learning C programming language. At last, we will talk about the theoretical foundations of VoIP, the technology we use in our system.

2.1 Collaborative Learning

Studies have shown that collaborative learning procedures have proved to be more effective than traditional instructional methods for student's learning and academic achievement process. It also improves participants' satisfaction with the learning [4, 11]. Learning is sharing, and more shared that is more learned. It is even supposed that students are learning as much from each other as from teaching material of course or from the teacher in the class. In America, the studies have also presented that students who usually use the collaborative learning procedures in class, they have more interaction with each other, and they are more satisfied with their learning experiences. Besides, group-oriented collaborative learning, reflection and connection enhance learning.

Collaborative activities are one way of learning by allowing individuals to exercise, verify and improve their mentality through questioning, discussing and sharing information during the problem-solving process [4]. And then, collaborative learning has an obvious potential to improve critical thinking, creative thinking, elaborative thinking, social communication, and social skills (leadership, decision-making, trust-building, conflict-management, etc) [6, 12].

2.2 Teach / Learn C programming Language

C programming Language is a general-purpose, structured, procedural and imperative computer high-level programming language. It developed in 1972 by Dennis Ritchie at the Bell Telephone Laboratories for use with the Unix operating system. Although C was exploited in last three decades, it is also one of the most important and popular programming language at this time [1]. In practice, Students need to know how to [13]:

(1) Discover and understand the problem
(2) Work toward a solution
(3) Rework the solution into code
(4) Enter the code into the computer
(5) Debug syntax errors
(6) Test and debug logic errors
(7) Verify that the problem has been solved

Through these seven steps, students can learn logical thinking and how to solve the problem of C programming language. Besides these steps, students have to learn the syntax and structures of C programming language. Finally, students will accomplish more tasks and improve problem-solving skills when they master these steps.

2.3 Voice over Internet Protocol

Voice over Internet Protocol (VoIP) is a protocol optimized for the transmission of voice through the Internet or other packet switched in networks [14]. And VoIP is a technology that allows users to make telephone calls using a broadband Internet connection to take the place of an analog phone line. Through the low cost feature of the internet usage, VoIP can decrease the telephone call costs comparing with the traditional PSTN (public-switched telephone network) system [15]. Furthermore, it can also mend distorted audio, echo and loss of the voice data on the process of transmission [16]. Since the VoIP technology was developed, many VoIP protocols have been proposed. H.323 is considered as the first generation VoIP protocol [17].

In June 1996, ITU (Internet Telecommunications Union) began to institute relevant communication protocols to H.323 [18], it can operate Video Telephony in Package-Based networks and use on the Multimedia Conferencing, etc. The main architecture of H.323 includes H.323 Terminal, Gateway, Gatekeeper, and MCU. The purpose is that can make VoIP to transmit the voice data through RTP (Real-time Transport Protocol) and incorporate the PSTN, Integrated Services Digital Network (ISDN) and Broadband ISDN (B-ISDN) in the telecommunication system [19]. Gateway is a channel that connected with other communication systems, and it is responsible for the exchange of the network package and conversion of circuit exchange. Gateway provides the functions about Signaling Translation and Decode. Gatekeeper is the administrator in H.323 system, and its main function includes Address Translation, Admission Control and Bandwidth Management. Besides, it also manages the H.323 system of Terminal, Gateway and MCU. MCU offers the function of multi-communication, and it consists of MC (Multipoint Controller) and MP (Multipoint Processor); MC manages about the process control, MP is responsible for decode, encode and mix of audio or video [20].

In next section, we are going to present our system architecture of the collaborative learning tool, and introduce the major function about the tool.

3 System Architecture

Our system architecture is composed of voice server and master server (see Fig. 1). Considering the collaborative learning efficiency, we designed three users a team which includes one team leader and two partners to use our tool.

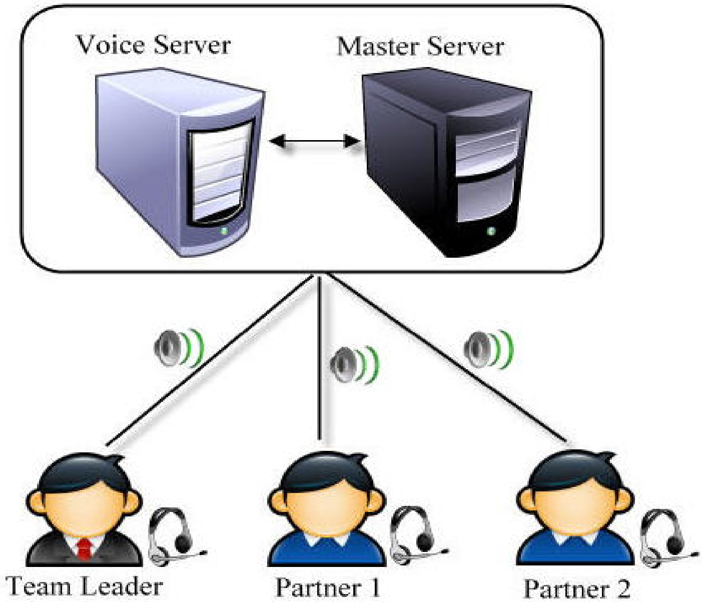

Fig. 1. System architecture

Master server mainly controls the learner information, such as learner portfolio and information transmission. We list the functions as follows:

(1) User Login/Logout: When user login the system which will record the IP address and learner information. After the user logout, the system will close the editing window and terminate the connection.
(2) Login User: We designed three people in a study group which is consisted of group leader and two group members. Because the main purpose of our system is to assist the group's work and cooperate together, to finish their homework and task.
(3) Record and Communicate the Message in the Chat Room: Users can discuss how to program or what kind of function should be used in the chat room. Master server will broadcast the instant message and record the message in a text file which will be stored in system record file permanently.
(4) Dispatch the Program Editor Sequence Automatically: Master server dispatches the users with login order, the user has his/her own editing interface.
(5) User Synchronous Programming: User can edit the program in each editing window; the user program will be broadcasted to the team member after a period of time.
(6) Record the User Program Progress Automatically: The system will record user's program progress automatically in a period of time, in case that the users disconnect abnormally to lose the information.
(7) Connecting to Voice Server: Connecting and recording the voice server IP address to support voice communication service simultaneously.

A voice server supplies user communicates with voice and records the discussion. Voice server applied VoIP (Voice over IP) technique to connect all the users in real time. Voice communication is divided into group talk and private talk. Group talk furnishes users voice talk with other team members. Private talk supplies one to one discussion to solve the program writing problem.

In Fig. 2, this is our tool interface, the description are in the following:

(1) Editor: The upper side has three columns for three users to edit the program. The left window is designed for team leader, the other two windows for the team members. The system will distribute the user interface automatically. In Fig. 1, team leader can arrange the sub-tasks for the other two teammates. For program writing, there will be one main program and other functions. Team leader handles the main program, the other two teammates focus on functions writing. The system will record user’s program progress automatically in a period of time, in case that the users disconnect abnormally to lose the information. During the process of program writing, the user can't edit other members’ editor besides his own editor.

(2) Chat Room: Chat room plays a role to supply a text typing mode for uses who like to copy the code and communicate the programming problems. In programming course, some users have problems using the commands and variables. Some problems are suitable for text mode and some are proper to talk with voice directly. The similar situations occur in MSN communication in our daily life. Sometimes, people just like talk or type text when discussion. Therefore, we provide voice and text tools for communication.

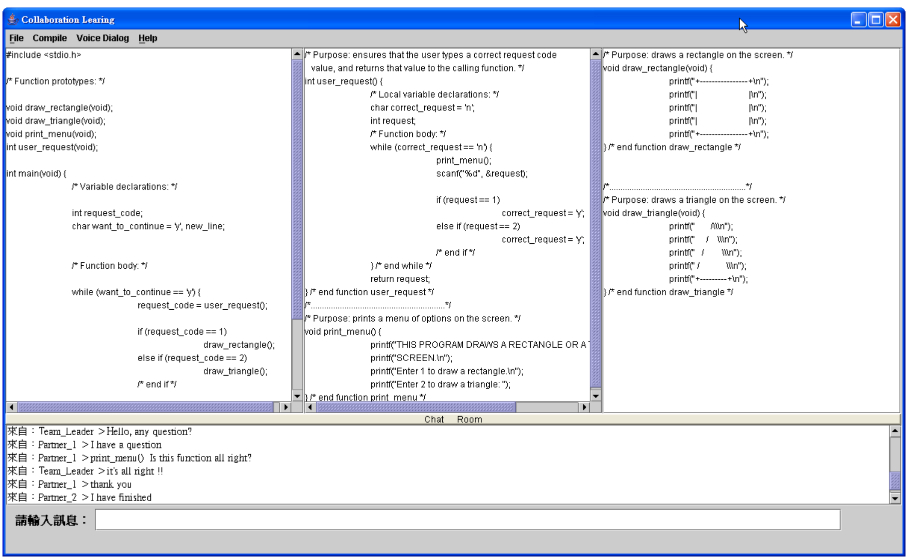

Fig. 2. Editing program collaborative writing example

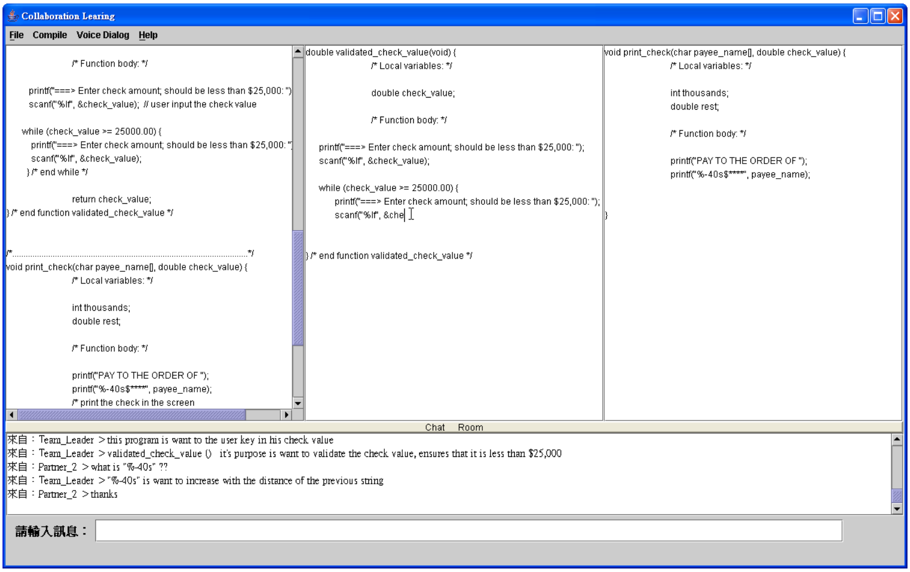

Fig. 3. Editing program by imitating other user's code example

(3) Menu Bar: There are some functions in our menu bar. First function is [File] which is supported for users to import or save the program file. Users can exit the system by [Exit].When users completed the program, they can push the [Compile] to compile the code. [Voice Dialog] assists the users to talk with voice. For example, users can choose group talk, private talk (one-to-one talk) or suspense talk. If the users have questions using the tool, they can get the related information in [help] function bar.

Users can program cooperatively with the other two teammates or learn how to write a simple program by imitating other codes. Fig. 3 shows the cooperative programming. All the team has to write the program. Team leader is responsible of main program. The second user is in charge of user_request( ) and print_menu(). Third user writes draw_triangle( ) and draw_rectangle( ). They can discuss and teach each other. Fig. 3 demonstrates the imitating programming example. Team leader completed a simple program. The other two users follow and learn how to code.

4 Discussion

There have some similar collaborative tools developed in last 5 years, like NetBeans Collaboration Project, it's a module named "Developer Collaboration" [21]. This module emphasizes that users can collaborate and share their work with Sun engineers or their team members simultaneously. And users also can communicate easily with each other and real time file sharing. Users can enter a message and then send it to the other participants in the conversation. And users can enter messages in the chat input pane in several formats: Plain text, Java, HTML, XML. Furthermore, user can share files with other members within a conversation. Files are shared using the Shared Files collaboration channel visible within each conversation window.

Our tool has some elements that are differ from the above-mentioned tool. Now, we will address some difference elements as follows:

(1) Voice communication: Besides text conversation, we also provide voice communication mode to improve the efficiency of communication. Because users communicate with each other in text mode, they may type too many word for conversation, and they will waste too much time. For this reason, we join voice communication mode to assist with text mode.

(2) Share information faster: Our tool can present users' mutual editor panel more immediately, and show each member's progress. It does not need to open other windows or channels to share the progress and information presently in addition, and then it can be faster to discover and solve the problem.

Table 1. The comparison with other similar tools

	Our tool	**NetBeans Project Developer Collaboration**	**Turbo C**	**Dev C++**	**Visual C++**	**C++ Builder**
Programming Editor	Has	Has	Has	Has	Has	Has
Voice communication	Has	NONE	NONE	NONE	NONE	NONE
Text communication	Has	Has	NONE	NONE	NONE	NONE
Share information	Has	Has	NONE	NONE	NONE	NONE
Problem-solving	Has	Has	NONE	NONE	NONE	NONE

Following above topics, we compare our developed tool to other tools as show in Table 1. The traditional programming editor only has editor; it doesn't have voice and text communication, and also can't share information synchronously. We compare some programming tools, such as Turbo C, Bloodshed Dev-C++, Microsoft Visual C++ and C++ Builder. Turbo C is an Integrated Development Environment and compiler for the C programming language. It was first introduced in 1987 and was noted for its integrated development environment, small size, extremely fast compile speed, comprehensive manuals and low price. Bloodshed Dev-C++ is a full-featured Integrated Development Environment (IDE) for the C/C++ programming language. It uses Mingw port of GCC (GNU Compiler Collection) as it's compiler. Dev-C++ can also be used in combination with Cygwin or any other GCC based compiler. Microsoft Visual C++ (often abbreviated as MSVC) is a commercial integrated development environment (IDE) product engineered by Microsoft for the C, C++, and C++/CLI programming languages. It has tools for developing and debugging C++ code, especially code written for the Microsoft Windows API, the DirectX API, and the Microsoft .NET Framework. C++ Builder is a popular rapid application development (RAD) environment produced by the CodeGear subsidiary of Borland for writing programs in the C++ programming language. C++ Builder combines the Visual Component Library and IDE as found in Delphi with a C++ compiler. C++ Builder includes tools that allow true drag-and-drop visual development, making programming easier by incorporating a WYSIWYG GUI builder into its IDE. The NetBeans project "Developer Collaboration" has editor and text communication, but it does not have voice communication mode. Our developed tool can help learner solve their problem and share their knowledge or information immediately.

5 Conclusion and Future Works

In this paper, we develop a tool to support group collaborative learning, which combines voice and text communication mode to assist with the teamwork more effective. Learners will learn more problem-solving skills and more knowledge of C programming language when they interact with other users using our application. Through real time discussion and information sharing, users are going to complete their homework and project more and more.

Our tool has not passed the actual test and use of learners yet at present, we will examine the influence on the user of the system in the future. We expect to test user's satisfaction to the system through the way of user's questionnaire.

Acknowledgements

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Design and Implementation of an Internet-Based Platform for C Language Learning*

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Abstract. A designing model and implementing method of an Internet-based system for C Language Learning is proposed in the paper, which based on .NET platform. The communication between the system and the compiler of C Language is implemented by using redirect technology. More powerful compile and logic error-check function are provided in the system, which adopts C# Multi-thread technology and synchronous control theory. Object-Oriented design methods and C# Reflection technology are used to solve the problem of dynamic test-case scheduling, which makes the system be extensible and robust. In the platform, users can learn C language knowledge and do C program. Especially, they can find out the logic errors which are bugs and can not be discovered by the compiler in programs. Once the users can gain access to the Internet, they can get hints and extra help easily through the interactive system at anytime and in anyplace.

Keywords: logic error checking; compile error checking; distance education; C language learning.

1 Introduction

Long-distance education is a teaching channel in full swing in the world which breaks through time limit by using computer technology and the Internet [1]. One key point to the success of distance education is Internet-based learning platforms. As far as we know, developing interactive systems of time-free, resource-sharing, system-opening and Internet-based is a hot research at present [2]. These platforms make the long-distance education be effective. So the design and development of virtual learning platform is a necessary part of distance education system [3].

Furthermore, C language is a required course for computer professionals. Though it is powerful and flexible, but it's difficult to learn [4]. Especially in long-distance education, the teachers are unable to face-to-face teach students. Meanwhile, in computer programming, a compile error occurs when the compiler encounters some problems in the

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code. And a logic error is a bug that causes the program to operate incorrectly or achieve the function incompletely. As a C-language learner, lacking of programming experience, the student will lose learning interest easily because of the huge number of compile and logic errors. Besides, the compile errors provided by TC are not all exact. They always contain many correlate errors. And the logic errors are hard to be solved. They usually hide in deep and can not be discovered by compiler. These factors make learning C language be difficult.

In recent years, different types of learning platforms used to distance education are being researched and designed. An Internet-based system for Java language learning is proposed in Ref. [6], which can compile the student's program and view the error messages through the student's workplace in the online system. A component-based Virtual Laboratory Platform is introduced in Ref.[7] and [8]. It uses Java Bean to implement the virtual experimental equipments, which improves the developing efficiency and achieves the software reuse. Ref.[9] and [10] proposes an interactive learning environment for teaching and learning of computer programming. Although these platforms are interactive and timely, they only offer a simple compiling and debugging environment, but without logic error-check function. If learners meet logic errors and difficult compile errors, the systems are unable to provide effective help.

Therefore, an Internet-based system for C Language Learning is proposed in this paper, which provides more powerful compile and logic error-check function. The system is robust, timely and extensible. It can improve the teaching and learning of computer programming in distance education.

The remainder of this paper is structured as follows. In section 2, we introduce the system architecture and function. Section 3 describes the design and implementation of compile Error-check. Section 4 shows the design and implementation of logic error-check. Section 5 gives an example in the system, and the last section is the conclusion.

2 System Architecture and Function

The Internet-based Platform for C Language Learning is composed of two parts: the client and the server. Its architecture is shown in Figure 1. The client mainly provides C language learning and doing programming environment, which based on .NET platform. The server based on .NET and SQL Server 2005, it is mainly responsible for managing users, documents and databases and achieving logic error-check function. The server contains three databases: User DB, Test-case DB and Question DB. These databases are managed by DB management module in standard.

The system module is shown in Figure 2. The client contains user login, compile and logic error-check, TC programming and auxiliary modules. The server contains user management, DB management, logic error-check service and auxiliary service modules. The compile error-check model offers programming environment and powerful compile error-check function. The logic error-check model provides safety-test, compiling and debugging for the .C source files received from the client, which is implemented by redirect technology and DB management technology. The auxiliary module in client mainly provides a large number of learning materials and tools, which will be updated timely. And the multithreading and process management, document management and interface management are offered by the auxiliary service module.

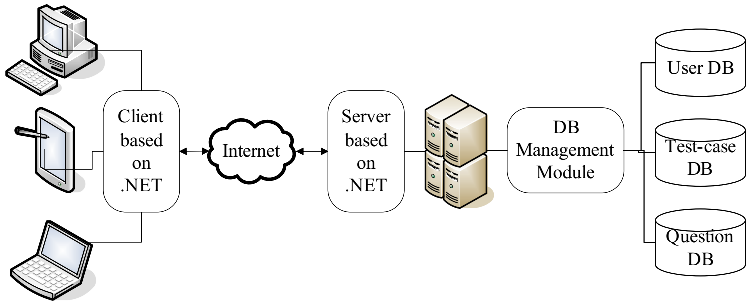

Fig. 1. The architecture of the system

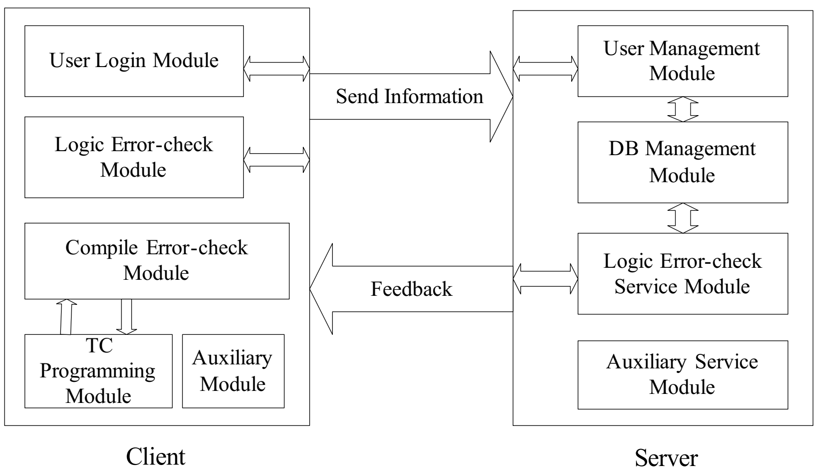

Fig. 2. The system module

Users can learn C language knowledge and doing program in Turbo C 2.0 programming environment. If they meet compile errors which are difficult to solve, users can get hints and extra help form the compile error-check module and then rectify the grammatical mistakes. After the program ran successfully, users can send the source code to the server to do logic error-check. The server will return the results of the program quickly and display it in the massage frame. According the feedback, logic errors in the source code can be corrected.

3 Design and Implementation of Compile Error-Check

Compile Error-check module is responsible for supporting users more accurate and comprehensive compile error messages. Its work process is shown in Figure 3. It obtains error messages in two ways. One way is to analyze the TC errors by interacting with the Turbo C 2.0. The other way is to infer the errors from the source code through kinds of algorithms provided by the system.

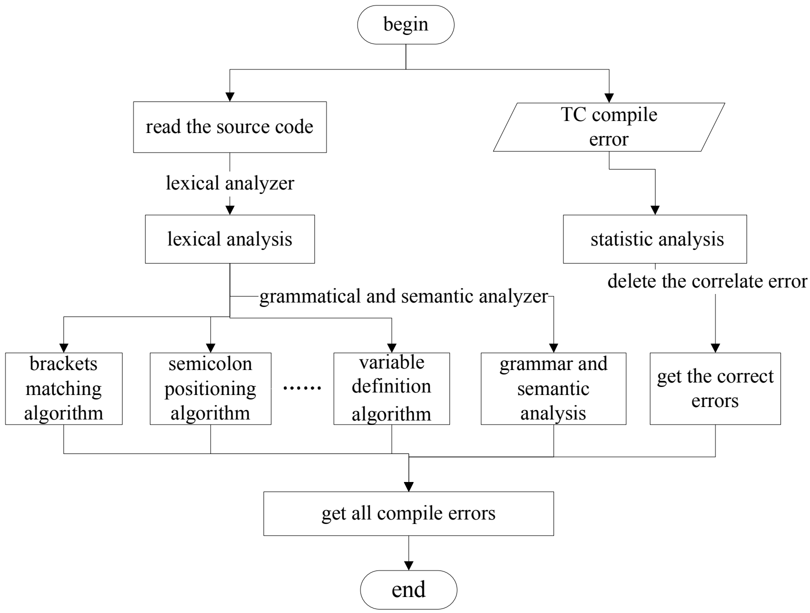

Fig. 3. The flow sheet of compile error-check

The first way is mainly to capture the error messages of Turbo C 2.0 compiler and to analyze the possible reasons. The communication between the system and the compiler is implemented by redirect technology under DOS. Meanwhile, the system saves these errors to a text file, then it positions each error correctly according to the analytical database. This way is responsible for deleting the relative errors and positioning the mistakes correctly. The main code is shown in the following:

```
private string RunCmd(string command)
    {
      Process p = new Process();
      p.StartInfo.FileName = "cmd.exe";
      p.StartInfo.Arguments = "/c " + command;
      p.StartInfo.UseShellExecute = false;
      p.StartInfo.RedirectStandardInput = true;
      p.StartInfo.RedirectStandardOutput = true;
      p.StartInfo.RedirectStandardError = true;
      p.StartInfo.CreateNoWindow = true;
      p.Start();
      return p.StandardOutput.ReadToEnd();
    }
```

The second way is mainly to analyze the source code independently and to find out some hidden errors, which provides expert-level guidance for users. It can make up for the shortcoming of TC compiler. As we know, Turbo C 2.0 positions errors incorrectly sometimes and usually causes some correlated errors. Though it's a classic C language compiler, Turbo C 2.0 only guarantees that the first error is correct. For example, sometimes losing a ";" will cause more than 10 errors. Besides, the external errors may shield internal errors in some compound statements. The C-language learners will feel terrified and don't know what to do next because of these incorrect errors. This way is useful to deal with this problem. It analyzes the source code with different methods, which contains lexical analysis, grammatical and semantic analysis. There are kinds of algorithms in the system used to find out the errors in the code, such as brackets matching algorithm, semicolon positioning algorithm and variable definition algorithm. And they are self-contained and can be replaced and extended in the future. These algorithms are high efficient and can find out the hidden errors which may not be discovered by TC compiler.

The two ways are good supplement to each other. And they will be unified in the end and then return the feedback to users. So the error messages presented by the system not only contain the correct TC errors, but also include some hidden errors in the code. They are more comprehensive.

4 Design and Implementation of Logic Error-Check

Logic Error-check is the key module in the learning system, which is responsible for helping users to find out the logic errors in their programs and checking the codes whether have achieved the function of the program completely. It contains document processing, compile, safety-check, redirect input and output, test-case scheduling and feedback sub-modules. Its structure is shown in Figure 4. If any of sub-modules has appeared mistake, the server will return an error message to the client and delete the program directly.

The document processing sub-module receives and processes the .C source files sent from the client. And the compile sub-module is responsible for compiling the source code, which is realized by the DOS command and the outside interface provided by the .NET platform. It can test the program whether has compile errors. The compile sub-module will call TC to run the program if there are not compile errors in the code.

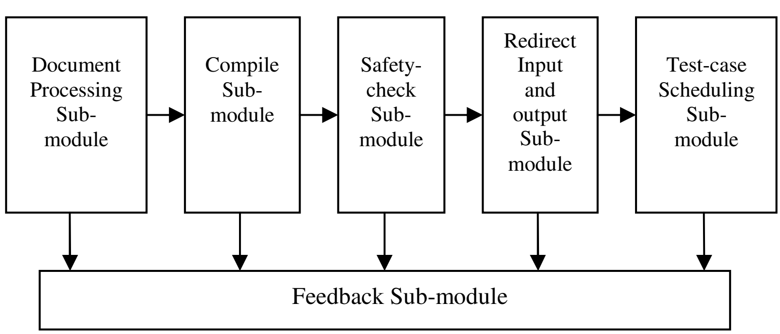

Fig. 4. The structure of function-test Module

The safety-check sub-module is mainly to make sure the programs are safe to the computer. Usually, the computer will be in danger if the programs are in death cycle. Though we can interrupt the death cycle compulsively in Turbo C 2.0, the functions provided by the server are all automatic. So it is necessary to provide a good method to track the program's running and delete the malicious code in time. The Process component is used to achieve this function in the sub-module, which is a useful tool to start, stop, control and monitor applications in the .NET platform. And it can get the information of currently running process, including thread set, performance and loadable module (. Dll and. Exe file). So the safety-check sub-module can judge the program coming to an end or not by this information of process. If the process has been closed in normal at prescribed time, it means that there is not death cycle in the program. Otherwise, it indicates that the process is dangerous to the computer. The Process component will call the interruption and delete the program at the same time. The main code is as following:

```
Process myProcess;
 myProcess = Process.Start(exe_file); //run the .Exe file
  for (int k = 0; k < 100; k++)
  {  if (!myProcess.HasExited)
     {   myProcess.Refresh();
        Thread.Sleep(50);
     }
     else
     {   break;  }
  }
  if (!myProcess.HasExited)
// If the process hasn't been closed in normal
  {   myProcess.Kill();    ......  }
myProcess.Close();
```

The redirect input and output sub-module is used to take over the input and output of the programs when the platform does logic error-check function. The system tests the code whether has achieved the function completely only according the outputs of the program. However, the programs of users usually get their inputs from keyboard or their designated files, so the system can not check the correctness of the outputs. The sub-module must take over the inputs of the programs by the test-cases firstly. The class "ReplaceEdit" is used to implement this operation, which analyzes the .C source files and replaces the input-functions and output-functions of keyboard or files in the source code. For example, keyboard output-function "printf" is replaced by the file output-function "fprintf", keyboard input-function "scanf" is replaced by the file input-function "fscanf". So the source code will have specific input and output after being dealt by the redirect input and output sub-module.

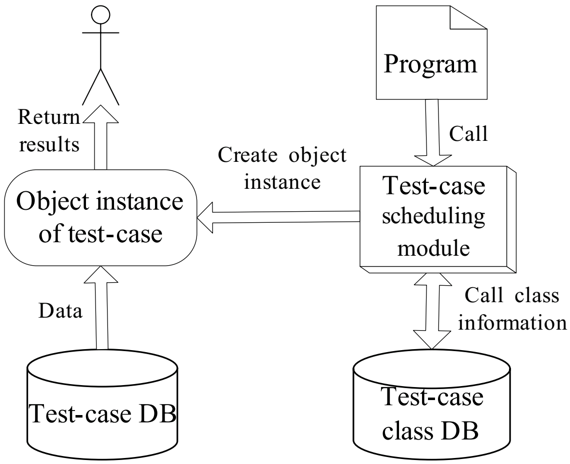

Fig. 5. The structure of test-case scheduling

The test-case scheduling sub-module mainly manages and schedules the test-cases and methods. In order to test the programs whether have logic errors, a large number of test-cases and analysis methods are needed in the system. Usually, each program needs a corresponding test-case class to run it independently, because different programs require different test-cases and methods. If we write test-case class for each program, the system code will be prolix and bad for extending and modifying in the future. So the test-case scheduling sub-module supports the dynamic creation of test-case class for each program, which uses Object-Oriented design methods and C# Reflection technology. Its structure is shown in Figure 5. There are two databases in the sub-module: test-case DB and test-case class DB. The test-case DB contains different test-cases, and the test-case class DB is used to save the information of the test-case classes. The test-case scheduling sub-module uses the Object-Oriented design methods to manage and communicate with these two databases. It calls the information of the test-case classes by the scheduling module.

With the types of programs increased, the system code will be more complex. The parts in the sub-module should interact with each other only through their interfaces and can be replaced without affecting other parts of the sub-module for keeping the platform be flexible and extendable. The Factory method, Condition external and C# Reflection technology are used to achieve this function. The Factory method can accomplish reconstruction technology and provides the interface of test-case. The Condition external offers the uniform information management by using configuration File. The C# Reflection technology can create an object instance of the test-case class for each program by calling the class's attributes and methods. So each part in the sub-module is self-contained and can be replaced and extended.

5 An Example in the System

The Internet-based system for C Language Learning provides programming environment, rich learning materials and more powerful compile and logic error-check functions.

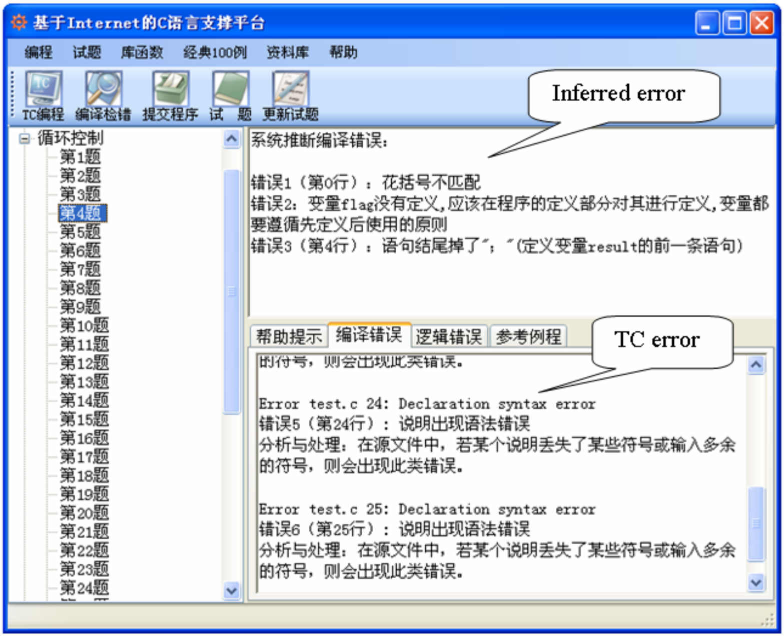

Fig. 6. The result of compile error-check

Even in the absence of face-to-face interactions in the classroom, users can take programming training and improve programming skills through the platform in distance education.

The main frame of the client is divided into three parts: program content index, system-compiling textbox and TC-compiling textbox. After choosing the problem in the index, users can click on the TC programming into Turbo C 2.0 environment and do programming. If they meet the compile errors that can not be solved, they can click on the compile error-check button in the toolbar. They will get hints and extra help from the platform. For example, a user wants to do one problem, but he failed to rectify the compile error by himself, so he can use the compile error-check function. The system will display the errors which are obtained by analyzing the source code in the system-compiling textbox, and present the analysis of TC errors in the TC-compiling textbox. Its result is shown in Figure 6.

The Figure 6 shows that the errors displayed in the system-compiling textbox are more concise and accurate. There are three correct compile errors in the program, but the TC compiler shows six errors. Besides, the error-- Undefined symbol 'flag' in function main was presented by the system, but could not be discovered by the TC compiler. And the errors displayed in the TC-compiling textbox are more detailed than the errors displayed in Turbo C 2.0. Equally, it is also simple for users to do the logic error-check for the programs. After sending the source code to the server by using the submission button, the results of logic error-check will be returned quickly. And the platform will presents them in the logic-error analysis frame.

6 Conclusion

This paper introduces the structure and implementation of an Internet-Based platform for C language learning in detail. More powerful compile and logic error-check function is provided for C language learners in the system. The compile error-check function of system excludes the correlated errors of TC compiler, and it solves the problems of positioning errors incorrectly. It can find out the hidden errors in the code by using a number of analysis algorithms, which makes the error messages more accurate and efficient. The logic error-check function in the system can help the users to rectify the logical errors by themselves. It can also check that the function of programs is achieved completely or not. Besides, Object-Oriented design methods are used in the system, which make the platform with strong compatibility. In our subsequent work, we plan to make our system more powerful in logic error-check function and provide a good reference model to design other language learning platforms.

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Virtual Education System for the C Programming Language

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Abstract. Web-based interactive learning is an important educational trend. In this paper, we implemented web-based virtual education courseware for the C programming language. It consists of two major components: a creative lecture component for students and an evaluation component for lecturers. The lecture component contains HTML-based lecture notes with creative multimedia content, such as flash movies and video clips, and an effective web-based compiler which compiles C programs at the server. These are submitted by students through the Web and the program returns their execution results to the students' PCs. There is also a submission component of a student's reports and an online examination. The administration and management system for attendance checking, report assignment, online examination and scoring, etc is implemented using web technologies such as HTML, Java, Java script, PHP and MySQL database. This system enables students to easily understand the content and programming techniques of the C programming language. It enables lecturers to achieve higher productivity, saving them time and labor.

Keywords: Web-based Virtual Education, Java Applet, Web-based Compiler, PHP, MySQL.

1 Introduction

In addition to enhancing traditional educational methods, Information Technology (IT) can also enable original methods of education delivery and innovative pedagogic strategies. Teaching is no longer confined to a time and a place. The temporal and physical boundaries of the traditional classroom are stretched into a learning space. A growing number of universities worldwide are now offering virtual education problems. Several companies are also providing online training for their employees. A simple search on the worldwide web will yield hundreds of web-sites offering virtual courses or resources for developing and delivering such courses [1-3]. Web-based learning is beneficial for those students who cannot attend classrooms because of their personal or professional commitments, their limited financial resources, or physical limitations. The main advantage of effective on line web-based learning is that it

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provides learning facilities on the Internet in real-time: 24 hours/day, 7 days/week, accessible anywhere, anytime, eliminating conflicts with one's schedule. Because the instructional material is always available, learning is self-paced. From the point of view of instructors, once the class material is in electronic format, it's easy to modify and keep up to date. In addition, the organization of the material will be enhanced because there will only be a single repository for everything. Another objective of a virtual laboratory is to provide hands-on lab activities to enhance online courses.

A study at East Carolina University [4] found that a virtual laboratory helped students to understand concepts and theory in online courses. A virtual laboratory is particularly useful when some experiments involve equipment that may be harmful to students. The laser virtual laboratory developed by the Physics Department of Dalhousie University [5] shows how to perform dangerous laser laboratory work in real-time by controlling equipment through the Internet. A remote laboratory called VLAB [6] for an oscilloscope experiment was recently set up in the Department of Electrical Engineering, National University of Singapore. These remote laboratories are actual laboratory experiments that are run remotely via a web interface, and are well suited to distance learning courses, where students need not be physically present on campus. The EE laboratories at the University of Auckland are an excellent example of the transformation of laboratories based on the changing needs of an institution. This process accelerated measurements, but the ever-increasing student numbers since then have resulted in severe unavailability of equipment. It is now desirable to simulate electrical equipment and provide access to the labs over the Internet, so that students can perform some experiments away from the laboratory. The virtual laboratory system for basic circuit theory implemented by the electrical communication department of Schoonchunhyang University [7] is composed of four important components: Principle Classroom, Virtual Experiment Classroom, Assessment Classroom and Management System. Through this virtual laboratory system, students can effectively study the concepts and theories related to the engineering experiments, and to the means to operate equipment such as multi-meters, function generators and digital oscilloscopes. Finally, the system has resulted in several positive outcomes, such as reducing the total experimental hours and the damage rate of experimental equipment.

In this paper, we have implemented creative multimedia content composed in a virtual laboratory, which provides educative interaction between learners and content, and enables learners to effectively understand the C syntax and programming concepts. In particular, our virtual education system for the C programming language shares the commercial software packages. This makes the system independent of the process of commercial software development, in which a particular version of the software might become obsolete very quickly. Our virtual education system uses a server side compiler in the LINUX environment, via the Internet instead of using a desktop commercial compiler. Therefore, not all students need to purchase and install a commercial compiler on their PC in order to study the C Programming Language. Provided learners can be connected to the our C course-ware through the internet, anytime and anywhere, learners can submit their C source files and review their execution results, which are implemented and returned by the C compiler on the web server. Learners need not install their own C compiler on their PC, which saves software costs and maintenance labor. Learner and teachers communicate with each other using the administration and management system, which provides different types of functions such as attendance checking, reporting assignments, online examination, scoring, teacher' advice etc. The administration and management is implemented using web technologies such as HTML, Java, Java script, PHP and MySQL database [8-11].

The rest of the paper is organized as follows. In Section 2.1, the system is described from the learners' perspective, which includes creative lecture note content, web-based C compiler structure and functions. In Section 2.2, we describe web-based C compiler implementation. Section 3 describes the student response to a C programming lecture. Section 4 concludes the paper and discusses a direction for future work.

2 Virtual Learning System for the C Programming Language

Our C courseware largely consists of two components, shown in Fig. 1. One, called a Virtual Learning System, is concerned with learners' activities, the other with teachers' activities. The Virtual Learning System assists learners in easily and effectively learning the C language grammer,and programming concept and techniques. The system includes HTML lecture notes, multimedia content facilitating the process of understanding, and an effective practice environment consisting of a web-based C compiler implemented by GCC/CGI [12-14]. The other is an evaluation and management system for teacher and students. We will describe this in section 3.

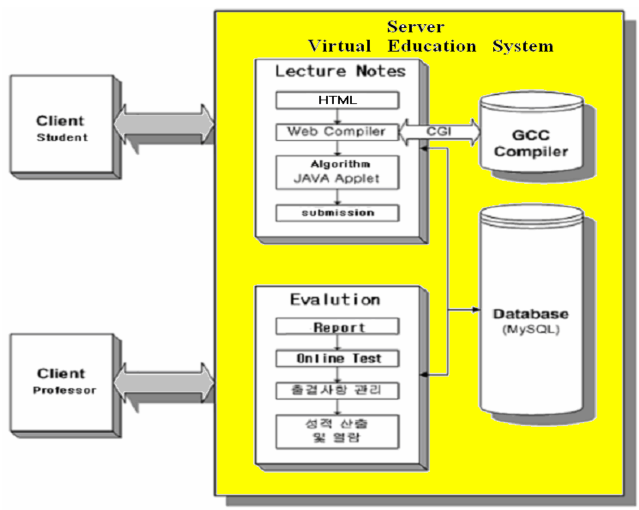

Fig. 1. Configuration of the Virtual Education System

2.1 Lecture Notes

The learner primarily has access to HTML lecture notes consisting of 16 weeks of content, as shown in Fig. 2. After pressing the 6th week control hyperlinked, next page moves to control page. A student can listen to a brief introduction of the week by clicking the sound button. Then, he or she can be guided by a Flash Movie animation, for an explanation of particularly complex concepts and programming techniques [15-17].

Most lecturers have felt that there were difficulties in teaching concepts of computer programming. For example, it is difficult for students to comprehend the overflow and underflow concepts. Thus, we hope that Flash animations will help students understand concepts. The Flash animation in Fig. 3 shows when an overflow occurs. Learners can easily grasp the concept of overflow for an integer type variable.

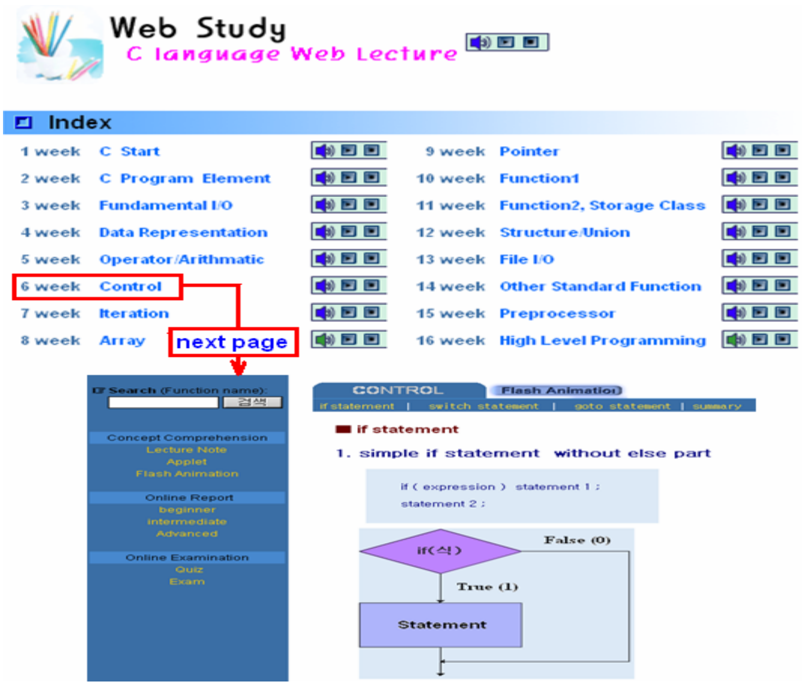

Fig. 2. An HTML page for lecture notes

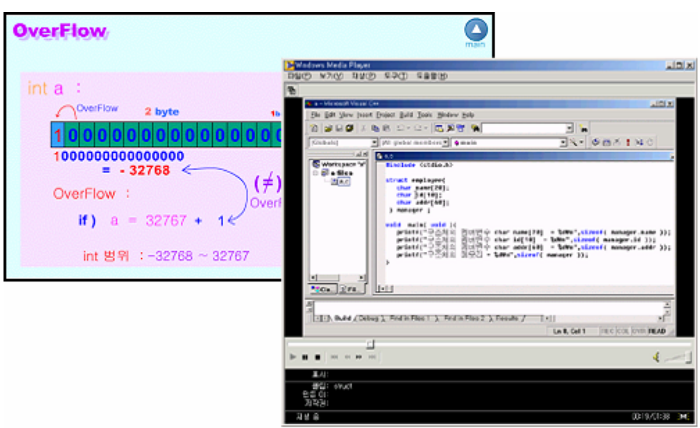

Fig. 3. Flash animation for explanation of the overflow concept

More interactive content made by Java Applets are provided. Learners can enter proper values into the Applet and observe which results are returned. The printf function writes formatted output to standard_out (stdout). There are many cursor control sequences and conversion characters for the printf command. The learner needs to comprehend the effects of control character usage. Therefore we implemented a Java Applet for printf. The Applet for the printf function in Fig. 4 waits for 3 values of integer-type variable a, double-type variable b, a character-type variable and a format for printout, which learners can select from a list box, shown in Fig. 5, or enter their own into the output format text box. Using this Applet, learners can very easily observe the relation between print formats and printout results, which give learners different types of experiences about print formats.

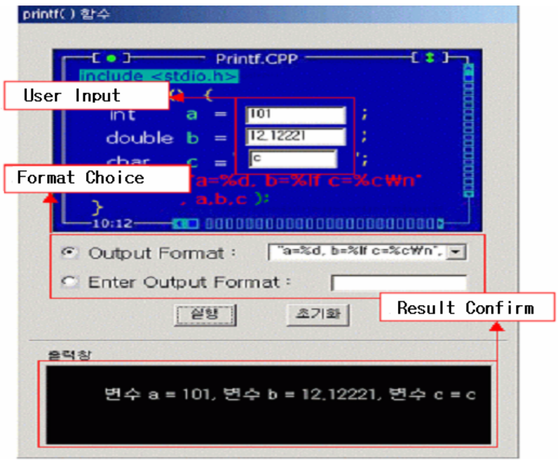

Fig. 4. Applet for the printf function

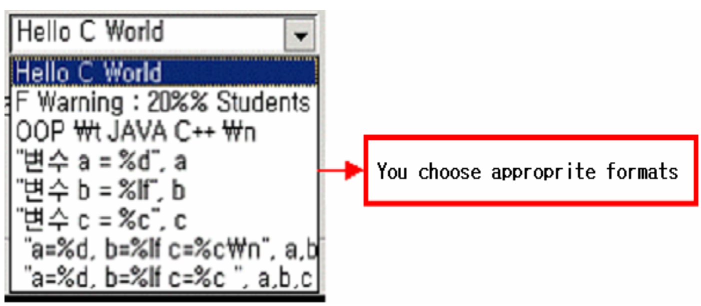

Fig. 5. List box for format selection

Fig. 6 is an applet for an iterative statement (while, do-while , for, nested for , break, continue). After students choose a panel in a Top-down panel, and insert a value in a user input textbox, they can confirm the result of the program for the chosen value.

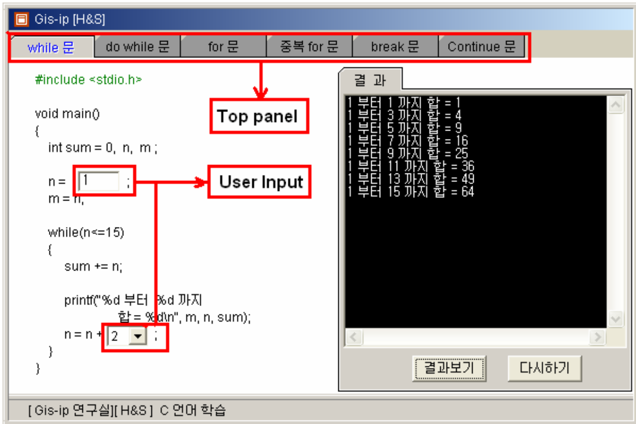

Fig. 6. Interactive statement applet

A pointer is a variable that contains the address of another variable. Since a pointer contains the address of an object, it is possible to access the object indirectly through the pointer. Pointers are so commonly used as references in general, partly because they are sometimes the only way to express a computation, and partly because they usually lead to more compact and efficient code than can be obtained by other means. However, it is difficult for students to understand the concept of a pointer. Therefore we implemented a pointer applet. Fig. 7 is an applet for comprehension of the concept of a pointer address. After students choose an item from a selection box and guess the result, they can in fact confirm the result.

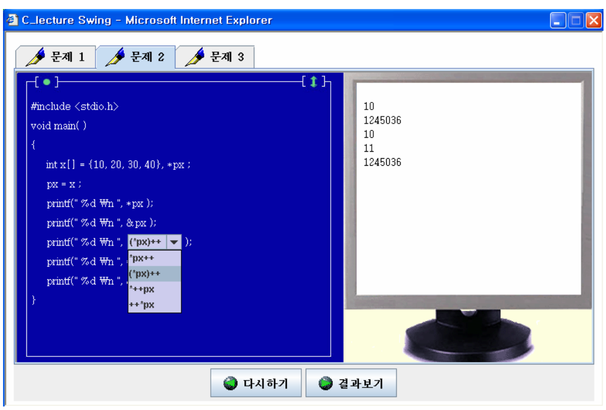

Fig. 7. Numeric calculation

An animation or visualization for comprehension of the algorithm concept is the most efficient means to learn different types of algorithms. Sorting is one of the most pedagogical exercises to introduce algorithms. Sorting refers to algorithms that take the items from the array and put them in order. The goal of the sort applet is to present students with a visual way to understand the means by which the most common algorithms work, and how different approaches can yield different results under different conditions. We hope this java applet will help students understand the intricacies of sorting, and also popularize a visualization method as a pedagogical tool to teach algorithms. We implemented the following algorithms: bubble sort , selection sort, insertion sort, shell sort and quick sort. To test that the algorithms performed the sort correctly, a small data set was chosen and executed step by step. The Sort applet is composed of a source component and an animation pad component. The pads are filled with unordered numbers, as shown in figure 8 [15][16]. Learners select one of the different types of sorting algorithms shown in Fig. 9, in order to understand its principle. They can understand the sorting procedure systematically, through graphics. Learners effectively understand and analyze the advantages and disadvantages of each type of sorting algorithm.

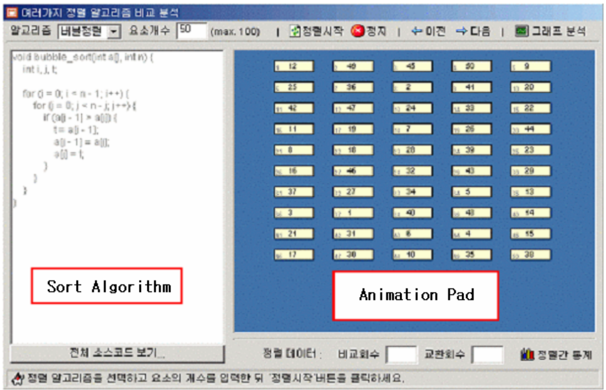

Fig. 8. Applet for understanding a sorting algorithm

2.2 Implementation of a Web-Based C Compiler

Intranet Compilers Architecture; during software development it is important to justify which components of the software should run on the client machine and which components should run on the server. Client side programs – Java Applets - are trans ferred through the network when requested and execution is performed entirely on the

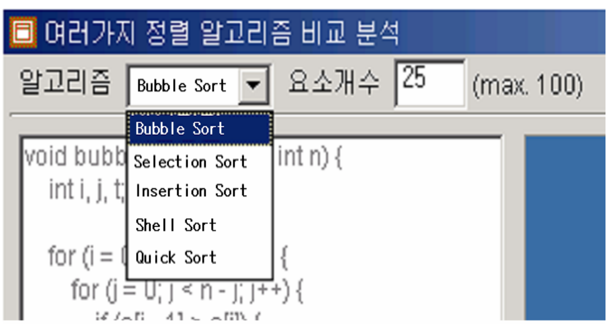

Fig. 9. Sorting method selection

client machine that made the request. This enables sharing of the computational cost between the server and client. This approach can be used when programs to be transferred to users are moderate in size, or are to be cached on the client machine, or the data is to be transferred between server and client, in case the application is run on the server, when it is very large. In the case of platform independent solutions, such as Java, lower computational performance may be prohibitive. Using CG,I much less information has to be passed to the server. The server executes instructions based on the given information and sends the results back to the local machine that made the request. This is used in the opposite cases, when the software package is large or must not be released to the user, or when the amount of data to be transferred is small. However, large number of clients that access the server simultaneously would make the CGI-based approach undesirable. Therefore, in order to solve this problem, we implemented a web-based C compiler. Our system for C programming uses none of the commercial software packages. This makes the system independent of the process of commercial software development, in which a particular version of the software might become obsolete very quickly. Our system uses a server side compiler in the LINUX environment, through the Internet, instead of using a desktop commercial compiler. Therefore not all students need purchase and install a commercial compiler on their PC in order to study the C Programming Language. They just connect to our system using a Java Applet and send their C language source code to the server side, then, the result of program execution will be be returned to them. The web-based C compiler shown in Fig. 10 is implemented by Java I/O Applet and GCC at the server-side. This system is providing a web-based compiler to make learning content to change program code directly and confirm it exactly. Utilization of the web-based compiler will be economically helpful to students who do not have a separate C compiler. In Fig. 11, a Java I/O Applet receives program source code from the clients., In Fig. 12, it makes them a file and passes them for compilation via GCC.. In Figs. 13-14, GCC's execution result or error messages will be returned to the clients by the Java I/O Applet.

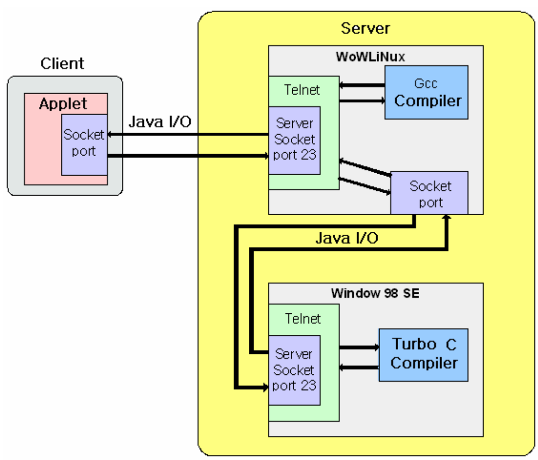

Fig. 10. Functional diagram of a web-based compiler

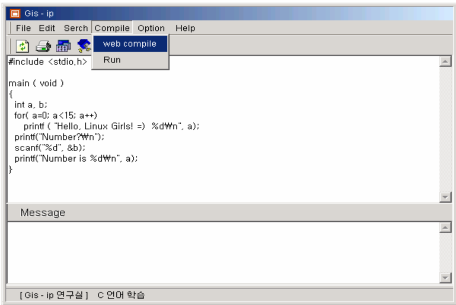

Fig. 11. Writing C source code

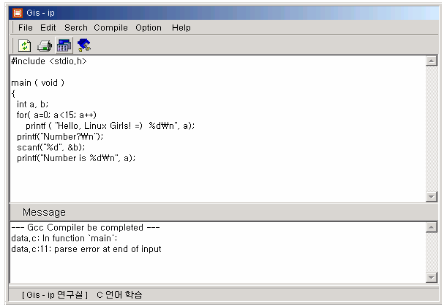

Fig. 12. Making a file for compilation

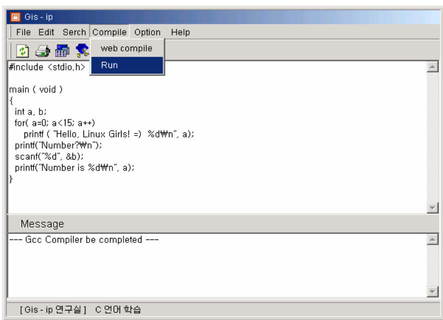

Fig. 13. Execution

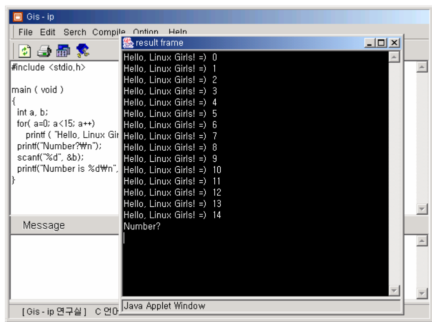

Fig. 14. Results returned

Qualitatively, the system effectively helps students to easily learn the C Language syntax and programming. The integration of multimedia education contents with the web-based C compiler support system enables students engage in C programming exercises, any time and any where, provided they have access to the internet.

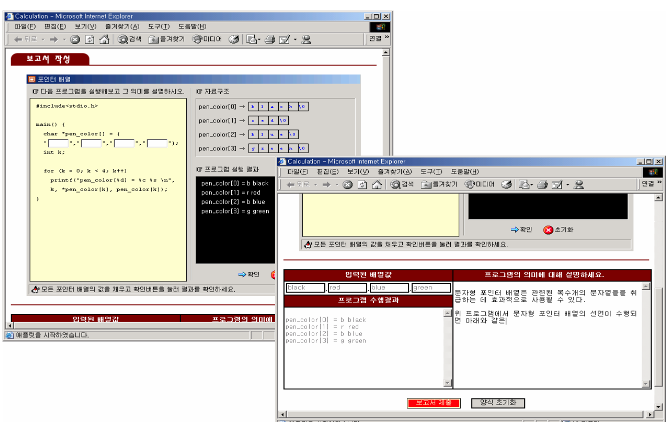

Fig. 15. On-line report writing and submission

2.3 Online Report and Examination

Learners' activities for report materials in the lecture notes content are shown in Fig. 15. They are saved on the database and can be restored in printout form, as shown in Fig. 16, which is given a unique ID for preventing duplication. Learners must hand in printouts to teachers for evaluation.

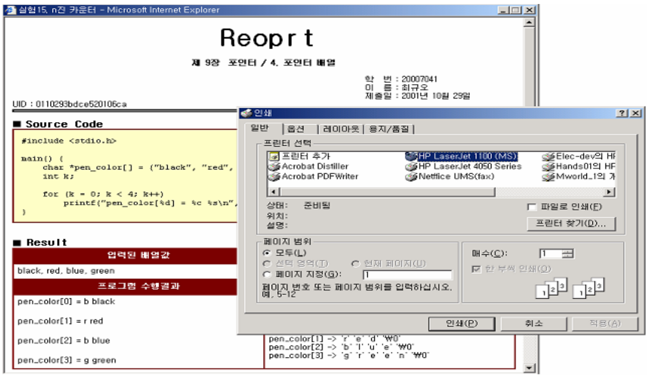

Fig. 16. Printout of report

3 Student Response to C Programming Lecture

Since 2001, students have been surveyed about a C programming lecture in four courses, at Soonchunhyang University, Korea. Over 50 students completed the survey each year, rating 6 statements on a five-point scale, ranging from ‘strongly agree’ to ‘strongly disagree’. More than 80% of students selected ‘SA(Strongly Agree)’ or ‘A(Agree)’ when answering these questions. The survey results are encouraging. The authors believe that these results demonstrate that the C programming lecture enhances the students’ understanding of C programming.

Table 1. Font sizes of headings. Table captions should always be positioned *above* the tables.

Question	SA	A	N	D	SD
1. This content helped me understand the C programming lecture.	33	48	13	3	1
2. Flash Animation helped me understand the concept of an algorithm	35	58	6	1	0
3. Java applet quiz helped me understand the syntax of the C language.	25	55	16	3	1
4. The C laboratory exercise improved my programming skills.	30	62	7	0	1
5. The web-based C compiler helped me learn C programming.	28	52	14	4	2
6. The C laboratory exercises were many and varied.	24	56	15	3	2

4 Conclusions and Future Work

We have implemented an efficient and cost-effective virtual education system for C programming, which can be used to enhance the quality of C programming education. The use of a simple and user-friendly design, enables a high number of people to easily access the virtual education system. Thus, advanced training using our virtual education system will be available, even when an expensive C compiler is not provided for the students' PCs.

Our virtual education system has two important components: a virtual learning system and an evaluation/management system. The virtual learning system provides a very effective and convenient learning environment, based on lecture notes for the C programming language, using creative multimedia content such as Flash movies and a Java Applet. This enables learners to easily understand the subject. The virtual learning system also provides a web-based compiler that compiles C programs at the server side. These programs are submitted by students, through the Internet. The server returns their execution results to the students' PC, thus, students need not install their own C compiler on their PCs.

Students' activities such as attendance, reports and examinations are all stored and evaluated by the evaluation/management system. The evaluation/management system for attendance checking, report assignment, online examination and scoring, etc is implemented using web technologies such as HTML, Java, Java script, PHP and MySQL database. Although education is provided virtually through the internet, teachers can effectively observe and advise students with the assistance of our evaluation and management system, because our system provides different types of statistics for teachers, such as the correct answer ratio and degree of difficulty about each question.

Our system enables students to easily understand the contents and programming techniques of the C programming language. It enables lecturers to achieve higher productivity, saving them time and labor.

Future work includes:

* Implementing a discussion group or Frequently Asked Questions (FAQs), to provide more channels for student discussion.
* Supplementing this virtual laboratory with synchronous communication methods, such as video conferencing, so that instructor and students can interact directly in real-time.
* Updating this virtual Laboratory for a study of the effect on student learning outcomes.

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Development of Contents Improving the Effectiveness of Self Learning, for the C Program Language

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Abstract. The web affords unique opportunities to assist students in learning. Due to the rapid proliferation of the web in recent years, many educators seek to improve the effectiveness of their instruction by providing innovative web-based course material to their students. In particular, many web-based educational contents are being developed. It helps to teach and train students. It is spreading widely due to repeated learning any time, any where. In this paper we implemented C functions and quizzes for checking comprehension of statements in a C programming lecture, developing scenario related concepts and algorithm comprehension. We used visual representation. The web-based contents were implemented as FLASH animations or Java applets.

Keywords: Web, FLASH, JAVA APPLET, ANIMATION.

1 Introduction

With the development of information communication, the information oriented wave that has been revolutionizing the social environment is also having a similar effect on the educational environment. To meet the needs of a rapidly changing information-intensive society,, the student needs to master new techniques and knowledge while working.. The student needs easy access to education and training for a change of his or her occupation. It is gradually becoming increasingly clear that education available via the web is important. In the modern society of the information age, education is being taken out of the lecture room through the development of high technology. The concept of learning is extended to the wide area of an information network. The rapid development of the computer network, with the emergence of the web, has changed the face-to-face method of traditional education, into teaching-learning between teacher and student which is not face-to-face and free from constraints of time and space, since we are using a variety of communication methods. Whenever and wherever we choose, we can easily learn using internet. Because of such advantages, many

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contents using the web were developed, and these are based on the main teaching materials and the secondary materials. The web-based contents should generally be interactive, and these should offer various media and in particular be made for piquing the student's interest. The guideline for development of contents consists of an interactive contents model, a process contents model, a practical contents model, an animation contents model, a multimedia contents model etc., as shown in figure 1. These models are not mutually exclusive [figure 2-5].

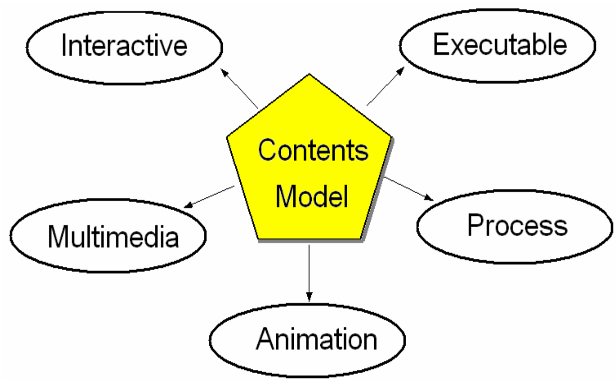

Fig. 1. Web-based education; cyber contents model

1.1 Interactive Contents Model

Based on the development of virtual education at Arizona state university, they achieved good results because of the fact that users are capable of seeing interactive control methods about signal processing, using distance education to use a graphics processing function in JAVA, as shown in figure 2.

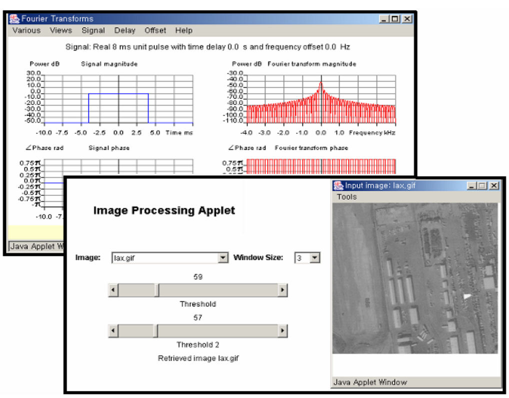

Fig. 2. Interactive contents model

1.2 Practical Contents Model

This model can enable the user to experience the processing of algorithms as a visual display, and aid in understanding the principles of algorithms. At SUNCHUNHYANG university, research team member[Kwan Sun Choi, Hong Gu Jheon], developed a web-based C compiler system, capable of using a server side compiler which doesn't require installation. The computer working on the internet using the web creates C program source code, and compiles and obtains the external results[5].

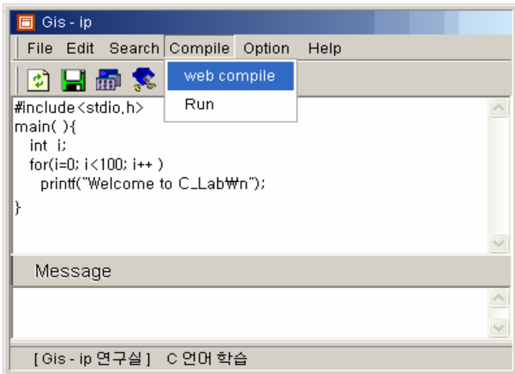

Fig. 3. Practical contents model

1.3 Process Contents Model

For this model the learning contents are presented in stages. To acquire the principles, the learning contents are arranged successively, such as an application program, a device using method etc. Figure 4 compares a human and a computer with respect to storage capacity, connection complexity and data transfer speed. This shows the process that occurs, and the user presses a button for the next stage.

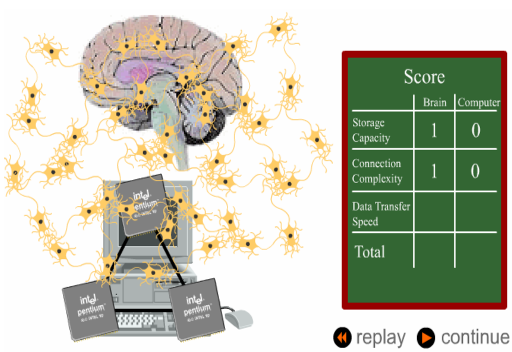

Fig. 4. Compares a human and a computer with respect to storage capacity

1.4 Animation Contents Model

An abstract principle or a concept represented as a simple image and a text through an animation based on a scenario, can enable a user to understand more and master difficult concepts. figure 5 is the animation of a checker game, implemented with a JAVA applet.

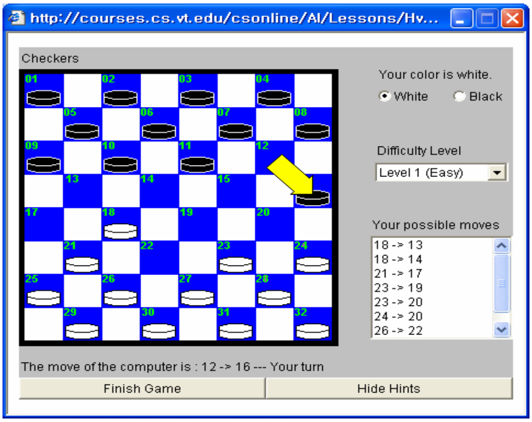

Fig. 5. A Multimedia contents model

This model is presented to a user using an image, a graphic, and visual symbols in general. Figure 6 was a simulated experiment that has been implemented by Dong Sik Kim, Sun Hyum Lee, Kwan Sun Choi in SUNCHEONHYANG university research team. This was implemented as a measuring device and a circuit device, virtually, with software on the web, just as an experiment in an actual state. Then, students practiced an interesting preliminary experiment, using a mouse for an easy operation. Wiring methods are represented by visual symbols.[8].

This study aims to develop virtual education contents using the web. Thus, we produced a flash quiz , to measure the ability to use a function, concept understanding

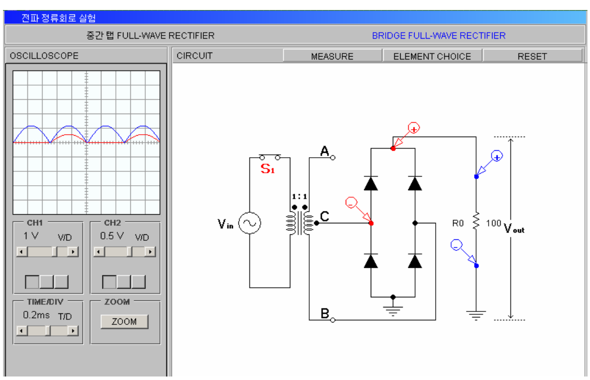

Fig. 6. Multimedia contents model

and the level of understanding of statements. While we were developing the educational learning contents, since it is important to study a programming language for aiding in understanding of algorithms,, we made sort algorithms and hanoi top transfer algorithms in JAVA. In this article, we provide an explanation of the making of flashes of a C language standard function, quizzes made with flash, flash animations to understand concepts, and making an applet to understand an algorithm.

2 Implementation of Contents Using JAVA, FLASH

In this article, we produced various contents to use flash and JAVA to help students who attend a computer programming lecture to understand the concepts. We implemented all functions which are used in the C language, and how to use these, with flash animation. If students search for a function's name with a search function, students will be able to perform functions that are implemented with flash animation.

2.1 The Flash Production of a C Language Standard Function

Firstly, if a student inputs a log10 function, to be given for making an calculation with some real number value of common logarithms, and presses a search button, the results will be shown in a flash window, such as figure 8. If a student presses the play-button, the student can see how the X input value is transformed into log10(x) and assigned to Y as the output value. To stop, he or she presses a stop-button, and is able to

Fig. 7. Function Search window

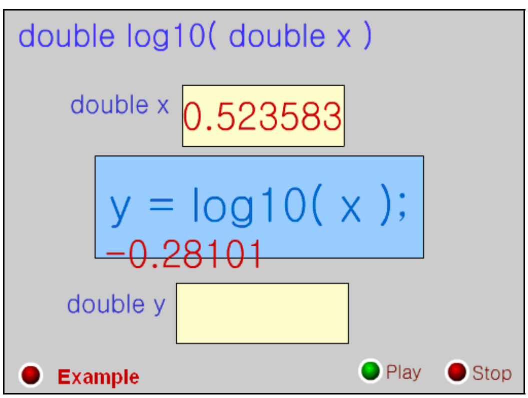

Fig. 8. Log10 function made with flash

halt the operations. If the student presses the speaker-button, he or she can listen to an explanation about a function, from the computer. If the student presses the button using the example, he or her can see the outcomes, such as the function of this example.

Secondly, The fseek function produced by flash that makes a stack pointer(fp) which is transferred any place, is shown in figure 9. Thirdly, as an animation of the fputc function, this function can write characters one by one, as shown in figure 10, We can see how to write "hello" in a character type variable str, through a writing process which opened a file in writing mode.

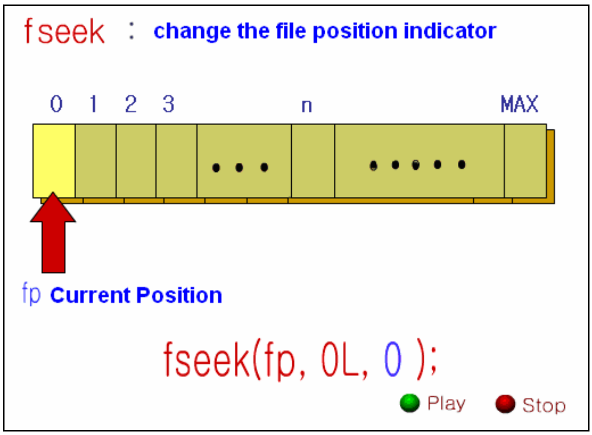

Fig. 9. Fseek function made with flash

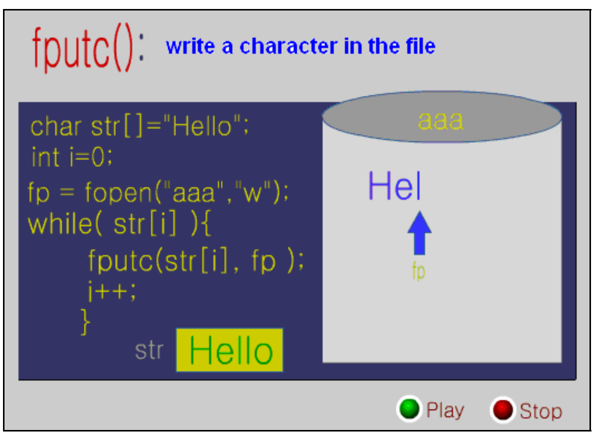

Fig. 10. Fputs function made with flash

Example of an 'if-else statement' quiz implemented to measure the user's understanding with flash. The student inputs any numbers in the text-box indicated by the finger. Based on the 'if statement', when the statement is true, a red box is drawn on the screen. When the statement is false, a yellow box is drawn on the screen, as shown in

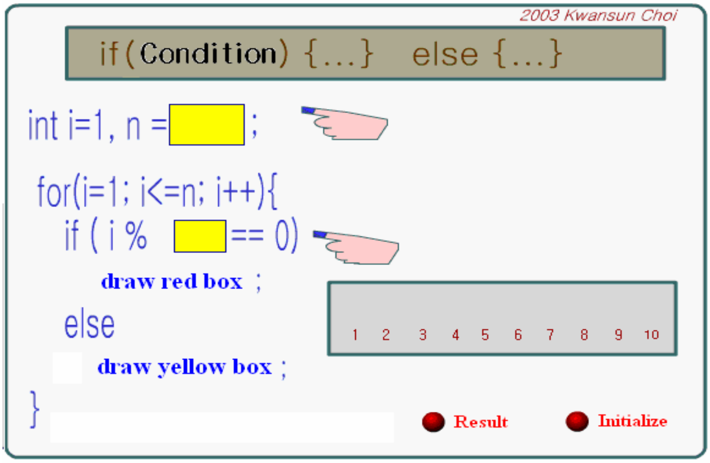

Fig. 11. If-else quiz made with flash

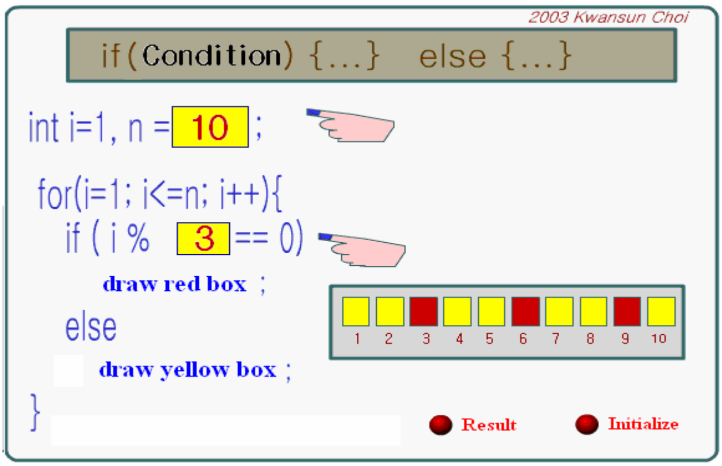

Fig. 12. If-else quiz operation

figure 11. If the student inputs a value into the text-box which is a multiple of three it draws a red box. If not, it draws a yellow box, as shown in figure 12. If the student wants to repeat from the beginning, he or she only needs to press the button for the first stage.

Figure 13 shows a flash quiz in which the student practices how to use an array of a two dimensional sort variable of character type. If the student inputs a free character line in the text-box indicated by the finger, a character is stored in a picture of the memory , below an address value. Students can understand the fact that the characters are stored in a[0], a[1], a[2], a[3], in sort element variables of character form. In this case it's expressed in pointer form, it can be shown as *a, *(a+1), *(a+2), *(a+3).

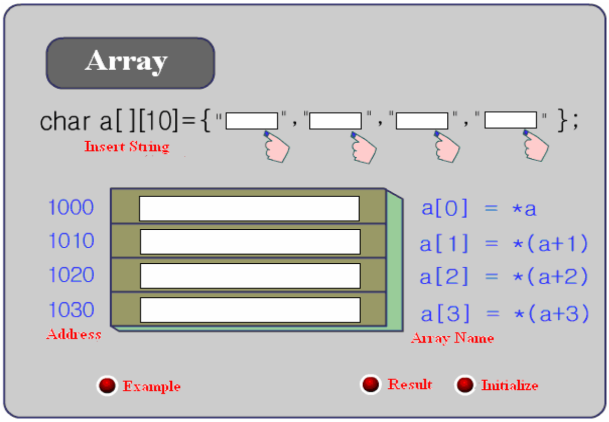

Fig. 13. Quiz about a sort variable of the character type

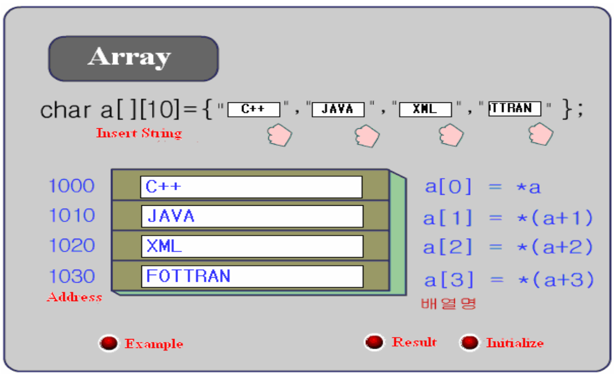

Fig. 14. Quiz operation about a sort variable of the character type

Figure 14 shows that this quiz is in progress, and the student has input C++, JAVA, XML, FORTRAN into the text-box and then presses the result checking button. The student can verify that each character in the lines were placed into each element a[0], a[1], a[2], a[3] in a sort variable of the character form.

2.2 Flash Animation Production to Understand Concepts

Assume that an integer number's data occupies two bytes of memory , and consider positive numbers and negative numbers. The range of numbers which is possible is -32768-32767. If there is a smaller value than -32768 among the values assigned to variable, an overflow occurs. An underflow is assigned to smaller numbers than can be assigned to a variable. An overflow is assigned to larger numbers than can be assigned to a variable. In order to make overflow and underflow concepts easier for students to understand,, we produced a scenario and implemented flash as follows. A fish is compared to an integer number's data and a nursery is compared to the role of

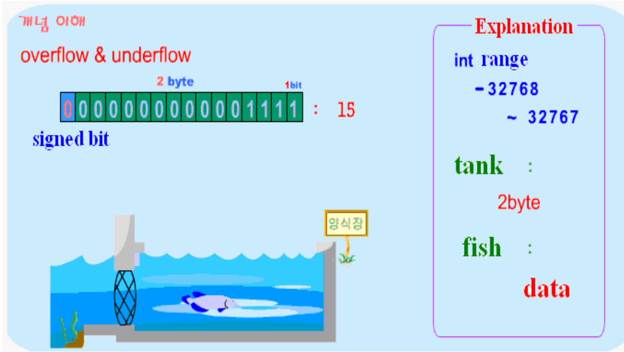

Fig. 15. An integer number's range

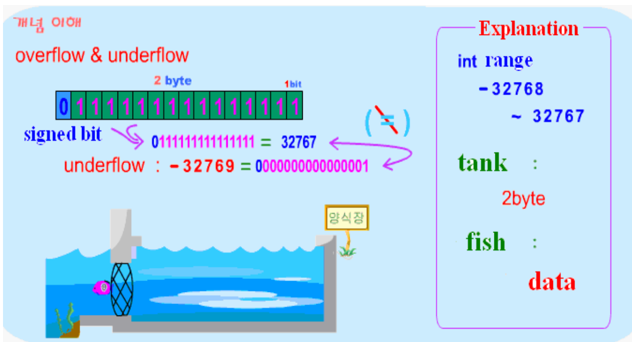

Fig. 16. Example of an underflow

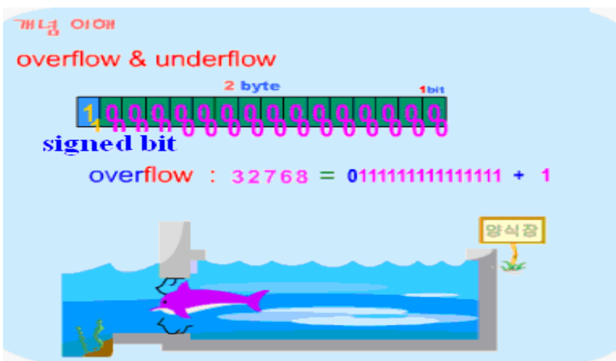

Fig. 17. Example of an overflow

data contained in variables The proper fishes only live within a fish tank, but the smaller fishes will escape from a net, as shown in figure 6. This is an underflow. Very large fishes will escape by tearing a net, as shown in figure 7. Therefore, figure 7 shows that large fishes can't be put in a net.

2.3 Production of a JAVA Applet for the Purpose of Understanding Algorithms

There are educational contents which consist of a sort algorithm and hanoi-top transfer algorithms, which deal with the C language and are comparatively complex algorithms[10-11]. We use JAVA to utilize an algorithm learning applet on the web. Real-time technical animation with JAVA threads is used to aid in understanding an algorithm[12-15].

Firstly, figure 18 is the main screen of a sort algorithm learning applet. In this study, we deal with five sort algorithms, namely, bubble sort, selection sort, insertion sort, shell sort, and quick sort .

The entire applet consists of the top toolbar, the source code implementing each sort algorithm as C language, at the left side, and the animation pad, at the right side. This pad is arranged randomly to sort values. Based on a student's inputted sort factor, we used it to see how to randomly arrange the numbers from one to the number of the sort factor . For example, when a student performs a ten sort, the applet shows on the first screen that numerals from 1 to 10 are randomly arranged.

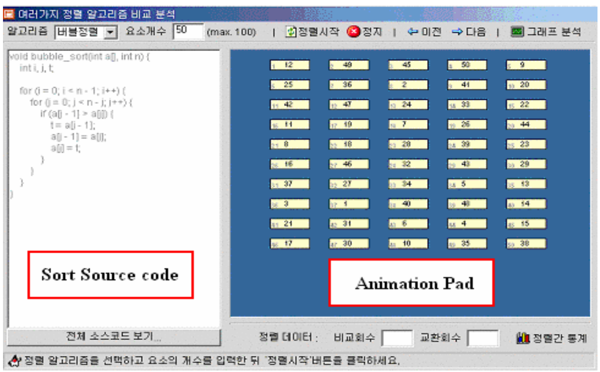

Fig. 18. Applet of sort learning algorithms

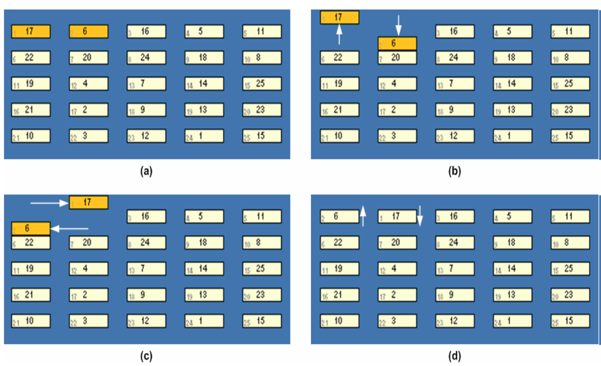

Fig. 19. A numeral pad animation process

A student selects sort algorithms at the applet tool bar, and inputs the units using a numeral pad. Then, the student clicks a sort start button, then the sort process ends.Between sorts, a code section shows that a sort source is now selected, as shown in figure 18, and creates a numeral pad animation. A source code section shows a red square, indicating the current line of source code. The light side of a numeral pad animation shows an image, as shown in figure 19. The sort animation process shown in the figure first changes the numeral pad into a heavy yellow(a), continuously moves vertically in space(b), exchanges a pad in (c), finally moves vertically, then the color of a pad changes into the original color(d).

The animation process, such as that of figure 20, shows how numerals are sorted. By contrast, the characteristics of sort algorithms can be analyzed through graph animations, such as figure 20. When the student presses the 'graphic analysis' button to see this sort process as a graph, a new frame window is created and the sort process is shown as an animated graph. Figures 20 shows examples., These are screens which display a bubble sort process.

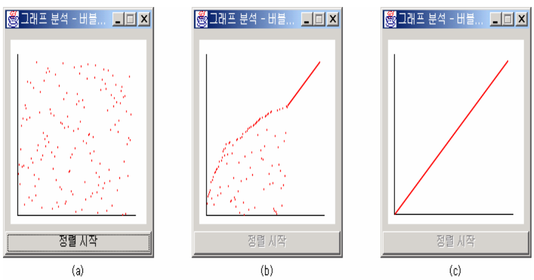

Fig. 20. Sort process graphs

The axis X is j and the axis Y is the value a[j]. (a) is the first stage, prior to sorting, (b) the halfway stage and (c) the final stage. We can see from the graph that the upper portion sorts quickly and the lower portion is sorting gradually. Thus, the time required for a bubble sort is very long because of the need to search for the maximum value and sort it imprecisely.

When the sorting is finished, two components of information appear in the bottom of the applet, as shown in figure 21. Students check how often values are compared in order to sort information, and how often values are exchanged. Then, this can be saved based on their sorts.

Data saved will be used later, with a measure comparing advantages and disadvantage of the sorts. For example, profitable algorithms are selected based on the number

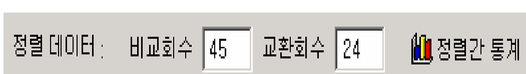

Fig. 21. Comparison of sorts and information window of the exchange times

of sorts and the states of the performed sorts. The student can study them to see when and how the most proper algorithm is applied.

3 Conclusion and Future Works

With the emergence of the web, learning can be done via indirect interaction between teacher and student, using multiple methods of communication free from constraints of time and space. Traditional learning methods are not needed because of the rapid development of computer networks. Students can easily use the internet for learning, whenever and wherever they choose. Much content to use the web is developed, and is from main teaching materials or secondary teaching materials. We developed content about how to use C language programming functions, quiz problems to check the concepts, statement understanding and a scenario to understand problems in depth by the visual expression of the algorithmic process. We created content about how to use the C language standard functions with only text, and how to use animations to include the phonetics of a language using flash. We created a scenario to enable students to understand concepts more easily, and changed it into animations. We made a quiz to check the level of understanding of C language statements. Students can study algorithms such that we implemented an action process, each a staged process, which can aid in understanding algorithms more easily. To handle content like this on web, we implemented with FLASH and JAVA.

A further extension of this study will be constructed by using multiple scenarios of algorithms, and implemented with applet and flash animations, to understand both the C language and algorithms.

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Introductory C Programming Language Learning with Game-Based Digital Learning

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Abstract. Educational game, motivates learners, is full of entertaining. Learners can practice and challenge themselves in an interactive game. In order to become formal tools in everyday teaching/learning process, we create Bomberman game which is included most concepts in introductory C programming language. It brings modern education concept in concert with the classical teaching and laboratory work. Learners can view the learning materials, reading/writing C codes, solving problems with C codes to control the movement of the Bomberman accompany with game music. Bomberman game combines continuous challenge, interesting storyline, fun and realism. This vivid learning environment can engage students spending their precious time for extensive practice since students have highly motivation to win the game. We hope that we have shown a new method for educational practice with game-based digital learning for teaching C programming course.

1 Introduction

Game-based digital learning (GBL) assists teachers use games to make learning fun and live up learning environment. Game-based digital learning applies competitive exercises, getting them to challenge themselves in order to motivate them to learn better even pitting the students against each other. In order to attract learners in GBL, learning activity often has fantastic characteristics and glorious treasure. Game and education is different. The instructor needs to make sure that learning the material is essential to scoring and winning in educational game. Why Use game-based digital learning? The reasons why we use game-based digital learning are learning motivates learners, learning more effectively when they immerse in the learning material and encouraging them learn from their mistakes. Amory et al. [1] tested first- and second-year university students play four kinds of games: an educational simulation game, a strategy game, a narrative-driven adventure game, and a first-person shooter. Students preferred the adventure and strategy games to the other games. The authors concluded that the most important elements which motivated the learners are logic, memory, visualization, and problem-solving. Lepper and Cordova [2] discovered that some games intended to be educational do not include useful learning. Game designer has to set the learning goals as necessary for winning the game otherwise the learning

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material would be neglected. Beck and Jacobsen [3] discovered that about half of the teachers are interested in trying games and simulations in class. More and more research focused on educational games ([1], [4), [5]). Game has potential to provide experienced platform, constructivist approach and learning behavior tracking environment. Learners are engaged with the learning material in game environment. Game-based virtual learning environments provide possible opportunities for learners to participate with authentic contexts while solving authentic problems [6]. Problem solving brings learners unique experiences which empower participants by providing learning opportunities. Some traditional teaching devices can't motivate learners [6]. Even e-learning provides less and less learning enthusiasm to learners.

The real issue of the first computer language is not what language to teach first but how to approach the teaching of the language [8]. The syntax and language constructs are really only a very small part of programming. The programming courses aim at building an effective foundation for the development of programming skills by emphasizing problem solving, logical thinking and programming process [9]. Problem solving and logical thinking involve a series of mental operations directed toward some goal [10] while programming process involves a series of computer operations. However, many students have become so weak in the development of learning strategies since their elementary education, especially for problem solving and logical thinking. Therefore, the challenge of the instructors faced is that a significant number of their students are not highly motivated to learn the programming language.

Computer games have become an integral part of the popular culture in modern societies. Moreover, "game-based programming" is the latest buzz word in the computer science educational curriculum. Research [11] shows that students today have a totally different way of learning – react more to interactive learning. If they are not entertained while they learn, the instructor has lost them. However, much of content that needs to be learned by students today lacks of motivation to them. The word "boring", "dry" and "too technical" often crosses their lips [12]. Finally, it leads to frustration. A good game helps students to enhance their learning techniques, such as learning by doing, learning from mistakes, goal-oriented learning, discovery learning, task-based learning, question-led learning, and etc [13]. Although game-based learning has been made a good progress in academic research [14], using computer games for educational purposes has been rather uncommon. Although learning by playing has been reported to education [15], nevertheless, it is still less popular in post-elementary education.

In this paper a new approach to the student activities that supplements the ordinary auditorium lectures is proposed. We apply a computer game, called Bomberman, to develop a C programming language course. Bomberman is a strategic maze-based computer game originally developed by Hudson Soft [16]. The original game was published in 1983 and new games in the series are still being published in this day. The current version is the fifth generation called "Bomberman Land". In this approach, students explore the problem in the form of games. The games-based approach provides an enriched interactive learning environment by asking students to come up with appropriate solutions to solve problems. The rest of paper is organized as follows. Section 2 describes how we teach introductory c programming language course in the past. Section 3 outlines the software design of the proposed Bomberman game-based teaching/learning tools. Section 4 shows some implementations of our tool. Section 5 compares our tool to other similar tools. Then, we conclude with discussion of current and future work.

2 Software Design

In order to design a flexible and practical architecture, we use web based server-client architecture. In Fig. **1.** System architecture, learners can access the learning and teaching tool from client. Server will collect learner's learning record after he/she complete the test. Learner may also see the learning progress from the web server. For the teachers, they may realize how many students are failed in the test to support learners some necessary teaching strategies.

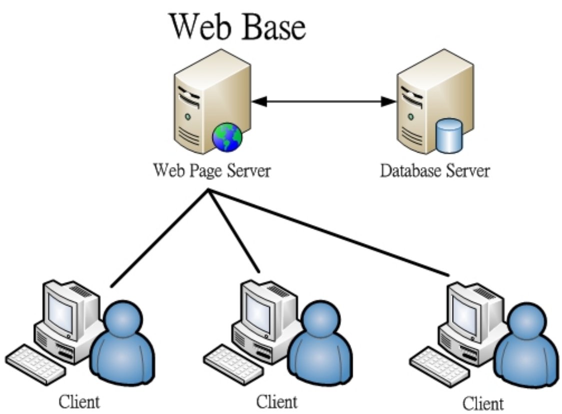

Fig. 1. System architecture

From the opinion of Din [13], a successful education game has the following five main factors:

(1) The game itself must be immersive.
(2) The playability of the game must be elevated.
(3) The game must be attractive, challenging, and competitive.
(4) The game should offer a goal or several goals for players to achieve.
(5) The game should allow players to track and manage their progress.

Based on the aforementioned characteristics and successful factors, we design our Bomberman teaching/learning tool. There are six components in the proposed tool shown as follows:

(1) Road Map – an overview of the teaching plan of selected chapters from the text book over the semester.
(2) Presentation – provide a platform for reading the teaching materials.

(3) Example – explore the fundamental programming paradigms through the demonstration of the Bomberman game.
(4) Exercise – structured lab works for students to practice the fundamental programming concept while playing the Bomberman game.
(5) Test – evaluate the learning result of students through problems solving while they are playing the Bomberman game.
(6) Progress Evaluation – report the achievement of students by comparing the benchmarks of participants' progress to point out personal learning developments.

2.1 Road Map

In order to give our students an overview of the programming course, we provide a road map as shown in Fig. 2. The "Road Map" component of the C programming teaching plan.

Each castle contains the course materials of a chapter to learn, examples to explore, exercises to practice and tests to pass. When the cursor falls at the castle, a window will be pop up to show the brief description of that chapter. When the student click the "Start" button, the sprite "Bomberman" starts to go forward to the next castle and experience the scenario of the next level if the student has already won the game in the previous chapter. Otherwise, it stays on the same place. If the "Bomberman" reach the exit, it means the student has gone through all chapters.

2.2 Presentation

We provide a function to let the instructor present the course materials in slideshow. The slideshow program was rewritten from the open source Jxpose [1818]. It is a presentation making software, a "Microsoft PowerPoint" like software written in Java. We have integrated the Jxpose software into our tool. If the student have entered the first castle in the aforementioned Road Map and then hit the left side "Presentation" button, then the slideshow of the first chapter course materials will be presented on the screen. It also provides a full screen show capability. Fig. **3.** The "Presentation" component" provides the slideshow functionality to demonstrate the C programming teaching material shows the slides of the chapter 1 prepared from our textbook [17].

2.3 Example

Examples can enrich the teaching contents and engage the learners. Since learning happens when learners work with the materials, we provide a platform to let students learn through example by reading (in this section) and writing new code (in the next two sections). The code is presented in the context of the game as a small piece of code that controls the movement of the sprite, "Bomberman". The success of the change is directly determined by the behavior of the sprite in the game world. Moreover, the examples and the exercise can ignite students in the habit of learner-to-learner interaction, collaboration and mutual assistance.

We supply a component 'Example' which involves two sub components: "Code Reading" and "Run" in our tool. Students can switch to another subcomponent by

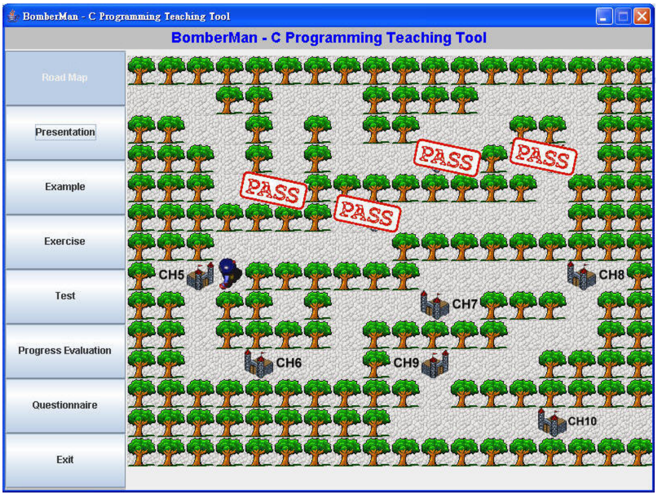

Fig. 2. The “Road Map” component of the C programming teaching plan

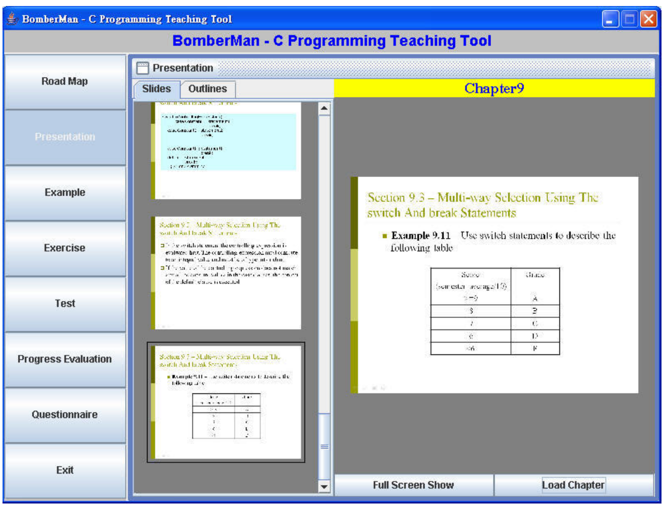

Fig. 3. The “Presentation” component” provides the slideshow functionality to demonstrate the C programming teaching material

selecting the tab of the sub component’s frame. In the ‘Code Reading’ sub component as shown in Fig. 4. We demonstrate the description of the example and the sample function written in C language that works for that example.

In the ‘Run’ sub component as shown in Fig.5, a “Bomberman” locates in the top left corner of a maze which consists of a grid of floors, blocks and trees. The walker “Bomberman” in the maze can only move into floor but not blocks and trees. The

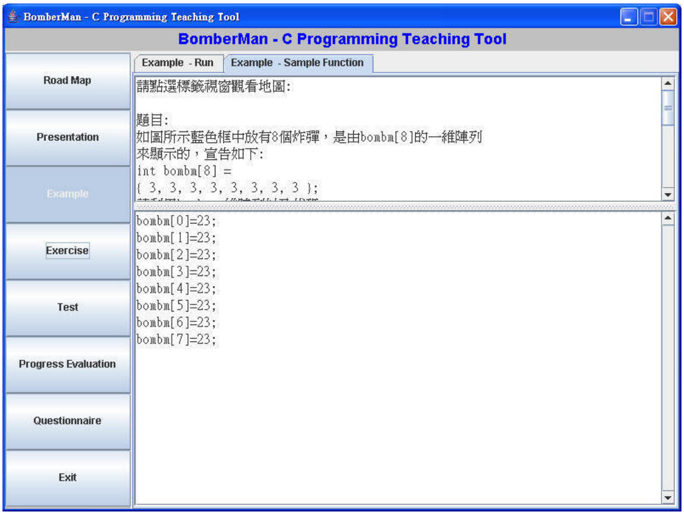

Fig. 4. The "Code Reading" sub-component of the component "Example"

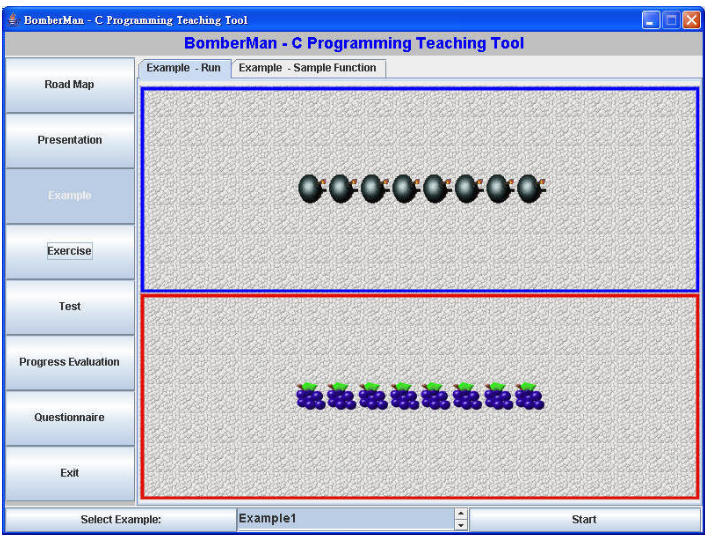

Fig. 5. The "Run" sub-component of the component "Example"

bottom left corner is designated as the goal to be reached to finish the example. Once the student click the "start" button, the bomber will start to walk according to the direction of the "moveit()" sample function. Apparently, the walker can reach the goal by continuously going down or going right if it can move forward. When the walker reaches the left corner, a popup window presents to notify the achievement. Then the walker stops at the bottom left location.

2.4 Exercise

The games-based approach enables students to tie in the design with coding. The game environment lets students practice skills in virtual scenarios. The drill-and-practice in computer games context may facilitate students to enhance learning and sustain interest for given topics over time. Running their "Bomberman" under control of their written code may enlighten their exercise desires. There are also two sub components of the "Exercise" component. Due to the restriction of paper length, we only show the "Run" sub component as shown in Fig. 6. In the "Edit/Compile" sub component, we provide the same layout as the "Code Reading" sub component of the "Exercise" component with four additional buttons. They are "Clear", "Load", "Save" and "Compile". "Clear" button clears the central scrollable text area that is used for coding. The "Load" button let students load any file with ".c" extension while the "Save" button let students save their written codes. The "Compile" button compiles the written codes in the central text area by Java C compiler (JavaCC) [19]. Once the student finishes the compilation, they can press the tab of "Run" sub component and give a trial. The "Run" sub component of the "Exercise" component is same as that of the "Example" component except that it has one more button to show the points that the student has gained. If we examine the two scenarios of Fig. 6. and Fig. 6., the difference is that there are some fruits located in the maze of Fig. 6.. The exercise requires students to write a "moveit()" function that not only can reach the bottom right corner but also can eat the fruits as many as possible. The exercises train students with the problem solving capability to further pass the evaluation in the "Test" Component.

2.5 Test

The "Test" component provides an excellent test bed for students. During testing, students construct their own knowledge by testing ideas and concepts based on prior

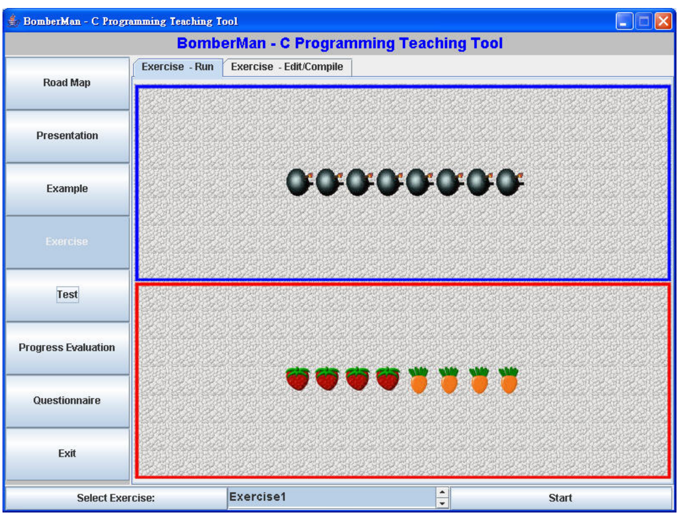

Fig. 6. The "Run" sub-component of the component "Exercise"

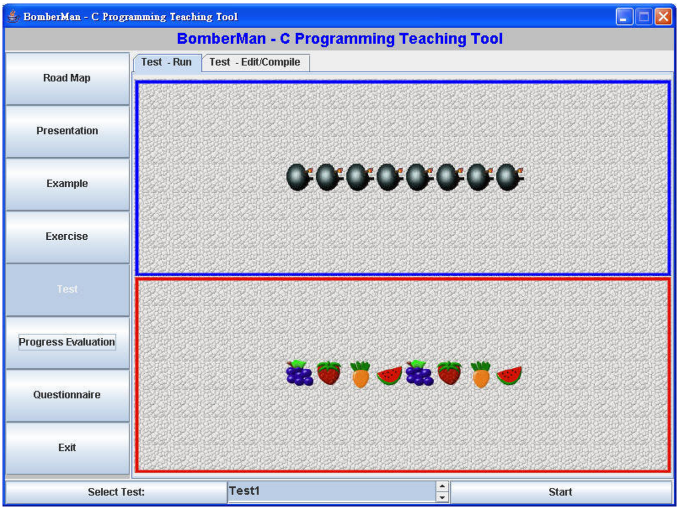

Fig. 7. The “Run” sub-component of the component “Test”

knowledge and experience in the “Presentation”, “Example” and “Exercise” component. By asking them to apply to a new situation, they need to integrate the new knowledge with their pre-existing intellectual constructs to solve different problems of the topics in the chapter. However, students can test their programs simply by clicking a button. The “Test” component is the same as the “Exercise” component except that it has a timer to log the elapse time for each testing question. Certainly, the testing questions are different from the exercise. They are more difficult and more exciting. Due to the restriction of paper length, we only show the “Run” sub component as shown in Fig.6 and Fig.7. The test requires students to write a “moveit()” function that not only can reach the bottom right corner but also can eat the fruits as many as possible. However, the “Bomberman” cannot touch any bombs. Otherwise, the bomb gets blown up with a great sound and the game is over. Students are then required to revise their written programs in the “Edit/Compile” sub component.

2.6 Progress Evaluation

Progress Evaluation collects information to determine what the impacts of the tests are on students at various stages of the intervention. By measuring the correctness and the time spent for each test question of each student, we can show a ranking report by using JFreeChart [20] package to encourage or to warn the student about their ranks. Students with poor ranks are required for extensive practice. A sample progress report of a student is shown in Fig.8. The report shows the number of trials ranking of the tester. The red bar means that the tester got a failure in that problem. Learners can view the report with internet browser.

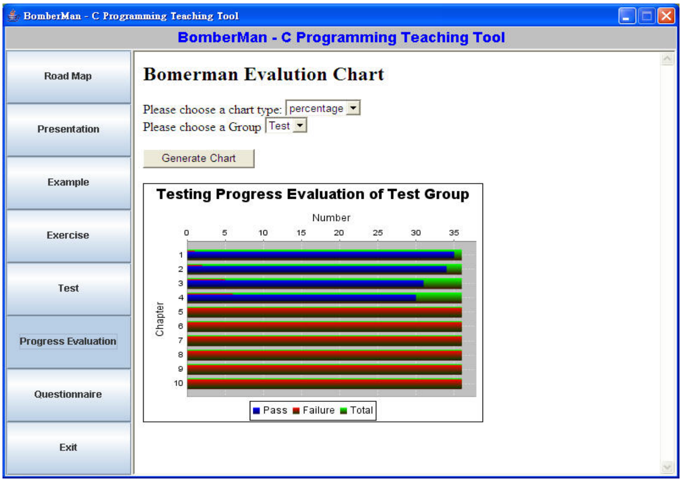

Fig. 8. The ranking report generates from the component "Progress Evaluation"

3 Comparison

Our tool has some elements that are superior to other similar tools. According to this approach, we address eight different aspects to compare to other tool:

(1) Interactive: There are interactive elements in the tool, for example, the tool will accommodate some feedbacks with Students when learning time.
(2) Amusement: There are animations, games, music and other entertainment effects in the tool, for example, user can create animations.
(3) Easy to use: There are obvious and plain buttons in the using environment.
(4) Using official program language: The tool is using the traditional program, for example, C language.
(5) Evolutionary learning mode: The tool can offers learning step by step, for example, differ degree of difficult course can be designed in the tool.
(6) Census analysis: The tool offers statistic and analyze Learning records when students are learning than show by statistical chars, for example, ratio of students passing through the test.
(7) Combine with teaching materials: There are some documents or teaching materials integrates in the tool, for example, ppt files can be presented in the tool.
(8) Storyline: The tool combine the question of real life with material, for example, designed the exercise that student need to count the correct fruit price.

Following these topics, we compare our developed tool to traditional tool and Scratch [21] tool as show in Table1. The traditional tool is so called the IDE (Integrated Development Environment) has a low degree of interactive and a low degree of amusement because it lacks edutainment sectors. Otherwise, it is hard to use in virtue of complicated editorial functions. We compare some programming tools, such as Turbo C, Bloodshed Dev-C++, Microsoft Visual C++ and C++ Builder.

On the contrary, our tool and Scratch tool have a high degree of interactive, a high degree of amusement and a high degree of easy to using. Scratch is not designed for a college student to studying because it is not using an official program language. Additionally, it has not offers teaching materials so that teachers need to prepare the materials by themselves. Our developed tool has two additional merits. One is the tool has tree differ degree let student can learning in proper sequence and the other is that the tool offers census analysis. Teachers can adjust teaching speed in terms of viewing the statistical chart that provides some useful information.

Table 1. The comparison with other similar tools

	Our tool	Scratch tool	Turbo C	Dev C++	Visual C++	C++ Builder
Interactive	High	High	Low	Low	Low	Low
Amusement	High	High	Low	Low	Low	Low
Easy to use	High	High	Low	Low	Low	Low
Using official program language	Has	Has	Has	Has	Has	Has
Combine with teaching materials	Has	NONE	NONE	NONE	NONE	NONE
Evolutionary learning mode	Has	NONE	NONE	NONE	NONE	NONE
Census analysis	Has	NONE	NONE	NONE	NONE	NONE
Storyline	Has	NONE	NONE	NONE	NONE	NONE

4 Conclusions

In this paper, we provide a game-based teaching and learning platform for teaching introductory C programming language. Bomberman game supports learning concept of C programming language and teachers can build a meaningful game environment to specify the sequence of topics for students to learn. Furthermore the difficulty of integrating the real world learning topics into the Bomberman game has been addressed by “codes injection” and “dynamically class reloading”. We have shown an alternated path for educational practice with computer games for teaching C programming course.

Acknowledgements

We would like to thank National Science Council and Chung Hua University. This research was supported in part by a grant from NSC 96-2520-S-216-001 and CHU 96-2520-S-216-001, Taiwan, Republic of China. This paper owes much to the thoughtful and helpful comments of the reviewers. At last, we would like to thank Dr. Wai-Tak Wong for his encouragement and guidance throughout this project.

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Interactive Video Game Platform for Game-Based Learning

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Abstract. Interactive video technologies are developed for providing interactions for users to get better interactivity in watching TV programs. Since receiving TV programs is a common affair for general users, many systems with interactive TV technologies are implemented for educational or commercial purposes. Learning by playing game is a hot topic in current distance learning systems. Most of game-based learning systems designed by computer programmers and domain experts. Generating interactive game courses is hard for content providers since they are not computer experts. The interactive game authoring tool proposed in this paper provides a friendly interface to help users to create their educational games easily. The students will be attracted in such learning platform with entertaining elements.

Keywords: We would like to encourage you to list your keywords in this section.

1 Introduction

There are many e-learning systems proposed in various field. Some game-based learning systems have been also implemented in recent years for motivating the students to enhance the learning performance. Video game is an effective factor to attract the students' attention. The traditional game-based learning systems integrate learning materials into video games. There are many types of game implemented in such game-based learning systems. Most of these systems require programmers and specified domain experts to design games with adequate contents together. It is necessary for developing a video game-based learning system with powerful content authoring tools to help the content providers to generate gaming content for educational purpose.

The purpose of this interactive video game-based learning system is to provide a friendly interface such that the general users can produce their own video games with educational elements. Comparing with the proposed game-based learning systems, the interactive video system for game-based learning provides a flexible interface to generate interactive video games with unspecified contents. The content providers can produce educational games without understanding details of computer graphics, video and even flash technologies.

F. Li et al. (Eds.): ICWL 2008, LNCS 5145, pp. 232 – 240, 2008.

2 Related Work

There are many systems about interactive TV proposed in recent years. Most of them are PC-based systems; the developers implemented these systems by integrating network, video encoding and transmission technologies. Various devices are adopted to provide manipulation to audiences. Remote control, PDA, tablet, keyboard and mouse are used for delivering the control made by users. Some game-based learning systems are also implemented to help students in learning concepts in various domains. Most of these systems are web-based; students can easily access these resources via network. In the follow sections, interactive video and game-based learning issues will be fully discussed.

2.1 Interactive Video Technologies

Technologies are widely applied to enhance the relationship between users and video. There are many video systems including interactivity features proposed in recent years. Hypervideo, interactive video and augmented video are used for naming such systems and technologies. The basic idea of interactive video is to provide more complex operations and feedback to users.

Video annotation systems using different techniques are introduced in some proposed systems. Annotations composed of texts, images, audios can be added in video segments. Video segmentation can be done by algorithms or human operations. With tags or metadata informs of XML or html format, videos with interactive elements can be presented to users. There are various scenarios generated by these authoring systems. With adequate properties, users can easily handle video segments. They can also retrieve target video scenes by filtering comments of segments. Such systems have enhanced impression and interest of users. Users can acquire different experience by using such interactive systems.

Besides these proposed systems, there are also interactions defined in various standards like MPEG-4 and MHP (Multimedia Home Platform). In MPEG-4, everything is considered as an object. By technologies of video tracking, objects can be separated from frames in video. Video producers can arrange properties for these objects and try to provide interactions to users. MHP is a middleware defined by DVB (Digital Video Broadcasting). It is used for providing interactive functions to people who watch digital TV programs. Applications and products implemented according to these standards provide choices of interactions to users in different platforms. Whether in PC, TV or other portable devices, users can access video materials with interactive operations.

2.2 Game-Based Learning Systems

Many game-based learning systems are implemented for helping the students to focus on the learning material. The students can get experience from making interaction with objects in the game-based learning platform. Comparing with the traditional e-learning systems, game-based learning systems provide more attraction to the students.

Games can be classified into several categories: action, strategy, role play and adventure games. There are different features and characteristics in such kinds of games.

In the proposed interactive video game-based learning platform, the design concepts of adventure games are adopted to construct the game platform. The most important idea in adventure game is, the players find clues and try to solve problems by exploring a specified scenario and investigating objects there. According to this mode of game play, video is used for scenarios and the interactive objects provide players to get experience by examining and operating them.

3 System Architecture

In the interactive VGBL platform, there are three major components need to be provide to help design games and integrate educational materials with it. Interaction, knowledge delivering and rewarding should be included in the VGBL game authoring tool and runtime environment.

3.1 Interaction Design

Interaction is the most import part of a video game. The interactions in games provide means to players to change states in game play. The players can get information from scenarios by making interactions and triggering events. There are different interactions and devices in various games. Without much difference from other adventure games, mouse and keyboard are responsible for delivering users' interactions to the interactive VGBL runtime environment.

Players can examine and move objects in a scenario by clicking or holding their mouse keys. Like ordinary adventure games, the players have a backpack to collect items in game. An inventory window is used for displaying what items the player owned. The players can get theses items from a scenario and use them in an adequate scene to trigger events. Interactive objects in video provide information to players. Users can get descriptions when they try to examine these items. There are also non player characters to give fixed conversation to guide players.

3.2 Relationship between Interaction and Knowledge Delivery

The ultimate goal of game-based learning systems is to deliver knowledge to students. Actually, it is not easy to design games with educational materials. Course designers can produce scenarios by shooting videos and defining relationship between objects in it. By creating interactive objects and setting the events, the designers provide means to players and deliver knowledge in the process of solving a problem. For an example, in a classroom in game, the NPC told players a computer was not worked and order players to fix it. Players examine the computer in video first and find a broken component inside. Finally, players move to another scenario, markets, to get the components they needed and return to classroom and fix the computer.

Students can obtain knowledge from the process of making decision and interaction. In the example, students get the instruction first, and then find the problem by investigating objects in game. Students will get different feedback after they install components into the computer by the content providers' authoring.

3.3 Rewards to Users

Rewarding for students is an important factor to motivate them to participant such games. Like general games, the rewarding mechanism is also applied in the platform. Players can get bonus if they make the right decisions which the content providers set in the authoring system. In this section, real rewarding is not discussed here because the lecturers will decide how to reward students themselves. In the interactive VGBL platform, some objects are considered as rewards. If players complete some requests or missions, they can get special objects in the inventory windows. Such objects differ from other interactive ones in scenarios; they represent the achievements which players have. The courses designer can motivate players to collect such objects by providing bonuses or other kinds of interaction.

4 Implementation

We have implemented an authoring tool to generate interactive video games for educational purposes. There are several subsystems implemented as follows:

4.1 Scenario Editor

Designing a game is not easy task for general users. The scenario creation is one of the most challenging parts of designing games. We try to use video segments to

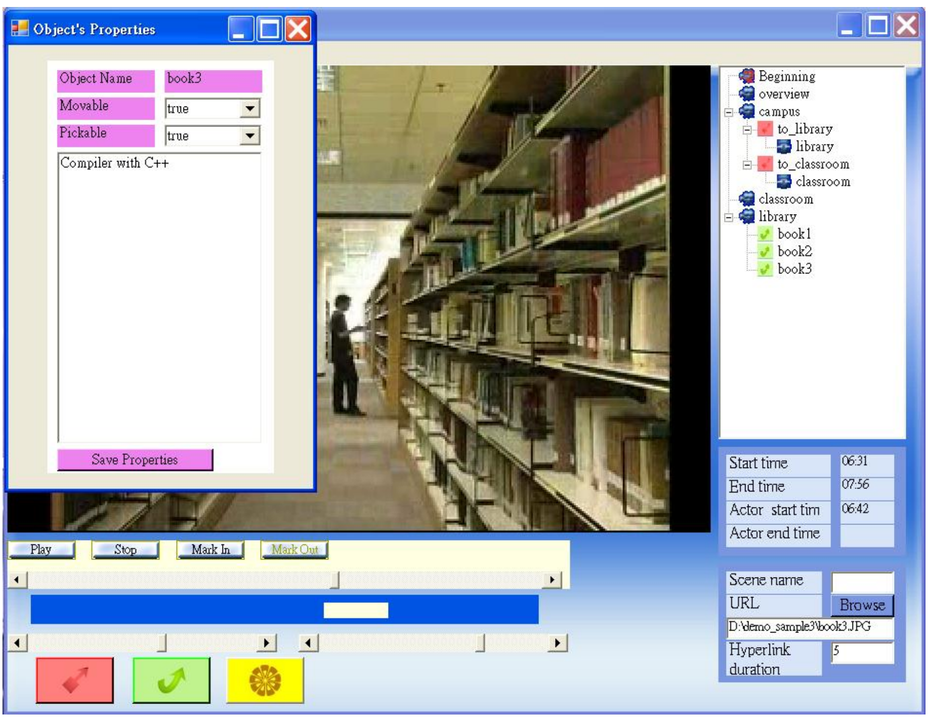

Fig. 1. The interface of interactive VGBL authoring tool

replace 3D scenarios because they are easy to produce. The users just need to select video files from network or video cameras such that video can be divided into scenario components by the authoring tool.

Figure1 illustrated the interface of the interactive VGBL authoring tool. Courses designers can also insert objects like buttons and images in the authoring tool.

4.2 Object Editor

The other important component of the authoring tools is the object editor. Image objects are mounted on a video scenario. The interactive object plays an important role in the interactive video game-based learning system. The users can make interactions with theses interactive objects to trigger corresponding events. An object editor is implemented for such requirements. Users can set the properties and events of objects in video and produce adequate feedback when users' trigger them.

4.3 Gaming Platform

A runtime environment is also implemented for users to participant the games. The gaming platform is an augmented video player with the interaction functionalities. The users can manipulate the avatar in a game scenario and make interactions with the interactive objects.

Fig. 2. An example of learning scenario

Interactive video technology is used to generate feedbacks to the users. By making corresponding interactions, the scenario changes and interactive objects pop out. With such environment, students would be interested in the contents and get concepts from the game play.

Figure2 shows an example of learning scenario in library. Three image objects are mounted on the video frame. Players can examine theses books by clicking them or drag them to inventory window. In this learning scenario, users may be assigned a task to find an adequate book to be a reference for his homework. Users need to select one of these books to complete the assignment. In the library, user can access information of these books and drag the appropriate one to the actor bounded in the red box.

5 The Scenarios

In this section, two scenarios are designed for evaluating the proposed platform with users' experience. These two scenarios are described as follows:

Interaction with keyboards and mice:
It is composed of a video scene of an English tutorial TV program. This program is a little complex in its structure. There several parts like conversations, grammars explanation, vocabularies explanation and reviews. In this scenario, a user use keyboards and mice to access texts, images, web pages and video scenes with arranged hyperlinks.

Interaction with interactive objects:
This scenario is different from last one mentioned above. A video scene for campus tutorial is presented to users. The scene begins at a building of campus. There is an actor in the scene and users can use different interactive objects to switch to next video scenes. Two interactive objects are presented in this video scene: baseball glove and basketball. If users drag and drop one of these interactive objects to actors, video scene switches will be triggered. For an example, if users choice the baseball glove, a video scene of baseball game with the actor will be presented. Otherwise, if the basketball is selected, a scene with basketball game will be played after the beginning video scene.

6 Experimental Results

A questionnaire with twenty questions for these four scenarios is used for evaluating the proposed platform. Every question in the questionnaire is an affirmative sentence. There are five options to user for every question: 5. strongly agree; 4. agree; 3. neutral; 2. disagree and 1. strongly disagree. All of these questions are listed below:

Interaction with keyboards and mice:

1. It is convenient for using mice to select objects
2. Structural video courses help me to understand learning contents.

3. Accessing web pages by interactive objects helps me to understand learning contents.
4. Accessing images by interactive objects helps me to understand learning contents.
5. I am satisfied with time of switches between video scenes and other media.

Interaction with interactive objects:

6. I can select objects what I am interested in easily.
7. The interactive objects of baseball glove and basketball are easy to understand.
8. Interactions by drag and drop are intuitional.
9. Web pages of campus help me to understand the campus.

In a class of basic computer concepts, we have totally 111 students to answer questions listed above. Table 1 shows the distribution from the highest score to the lowest one. The row of AVG shows average for each score level of questions. The row of STDEV shows standard deviation for all score levels. Table 2 shows the same results with percentages. Table 3 shows the results with accumulated percentages.

Table 1. Scores of questions

	score					
question	5	4	3	2	1	SUM
Q1	28	51	21	6	3	109
Q2	11	67	27	4	0	109
Q3	9	54	42	4	0	109
Q4	14	58	31	5	1	109
Q5	8	50	36	13	2	109
Q6	20	49	27	9	4	109
Q7	15	52	28	10	4	109
Q8	18	42	40	8	1	109
Q9	14	60	25	9	1	109
AVG	15.22	53.67	30.78	7.56	1.78	
STDEV	6.18	7.23	7.10	3.05	1.56	

According to experimental results in the table3, the better parts and worse ones can be distinguished. We take option 4 as a threshold to determine which parts are satisfied to users or not. In the third column of table3, percentages of users which select agree and strongly agree options are shown. The best two questions are Q1 and Q2. The results indicate users agree that the system is convenient and helpful. The worst

Table 2. Scores of questions with percentage

	Score					
Question	5	4	3	2	1	SUM
Q1	25.69%	46.79%	19.27%	5.50%	2.75%	98.20%
Q2	10.09%	61.47%	24.77%	3.67%	0.00%	98.20%
Q3	8.26%	49.54%	38.53%	3.67%	0.00%	98.20%
Q4	12.84%	53.21%	28.44%	4.59%	0.92%	98.20%
Q5	7.34%	45.87%	33.03%	11.93%	1.83%	98.20%
Q6	18.35%	44.95%	24.77%	8.26%	3.67%	98.20%
Q7	13.76%	47.71%	25.69%	9.17%	3.67%	98.20%
Q8	16.51%	38.53%	36.70%	7.34%	0.92%	98.20%
Q9	12.84%	55.05%	22.94%	8.26%	0.92%	98.20%
AVG	13.97%	49.24%	28.24%	6.93%	1.63%	
STDEV	5.67%	6.63%	6.52%	2.79%	1.43%	

Table 3. Scores of questions with accumulated percentage

	Score				
Question	5	4	3	2	1
Q1	25.69%	72.48%	91.74%	97.25%	98.20%
Q2	10.09%	71.56%	96.33%	100.00%	98.20%
Q3	8.26%	57.80%	96.33%	100.00%	98.20%
Q4	12.84%	66.06%	94.50%	99.08%	98.20%
Q5	7.34%	53.21%	86.24%	98.17%	98.20%
Q6	18.35%	63.30%	88.07%	96.33%	98.20%
Q7	13.76%	61.47%	87.16%	96.33%	98.20%
Q8	16.51%	55.05%	91.74%	99.08%	98.20%
Q9	12.84%	67.89%	90.83%	99.08%	98.20%
AVG	13.97%	63.20%	91.44%	98.37%	98.20%

two questions are Q5 and Q8. Users are not satisfied with time of switches between video scenes and other media, the delay may be improved for better using experience. Q8 indicates the drag and drop operation are not intuitional enough to users. Meaningful interactions are required for combining users and learning scenarios. The average of the 9 questions higher than score 4 is 63.20%, it means over 60% of users agree the performance of the learning platform.

7 Conclusion

A platform use interactive video technologies is implemented to design video games for educational purposes. Courses designers can easily produce contents with game factors by this authoring tool. Video segments are used for scenarios in the VGBL platform. These scenarios can be generated by cutting from films. Comparing to 3D scenarios, it's a cheaper way to produce game scenarios. Players can make interaction with objects edited by the authoring tool and get feedback or switch to other scenarios. Playing such games is attractive to students. Students can get experience and knowledge by making interaction and decisions in game play.

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Developing the Historical Culture Course by Using the Ubiquitous Game-Based Learning Environment

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Abstract. With the advance of information technologies, it is much easier to provide and construct various powerful e-learning platforms. Nevertheless, such kinds of e-learning platforms are available worldwide, but the percentage of using these platforms is still unsatisfactory. The main reason lies in the learning content and learning activities couldn't attract learner. Accordingly these e-learning platforms are not able to fit the needs of either learners or instructors. In this paper, we proposed an integrated learning environment called U-GBL (Ubiquitous Game-Based Learning) system. We used the technologies in interactive video, GPS (Global Positioning System), GIS (Geographic Information System) and RFID (Radio Frequency Identification) to construct the interactive game-based learning environment. Learners could utilize PPC (Pocket PC) to have the game-based learning activities anytime and anywhere. And we also demonstrated an example of the historical culture course content to explain the gaming scenario in our learning environment. We hope this U-GBL learning platform could help to enrich the learning motivation and to improve the learning efficiency.

Keywords: GBL, Ubi-Media, Game Design, Game Authoring Tool.

1 Introduction

Nowadays, more and more researchers have discussed on how to make e-learning systems more powerful and practicable. One essential issue lies in the attraction of learning content [1, 2]. They pointed out gaming implied some important elements, such as mission challenge, rewards and various fantasy content styles, to improve the learners' learning motivation. Another work [3] examines the behavior between gaming and learning. And they found the learning course combined with game elements will be helpful for learners to achieve the course objective quickly. In [4], the authors proposed a game style learning content on learning program language. By using password game, jigsaw puzzle game and random number game styles, they tired to train the learners' programming logical thinking and work flow control.

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Moreover, with the maturity of ubiquitous multimedia technologies, such as GPS (Global Positioning System), GIS (Geographic Information System) and RFID (Radio Frequency Identification) technologies, the location-based information is easier to acquire, such as the position of a particular event and the related information. Such information could be referred while making some content-aware decisions. Some researches claimed that this kind of learning style will be helpful for improving learners in mind thinking, memorizing and understanding of learning contents. If we could combine the ubiquitous multimedia technologies to enrich the learning motivation, it would be a great help to improve the learning performance in such learning environments. For instance, the works in [5] and [6] utilized GPS/GIS and RFID technologies with mobile device to construct a language learning system with context-aware concept. Such systems are based on mobile device system using the GPS/GIS and RFID to calculate learner's indoor position. In gaming phase, learners could collect the data for assigned missions via mobile devices in any particular position. The objective of this system targets at letting learners solve problem in their daily-life by utilizing the knowledge learned in school to. In [7], the authors utilized the mobile devices, RFID equipments and ubiquitous learning processing technology to construct the ubiquitous learning environment. Learners could have learning activities indoors and outdoors. The mProducer system proposed in [8] aims at building the personal experience datasets by using the mobile device, GPS and video processing technologies. Another work stated in [9] introduced the location-aware concept gaming model by using the mobile device, wireless and GPS technologies. In [10], the authors proposed the TIP (Tourist Information Provider) system by using the mobile device and GPS system. It provides the travel related information to users. In [11], the authors proposed a prototype model of M-learning. Some significant points for learning content design, learning portfolio design and learning target setting. In [12], the authors proposed the AR (Augmented Reality) simulation gaming system which utilized the mobile device and GPS system. This system is called Environmental Detectives, and its target focuses on water pollution. Team Learners could investigate the status of the water pollution in a particular place and try to find out the possible solution. Another gaming system is proposed in [13]. The authors proposed the BuinZoo game-based learning system which utilized the mobile device and the map system. Learners could learn the evolution of creatures by observing and affecting the evolution process. In [14], the authors indicate the concept of mobile gaming environment in the future. The system integrates the AR and MR (Mixed reality) human interaction architecture which utilizes the mobile device, GPS system and RFID technology. Gamers could do the gaming phase impressively in the real environment by interacting with other gamers.

According to aforementioned research, we would like to build an integrated learning system which allows learners to learn by gaming. Our proposed learning system utilizes the mobile technologies to provide more efficient game-based learning environment, and we called this integrated learning system as U-GBL (Ubiquitous Game-Based Learning) system.

The remainder of this paper is organized as follows. In Section 2, we will illustrate our U-GBL system architecture and its work flow. The related system modules will be demonstrated in Section 3. In Section 4, we will introduce the sample of the game content. In Section 5, we will introduce how to design the course assessment content for our U-GBL system. Finally, the conclusion and the future work are shown in Section 6.

2 U-GBL Environment and Workflow

Our proposed U-GBL system architecture includes three main elements, the authoring tool, the learning management system (LMS) and the game server. Instructors could design the game course content with the authoring tool. After finishing the game course editing, the related course will send to the backend LMS. When learner utilized PPC (Pocket PC) to get the connection from the game server, the server will connect to the LMS to get the learner's learning portfolio. Then related course material will be loaded by game server for game course deployment. At last, learners could enjoy or continue the game-based learning activities.

Our U-GBL environment overview concept is illustrated in Fig. 1. Instructors could utilize the predefined templates to design the interactive video course, and put game elements in any particular video segment. These elements are comprised of normal and hidden game elements. The normal game elements are mainly presented in game mission mode to delivery some important concepts to learners. The hidden game elements represent some integrated key points for rewarding. Those integrated key points might be some particular normal game elements and some particular key values, such as the position information stored in a RFID tag. Course designers could setup these RFID tags to make learners to do their learning activities. The system work flow is shown in Fig. 2.

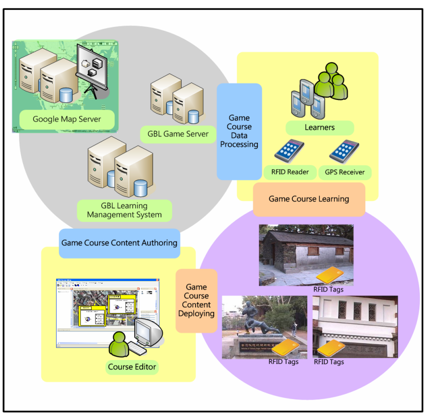

Fig. 1. U-GBL environment overview

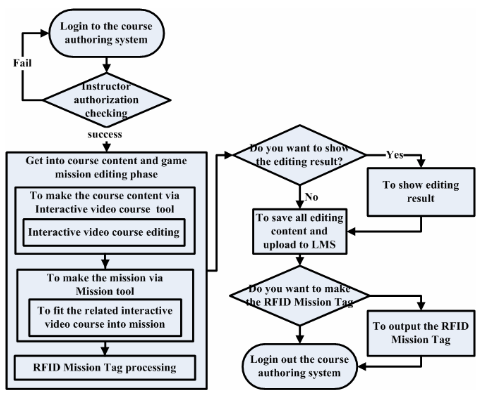

Fig. 2. Game Authoring Workflow

Learners could start their learning activities in the game lobby by selecting the interactive video course they want. After course finished, some hidden game mission will be available in screen. LMS will record the status and assign these hidden game missions to the learners. Learners could utilize the PPC to get these game mission data and continue the game mission solving progress. Learners could utilize the GPS/GIS functionalities to ensure the right gaming route, and use the RFID reader to start a particular game mission. When they finished all assigned missions, they are able to unlock other hidden game missions and related game elements. The related work flow is shown in Fig. 3.

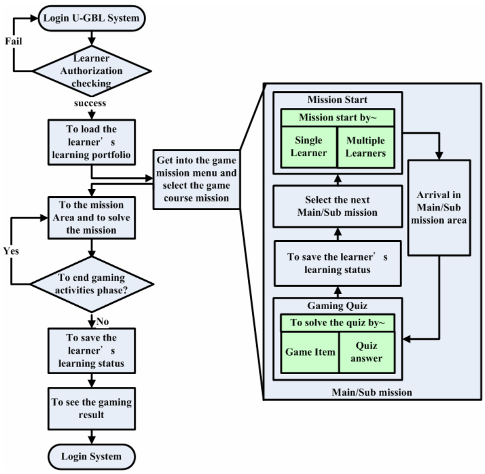

Fig. 3. Game Course Learning Flow

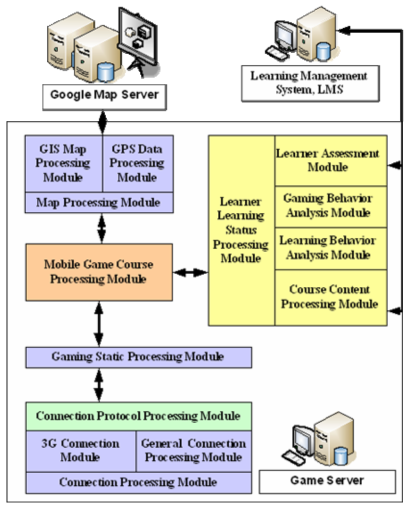

Fig. 4. Game server architecture

3 U-GBL System Modules

In this section, we would like to illustrate the system modules in mobile client, game server and authoring tool, respectively.

3.1 Game Server Modules

Fig. 4 shows the sub-modules of Game server as described below.

- *Connection Module* is responsible for wireless connection processing and normal connection processing.
- *Connection Protocol Processing Module* is responsible for the pre-processing of data connection protocol, as well as for the transferability of data format between wireless connection mode and normal connection mode.
- *Gaming Static Processing Module* focuses on managing the transmission data format and transmission mode.
- *Game Course Processing Module* applies to integrate and manage all data for the map processing module, learner's learning status processing module, course content processing module and gaming status processing module.

- *Map Processing Module* processes the related course and geographic information. It uses the feedback data from the GPS Data Processing Module and GIS Map Processing Module to present the related geographic information data. GPS Data Processing Module focuses on processing the GPS data from the mobile client, and sends specific GPS data to Map Processing Module. GIS Map Processing Module uses the GPS and related gaming data to make request command and send this request to GIS server.
- *Learner's Learning Status Processing Module* serves the management of learner's learning status and assessment. It utilizes the integrated feedback data from the Learner Assessment Module, Gaming Behavior Analysis Module and Learning Behavior Analysis Module. Learner Assessment Module focuses on learning assessment. Learner's learning status data could be loaded and processed from LMS by Learner's Learning Status Processing Module. Then, Learner Assessment Module could get and process the learner's learning status data from Learner's Learning Status Processing Module, and restore these data in LMS. Gaming Behavior Analysis Module focuses on managing the learner's gaming activities. Learning Behavior Analysis Module processes the course learning status and result. Learner's Learning Status Process Module integrates and processes the data form the Gaming Behavior Analysis Module and Learning Behavior Analysis Module. Finally the Learner Assessment Module serves the assessment analysis and stores the result in LMS.
- *Course Content Processing Module* focuses on content package compressing and decompressing.

3.2 Authoring Tool Modules

The Authoring Tool Modules aims at generating the Ubi-Media course content. Some important sub-modules are shown in Fig. 5as illustrated below.

- *General Connection Processing Module* manages the data connection.
- *Game Course Combined Module* manages the course format checking and data compressing.
- *Video Course Edit Module* is responsible for managing and providing the interactive game elements, puzzle style and game mission content.
- *Video Game Course Edit Module* integrates the Adaptive User Interface Presentation Module and Video Course Edit Module to provide the adaptive learning content editing interface for course designers.
- *Assessment Rule Edit Module* manages and provides the assessment rules.
- *RFID Tag Edit Module* focuses on course information processing, data checking and accessing.
- *Map Mission Edit Module* processes the mission data. RFID Tag Edit Module could produce some related RFID data and put them into the RFID tags. The processing results provided by Map Mission Edit Module and RFID Tag Edit Module will be integrated by Video Game Course Edit Module.
- *Adaptive User Interface Presentation Module* provides the adaptive authoring interface according to the preferences of course designers.

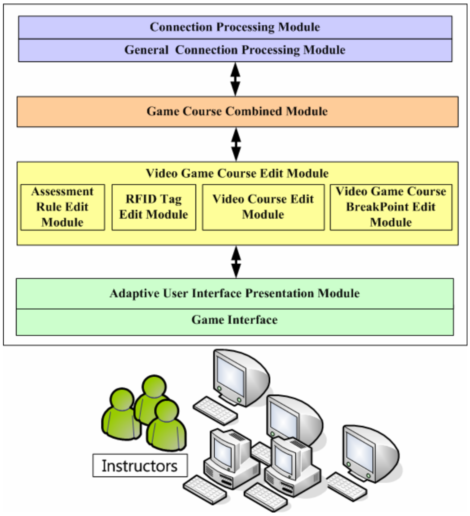

Fig. 5. Authoring Tool modules

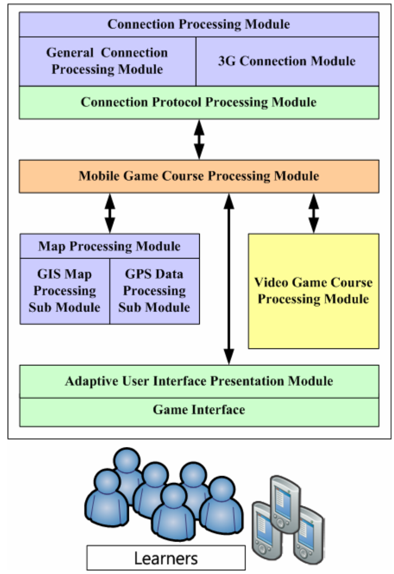

Fig. 6. Mobile client modules

3.3 Learning Client Modules

Learning Client Module can be considered as the gaming platform for learners, and some important modules are shown in Fig. 6, and related descriptions are discussed as follows.

- *Connection Module and Connection Protocol Processing Module* is similar to Backend Server Connection Module mentioned in the previous section.
- *Game Course Processing Module* presents and manages the learning and gaming status.
- *Map Processing Module* is responsible for map information processing, and coordinates with GPS Data Processing Module and GIS Map Processing Module. GPS Data Processing Module analyzes the GPS position and sends the dataset to GIS Map Processing Module to make the formal command request. And finally, Map Processing Module will send the formal request to game server and wait for the response from the backend server.
- *Video Game Course Processing Module* serves the course decompressing, processing and presenting.

4 U-GBL Game Content Design

In this section, we would like to introduce the course content for suitable game activities in our U-GBL environment. The related subjects are described in Table 1.

Table 1. Game Mission Design

Course Type	Local history and culture are involved.
Course Objective	Understand the local history and culture in real gaming activities in order to improve the impressions of learning content.
Learner Type	Normal Learners.
Prerequisite knowledge	Being familiar with manipulating mobile learning devices.
Learning portfolio record mode	Utilize the GPS and RFID positioning technologies to manage the learning path and related learning status.
Main game mission	To identify the celestials of "happiness", "fortune" and "health" as shown in Fig. 7.
Sub game mission	To identify the roofs according to the elements in Chinese cosmology

In game mission designing phase, according to the course content type, learners should utilize their live observation to learn the course content to improve the learning efficiency in remembering, understanding and comprehending. Accordingly in game missions designing phase, we have to consider some properties of game mission as shown in Table 2.

Table 2. Game Mission Properties

The key of main items	Mission properties descriptions
Course subject	■ Course content: The historic monument, representative vision, natural landscape, geographical features of a place and language could be a candidate for being a course content.
Mission types	■ Main Mission (Default): To arrange the main game plot. ■ Sub Mission: To arrange the sub game plot.
Learning activity types	■ Collaborative learning style (Default): To cooperate with other team in order to get the mission reward point together. ■ Competition learning style: To contest with other team in order to get the mission reward point respectively.
Techniques used	■ Technologies operation training: Such as photographing, post processing and manipulating system by using PPC are involved. ■ Relationship and team work abilities: Learners can talk to related people in order to get the related hint information. ■ Language: To utilized particular language to talk to related people in local location.
Cognitive Layer	We utilized the two-way specification table proposed by [15]. ■ Cognitive process dimension: Comprised of six items, including Remembering, Understanding, Applying, Analyzing, Evaluating and Creating. ■ Knowledge dimension: Comprised of four items, including Factual knowledge, Conceptual knowledge, Procedural knowledge and Meta-cognitive knowledge.
Knowledge of course content	The course content contains cross-domain knowledge that not only exists in one particular book but also in multiple books. This Field will record the related particular book content and chapter.

Table 2. *(continued)*

Learners Amount	Due to the limitations on location and learning effect, the amount of learners should be around 3 to 9 people. The default value is set to 3.
Mission Time	The total time for gaming activities.(10 minutes as default)
To prompt the end time of game mission	To give a hint before the end of game mission. (5 minutes as default)
Mission Points	The points for each solved game mission. (10 Points for each mission as default)
Mission Time Period	The suitable time period for missions.
Mileage	Each processing unit is measured in meters. (50 meters as default)

We will give the game mission design example as follows.

(1) Main mission design: At Danshui Zushi Temple

The celestials of “happiness”, “fortune” and “health” in many Chinese temples stand for blessing, wealth and long life respectively. Fig. 7 shows a main mission to photographic the celestials of “happiness”, “fortune” and “health” in order and to send these photos back to the game server.

a. Mission workflow:
- Learning prerequisite knowledge: The prerequisite knowledge might be getting familiar with the manipulating of camera, GPS and related device. It also contains the background knowledge for the mission and related software functionalities.
- Objectives:
  - ➢ Search for the celestials of happiness, fortune and health.
  - ➢ Take the photo in particular order.
  - ➢ Send back information, such as GPS data, gaming time, photo data and interactive portfolio to the gaming server.

(2) Sub-mission design: Along the way to the Danshui Zushi Temple

Fig. 8 shows a sub mission that when learners try to solve the abovementioned main mission, they could see some special building material along the way. This sub mission aims at finding them, taking three photos and sending them back to the game server.

a. Mission workflow:
- Learning prerequisite knowledge: The manipulating of camera device, mission map and related system functionalities via PPC.
- Objectives:
  - ➢ Search for the building on screen.
  - ➢ Take a shot on the building framework.
  - ➢ Talk to local residents and get some related information about the building framework.
  - ➢ Send back information, such as GPS data, gaming time, photo data and interactive portfolio to the gaming server.

At last, the Fig. 9 shows the user interfaces on our proposed U-GBL mobile learning devices.

Fig. 7. Main mission

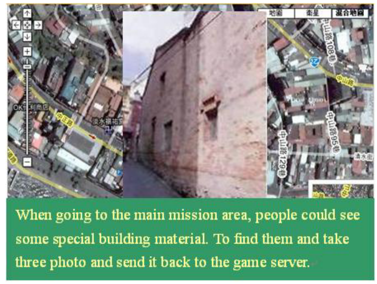

Fig. 8. Sub mission

Fig. 9. The GUIs on U-GBL mobile learning devices

5 U-GBL Assessment Content Design

In game mission design phase, we utilized the two-way specification table proposed by Anderson and Krathwohl [15]. This table has two dimensions. One is for knowledge dimension, and the other is for cognitive process dimension. The knowledge dimension indicates the knowledge classification which includes the factual knowledge, conceptual knowledge, procedural knowledge and meta-cognitive knowledge. The cognitive process dimension includes remembering, understanding, applying, analyzing, evaluating and creating. Knowledge dimension classifies the learning knowledge classifying from the "Learning" perspective. The cognitive process dimension classifies the learner's thinking model from the "Thinking" perspective. The sample of the two-way specification table in the U-GBL course contents is summarized in Table 3.

Table 3. The example of Two-way specification table in Danshui Zushi Temple Missions

Knowledge dimension \ Cognitive process dimension		Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	The suggestion amount of questions	The practical amount of questions
Main Mission	Factual knowledg								
	Conceptual knowledge				●				
	Procedural knowledge				●				
	Meta-cognitive knowledge								
Sub-Mission:	Factual knowledge	●							
	Conceptual knowledge		●		●				
	Procedural knowledge								
	Meta-cognitive knowledge								
The suggestion amount of questions									
The practical amount of questions									

With respecting to the gaming content evaluation, a game performance scorecard is utilized to serve this purpose. An example of a game performance scorecard is shown in Table 4.

The performance evaluation in course content assessment includes the items of paper-and-pencil performance, identification test, structured performance test, simulated performance and work sample.

- *Paper-and-pencil performance* examines knowledge and skill applied by learners.
- *Identification test* is applied to train the learner's identification skill.
- *Structured performance test* allows learners to take the same action in specific learning activities.
- *Simulated performance* provides the simulation condition to let learners do training for the particular knowledge or skill.
- *Work sample* utilizes the real study case to do the assessment.

Table 4. Game performance scorecard

Items for evaluation (In max points)	Game 1	Game 2	Game 3
Physical Quality (1 Point)			
Artwork (1 Point)			
Game Rules Clarity (1 Point)			
Game Content Involvement (1 Point)			
Adherence to Theme (1 Point)			
Time Length of Game (1 Point)			
General Feeling (1 Point)			
Discretionary (1 Point)			
Total Points (10 Points at most)			

6 Conclusion and Future Work

In this paper, we proposed the U-GBL system architecture based on the ubiquitous technologies to provide the attractive convenient and immersive learning platform to learners. By using this U-GBL system, it will not only improve learners' learning motivation but also improve learners' learning efficiency. And we also demonstrated a historical culture course example to show how to design the course content and assessment content in our U-GBL environment. Our U-GBL system is just a beginning to the future learning style, and we hope this system could be an important study case in the game-based learning domain.

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From Story-Telling to Educational Gaming: The Bamiyan Valley Case

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Abstract. Preserving the knowledge of previous generations and passing it to new generations is challenging. This process is usually based on an educational system or in any other kind of face-to-face tradition. However, developing countries usually face a lack of well educated people so that this process is hindered. This is even more problematic for countries having recently struggled through times of war. Hence, we apply a community-centered approach to capturing expert knowledge in non-linear digital stories and repurposing it in the shape of educational games. In particular, we support the vocational training of local employees within a cultural heritage community that aims at preserving Bamiyan Valley in Afghanistan.

Keywords: Technology Enhanced Learning, Knowledge Sharing, Non-Linear Multimedia Story-Telling, Educational Gaming.

1 Introduction

Cultural heritage worldwide faces risk of damage as a result of natural and human impact. This is a particularly serious problem for the preservation of cultural heritage sites in developing and post-conflict countries. In these contexts, local experts are a scarce resource and funds for external expert support are very limited. The situation gets even worse in countries shaken by internal and/or external tensions, which led to an exodus of local experts during the years of political instability. The impact on the human resource sector is devastating. In this regard, Afghanistan, having suffered from internal and external armed conflicts and wars in the past 25 years, is an especially severe case.

Since 2002 the international community has made great effort in rebuilding and recovering severely damaged Afghan cultural heritage. Under the appeals and guidance of the United Nations Scientific and Cultural Organization (UNESCO)[1] as well as the International Council on Monuments and Sites (ICOMOS)[2], RWTH Aachen Center

[1] http://whc.unesco.org/en/activities/2/ (last access: 28/05/08)
[2] http://www.international.icomos.org/risk/2002/afghanistan2002.htm (last access: 28/05/08)

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for Documentation and Conservation cooperates with international organizations as well as national institutions in the domain of cultural heritage preservation. In this context, capacity-building activities in heritage management for Afghan experts and conservation work on some of the most important monuments in the country such as the UNESCO World Heritage Site Bamiyan are key projects. Activities take place in tight cooperation with national institutions and local experts such as the Society of the Preservation of Afghanistan Cultural Heritage (SPACH)[3], the Departments of Archaeology and Historical Monument Preservation of the Afghan Ministry of Information and Culture, the National Research Institute of Cultural Properties Tokyo and with the participation of a new generation of scholars and students from the Kabul University. The creation of a UNESCO Cultural Master Plan for the World Heritage site of Bamiyan[4] is one of the most important outcomes of the project. However, it remains a difficult and complex task to recruit and coordinate a sufficient number of local and foreign experts to accomplish such an ambitious project. This is a typical example that acts as case study in this work:

> *"We are trying to specify the exact position of a large piece of debris in one of the giant Buddha caves in Bamiyan. This is a necessary preprocessing step for a potential later relocation of fragments and reconstruction of the giant Buddha itself. As a capacity building measure, experts instruct local heritage officials employed for the project to take photos of a stone fragment with a GPS-enabled camera [6]. But quality of the resulting data tends to be rather poor as the local employees have problems at using the equipment in the pre-defined sequence or they simply forget to reset the GPS bearing settings after a photo has been taken because the overall purpose of this activity is not fully understood for a variety of reasons*."

While educational infrastructures have to be rebuilt across the country, the brain drain of a whole generation also has to be stopped or even inverted. In our vocational training scenario we use educational games to teach adult employees the nature of a conservation project, the nature of data gathering procedures, and the correct use of the equipment. Since the creation of educational games from scratch is expensive and requires highly specialized technical and pedagogical skills, we use a semi-automatic approach in creating educational games from multimedia narratives. Starting point are non-linear stories created in our MPEG-7 [8] based multimedia integrated storytelling environment called MIST [22], which taps the multimedia repository of an online community with the intention of gathering the widespread information about the Afghan cultural heritage [14].

In this paper, Section 2 highlights the interrelation between (non-)linear storytelling and educational gaming in technology-enhanced learning (TEL) for vocational training [7]. Then we present the related work with an emphasis on multimedia capableness, interoperability and community support in Section 3. In Section 4, we introduce our methodology of creating educational games from expert knowledge captured in non-linear multimedia stories. Section 5 explains how our approach connects

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[3] http://www.spach.info/ (last access: 28/05/08)

[4] http://www.bamiyan-development.org/projects/cultural-master-plan (last access: 28/05/08)

non-linear story-telling and educational gaming in the case of Bamiyan Valley. Finally, conclusions and future work are presented in Section 6.

2 TEL for Vocational Training: Story-Telling and Educational Gaming Revisited

When making TEL productive for vocational training, a usual question arises: What are the main differences between guiding children in their learning processes and guiding adults? Knowles developed a theory called andragogy (mentioned by Barbara Kieslinger in her blog[5]) that specified fundamental aspects to be covered in adult learning [12, 13]. He figured out that adults – unlike children – are self-directed and expect to take responsibility for decisions. Moreover, adults prefer the instructor to behave as a facilitator instead of a lecturer. As a result, he postulated four principles to be incorporated in the process of adult learning [12, 13]:

1) Motivation: Adults need to know why they need to learn something
2) Experience: Adults need to learn experientially
3) Orientation: Adults approach learning as problem-solving
4) Readiness: Adults learn best when the topic is of immediate value

Table 1. Andragogical similarities between story-telling and educational gaming

Andragogy	Story-Telling	Educational Gaming
Motivation	Reliving real life tasks	Preparation for real life tasks
Experience	Non-linear exploration of story paths	Non-linear navigation through a virtual world
Orientation	Complex story graph	Interleaved sub-problems
Readiness	Problem solving by other members' experiences	Understanding of real life problems by reproduction

Table 1 depicts the andragogical similarities between story-telling and educational gaming. From the respective facets contained in story-telling as well as in educational gaming, it can be seen that both approaches emulate real life processes either within complex story graphs or as interleaved sub-problems. This is consistent with the main conclusion that can be drawn from the previous four assumptions for TEL in vocational training: TEL in vocational training requires learning to focus more on the process and less on the contents.

However, educational games require highly specialized technical and pedagogical skills to cover adequately complex learning topics. This difficulty can lead to a trivialization of the final games produced, which in turn can lead to a de-motivation problem. Indeed, as pointed out by Hamalainen [7], while the integration of learning and

[5] http://barbarakieslinger.zsi.at/index.php/2008/01/16/what-happened-to-andragogy/ (last access: 28/05/08)

gaming provides great opportunities, it also addresses severe motivational challenges (particularly in vocational training). As pointed out by Weinberger [25], an important source of de-motivation is the creation of excessively obvious tasks by designers during scripting.

In turn, non-linear digital stories are an ideal starting point for the creation of educational games, since each story addresses a known problem, so that the story recipient may gain benefit from other users' experiences. The results are real-life stories that set up the basis for non-trivialized educational videogames. In order to connect both aspects, we take a closer look at related work in the next section and will point out what (if possible at all) is needed to connect these approaches.

3 Related Work

There are very different approaches to group-based story-telling and educational gaming. In this overview, we focus on initiatives to foster knowledge sharing in communities of practice. We will also point out whether and to what extent these approaches cover both aspects in andragogical motivation: Reliving real life tasks from stories and preparation issues in educational gaming.

3.1 Related Work on Story-Telling

An application of group story-telling in knowledge management is *TellStory* [20]. It is a collaborative, web-based application that allows a group of users to jointly create a text-based story. A decisive deficit of *TellStory* is that it is text-based only and does not support the usage of multimedia.

StoryMapper is an approach to group-based story creation [1]. The collaboration process is guided by user roles (i.e. teller, organizer, associator/indexer and listener). For visual representation *StoryMapper* supports the use of conceptual maps and arbitrary media can be attached to the conceptual map nodes. Thus, *StoryMapper* is capable of modeling expert experiences within stories.

An approach towards group story-telling for team awareness and entertainment is *PhotoStory* [24]. *G*roup members may create stories jointly, which consist of pictures and their subtitles. The system is based on BSCW [11] and supports community collaboration and knowledge exchange according to the BSCW methodology. However, its current implementation only supports photos.

An approach to retrospective story-telling with digital photos is *iTell* [15]. In this aspect, *iTell* is in line with the intention of story-telling to support learning by sharing expertise within communities. *iTell* supports a 4-ary creation process (brainstorming, organization, writing and media association) including photos as well as voice recordings to be associated with linear text-based stories.

Collaborative audio-based storytelling is an approach focused on audio and its text-based metadata [10]. The system is also suitable for modeling non-linear media dependencies. However, *collaborative audio-based storytelling* does not support any other media and application of the stories for educational gaming is not considered.

An interactive environment for emergent story-telling is *StoryWriter* [23]. The idea is to create text-based and illustrated stories. The authors of stories are guided by rules that e.g. manage the interaction between characters. But *StoryWriter* is neither web-based nor collaborative.

In addition, there are several story-telling platforms especially for cultural heritage management such as the *CIPHER* project [5] and the *Instory* project [3]. Both of them focus on helping tourists explore cultural heritage sites using linear multimedia.

3.2 Related Work on Educational Games

Regarding the development of educational games, the field is very broad, as there are many different approaches to game development. These can range from writing them from scratch (using general-purpose languages such as C++) to GUI-based authoring tools than don't require any programming knowledge. Given the nature of this application, we will focus the discussion on such authoring tools.

Many game-authoring tools are actually non-educational commercial products targeted to amateur game developers willing to develop their own games without programming knowledge. This is the case of tools such as *The FPS Creator* and *The 3D Game Maker*, both developed by The Game Creators[6]. On the other hand, *Mission Maker* (distributed by Immersive Education[7]) was developed with educational purposes, but it is still a commercial product.

The Game Maker [19], on the other hand, is an academic project consisting on a GUI-based authoring environment that also supports a scripting language to extend the functionality of the tool. It has been used in several academic research projects related to educational gaming [2]. However, it was not specifically designed for the kind of game design that we are pursuing.

In this sense, the *Alice*[8] project, developed by Carnegie Mellon University, was originally designed to be a first contact with Object Oriented Programming, but its spin-off project, *Storytelling Alice* would fit the game design we are seeking. Unfortunately, its focus on being a tool to learn computer programming suggests that it may not be ideal for the integration with our previously existing tools.

3.3 Conclusion

In the previous overview we have introduced several approaches towards story-telling and educational gaming. As we have pointed out, current approaches are not suitable for combining community support with a comprehensive methodological support to connect the reliving real life tasks from stories and the preparation issues in educational gaming. Thus, next section introduces our approach to connect the structural properties of the story-telling with a specific gaming engine.

4 Creating Educational Games from Non-linear Digital Stories

As mentioned in the previous chapter there is no approach that exploits the expertise of non-linear digital stories for a latter usage in educational gaming. In order to tap

[6] http://www.thegamecreators.com/ (last access: 28/05/08)
[7] http://www.immersiveeducation.com/missionmaker/ (last access: 28/05/08)
[8] http://www.alice.org/ (last access: 28/05/08)

the vast repository of community-generated knowledge for vocational training contained in non-linear digital stories, we propose an efficient way of creating and converting these stories into educational games. This is the rationale behind the connection of the structural approach of the story-telling environment MIST (developed at RWTH Aachen University, Germany) with the <e-Adventure> educational game platform (developed at Complutense University of Madrid, Spain) via an XML-based interchange format.

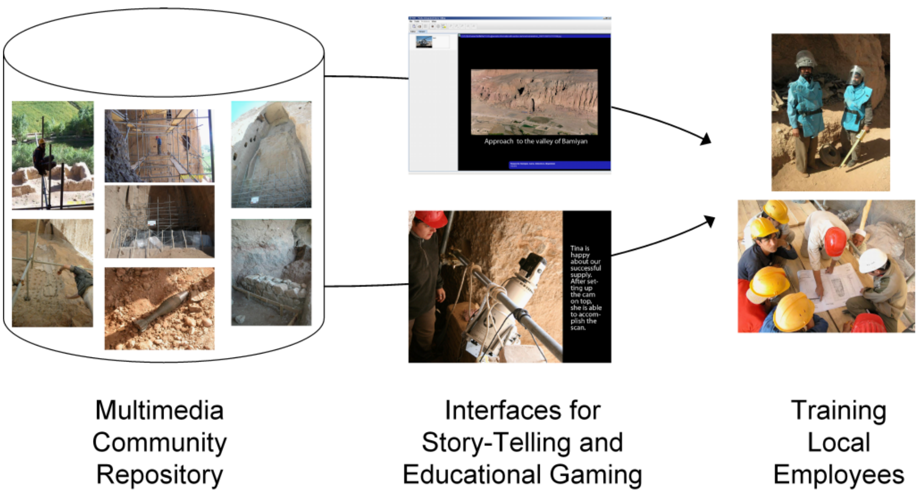

Fig. 1. Interconnecting story-telling and educational gaming for vocational training

4.1 Using MIST to Compose Non-linear Digital Stories

The first pillar of this approach is the story-telling environment MIST [22]. In order to help experts and instructors in creating useful stories (from a structural point of view), the MOD paradigm is applied (cf. [21] for details). The basis are multimedia contents that might either be re-used from our geographic information system ACIS or newly added at time of creation. Thus, the story designer might take benefit of the vast pool of already existing data in the community repository.

The MIST editor allows a temporal composition of multimedia contents. The story author can now create paths covering different aspects along the contents. Thus, the problems addressed depend on the path selected and lead consequently to different results in a story. Figure 2 shows the editor consisting of three main elements: Storyboard (on the left), problem hierarchy (upper right side) and media preview (lower right side). The storyboard is a graphical representation of stories according to MOD paradigm, which prescribes the decomposition into dedicated (potentially repeating) begin, middle, and end sequences.

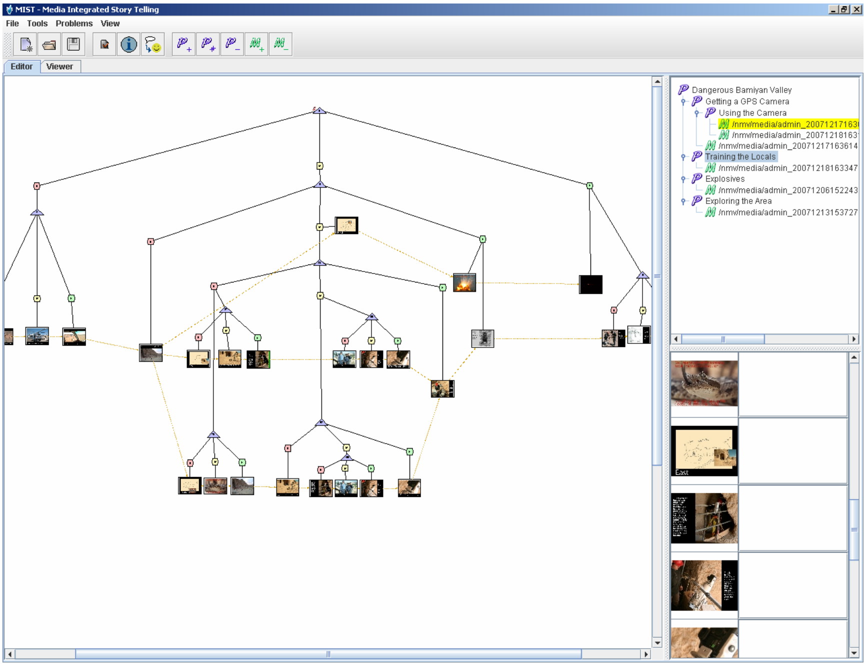

Fig. 2. Expert knowledge captured in a non-linear multimedia story

4.2 Using <e-Adventure> to Transform Non-linear Digital Stories into Educational Games

The other pillar is the <e-Adventure> platform, a complete solution for the development, execution and integration of educational games in Virtual Learning Environments [17]. The games are created using the <e-Adventure> editor, which is a GUI-based authoring environment for *point and click* adventure games. The games created with the editor bundle a description of the game content using the descriptive markup of the <e-Adventure> XML language [18] and all the media assets required for the game. These bundles are executed by the <e-Adventure> game engine, which can run stand-alone or being deployed through Virtual Learning Environments [4].

In our approach, the expert knowledge captured in the non-linear multimedia story using MIST is transformed into an <e-Adventure> game skeleton. The first step is to export the story to the domain-specific markup language used in the <e-Adventure> platform. The mapping between the non-linear stories created with MIST and educational games processable by <e-Adventure> is described in Table 2. As a result from the conversion process, a basic skeleton for an educational game is obtained. The MOD structure of the story is used to specify a basic set of transitions for the further creation of the educational game. In addition, the media contained in the non-linear story are set as background images of each scene.

In the next step, the dedicated editor of the <e-Adventure> platform is used to refine the raw educational game derived from the non-linear story. Even though the editor was designed for the creation of educational games from scratch, it can take the output of the exportation process as a basic game. Then, the users can leverage the editor to refine and improve the automatically generated game skeleton and turn it into a fully featured educational adventure game.

Table 2. Transformation rules from non-linear stories into educational games

MIST	***<e-Adventure>***	***Remarks***
<mediaNode type="*" id="{id}"> {URI/filename} </mediaNode>	<scene start="no" id="scene{id}"> <resources> <asset type="background"> uri="assets/background/{filename}" </asset> <name>scene{id}</name> <exits> ... </exits> </resources> </scene>	• Scene ID gets the prefix *scene*. • Content of <exits> defined by <successorRel> as shown below.
<successorRel> <relation> id="1" source="2" target="1" </relation> <relation> id="2" source="3" target="1" </relation> </successorRel>	<exits> <exit x="0" y="0" height="100" width="100"> <next-scene idTarget="scene2" /> </exit> <exit x="100" y="0" height="100" width="10="> <next-scene idTarget="scene3" /> </exit> </exits>	• Successor represented as exits starting in the top left corner. • Relation (source, target) means that source is a predecessor of target. The exits here (secene 2 and scene 3) belong to scene 1.

5 The Bamiyan Valley Case-Study

The approach outlined in the previous section has been used in the development of educational games for the specific training context of the UNESCO Cultural Master Plan for the World Heritage site of Bamiyan as described in Section 1. In order to raise awareness on cultural heritage preservation among local communities and to facilitate cooperation among international experts and local authorities responsible for site management, architects at RWTH Aachen Center for Documentation and Conservation created stories to be repurposed as educational games. These stories target non-professional or non-skilled locals involved in preservation and monitoring work, who require career training in working procedures to be done during on-site preservation work. The stories were automatically transformed into adventure game skeletons usable by the <e-Adventure> platform as described in Section 4. These skeletons could not be considered distributable educational games yet, but the narrative portion of the games was already created. Then, using the <e-Adventure> graphical editor, these skeletons were manually refined and turned into executable educational games.

Figure 3 shows the <e-Adventure> editor displaying a scene automatically generated from one of the non-linear stories. This particular game deals with the task of using a GPS-enabled camera to take photos of a stone fragment in one of Buddha caves in Bamiyan. Using the editor, additional resources (such as a GPS camera), characters and transitions between scenes (so-called exists) as well as (educational) dialogue between characters can be defined. In addition, back links – which do not exist in non-linear stories – can be inserted at this stage. The result of the process is the “Bamiyan Valley Educational Game”. Figure 4 contains two screenshots of the resulting point & click adventure being executed by the <e-Adventure> engine.

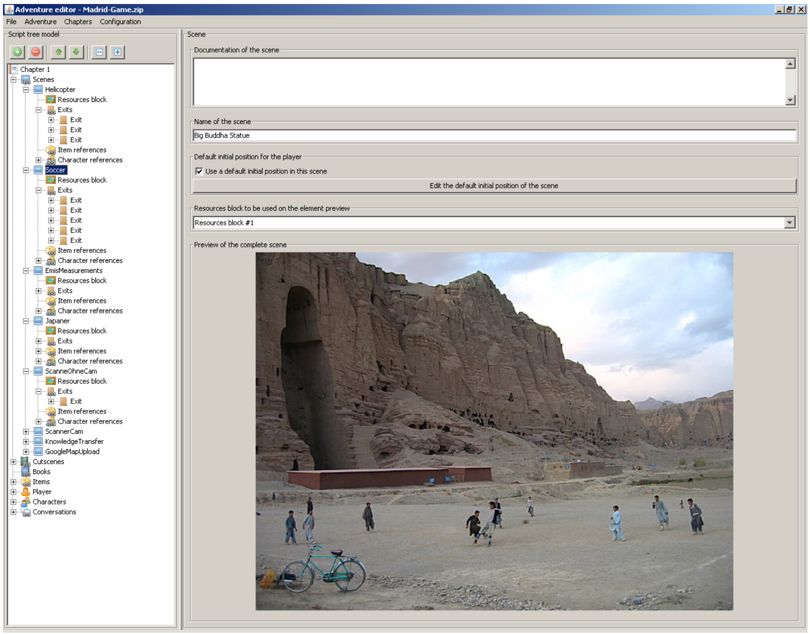

Fig. 3. Refining a game skeleton derived from a non-linear story in the <e-Adventure> editor

The designed game was introduced to a group of trainees from Bamiyan during a capacity building course at RWTH Aachen University within the UNESCO project for the preservation of the Bamiyan site. All participants of the course are employees of the local public administration in Bamiyan and selected in order to be trained on the long term preservation goals for Bamiyan as defined in the UNESCO Cultural Master Plan. The game was widely accepted and tried out with enthusiasm. It led to a truly collaborative experience in which some participants explained to others the "correct" answers to reach the game ending. The use of real-life imagery led to enhanced attention on behalf of the users to the assigned training tasks. It is planned to use the game in preparation of future conservation and monitoring tasks on site.

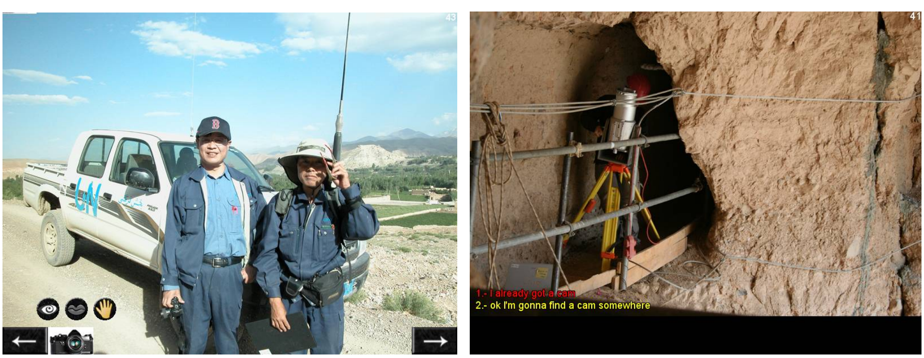

Fig. 4. Screenshots of the "Bamiyan Valley Educational Game"

6 Conclusions and Future Work

The process described in this work proposes a collaboration model between domain experts (cultural heritage experts in our case study) and game developers (instructors in this case, since <e-Adventure> is an instructor-oriented environment). The expert knowledge is captured in the shape of non-linear stories. This a collaborative process that uses specialized story-telling tools (such as MIST) to compose the stories using contents gathered and annotated collaboratively in ACIS for cultural heritage management in Afghanistan. The challenge was therefore to make this expert knowledge available for vocational training in educational games. Our mapping rules now make stories for technology enhanced learning by educational adventure games based on the <e-Adventure> platform. The XML bindings supported by both platforms facilitate this process, allowing a semi-automatic transformation process composed of an automated step (turning the story into a game skeleton) and a manual refinement process that fine-tunes this skeleton converting it into a game.

This approach reduces the cost of the game development process enormously. Tasks such as writing the narrative flow of the game, creating and/or gathering the art assets, and then creating and connecting scenes with content are usually the most demanding stages of the development process. This approach covers these aspects, leveraging the functionality of the ACIS platform for collaborative asset gathering and maintenance, using MIST to facilitate the creation of the non-linear stories and, finally, transforming these stories into basic game skeletons that include the different scenes already interconnected and populated with content.

Most game-based learning experiences also find problems when it comes to interweave content and fun. In adventure games, both aspects are actually connected through the narrative flow of the game [9]. Therefore, the quality of the final game (both in terms of educational value and appeal) depends heavily on the quality of the underlying story. Compared to other educational game authoring approaches, the creation of the storyline using specialized tools like MIST offers additional support for the creative process.

After the development of the case study we intend to apply the same approach in other fields like medical training, where <e-Adventure> has been used successfully as a standalone tool [16]. Additionally, we also envision non-educational applications of the approach: Commercial games often find difficulties when it comes to convert interesting storylines into functioning games without losing value in the process. The authoring approach supported by MIST facilitates the procedure of writing and maintaining the stories which can be transformed into games semi-automatically then. Whether this approach can be applied for the development of purely entertainment-driven adventure games is an interesting line for future research and development.

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Three Layered Thinking Model for Designing Web-Based Educational Games

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Abstract. With the rapid development of the Internet and multimedia technologies, it has become feasible for educators to produce Web-based educational games. However, challenges remain in terms of how to create content that ensures effective learning environments for different types of knowledge under a limited budget. Thus, this paper presents a three layered model of game design that integrates game goals within the curriculum and game design. The model stresses the importance of decreasing the task complexity and increasing the four flow factors: skill, challenge, concentration and pleasure. This model has been applied to an experimental study in which three games were empirically designed to test its practical usefulness. Findings indicated that the integrated quality of a Web-based game encourages the learner's engagement. Since Web-based educational games are at an early stage of development, this model promises to be a useful tool for all phase of educational game design.

Keywords: Web-based game, educational game design, game design framework, educational game evaluation.

1 Introduction

As the popularity of Web-based learning has surged, the development of Web-based educational games has attracted instructors and developers due to these games' ability to appeal to the "e-generation" of learners who have grown up with computer games [4]. However, there are two challenges in developing game-based learning materials for education. Firstly, the development of games, compared to other Web-based learning materials, is usually more cost-consuming and presents greater technical obstacles for the developers [11]. Secondly, compared to the leisured-based computer games, the development of skill-based educational gaming has one more challenge: achieving the goal of knowledge enhancement [5].

There are few studies which have guided the effective analysis and design phase on development of Web-based educational games. According to experience theory, game-based learning is considered to be a process that is based on adding new experiences to old ones. Therefore, to develop game-based courseware, one must not only consider the process of how the teachers' constructed their curriculum, but also the

F. Li et al. (Eds.): ICWL 2008, LNCS 5145, pp. 265–274, 2008.

learners' viewpoint on learning motives and flow. The main purpose of this study is to prompt a useful model that provides comprehensive considerations on design processes of Web-based educational games to motive the players' flows.

2 Perspectives on Web-Based Educational Games

Games are deeply engaging, visually dynamic, rapidly paced, effective tools for exposing students to knowledge [12]. Undoubtedly, they will be the key technologies use in the next-generation of educational tools in Web-based learning [4]. Improved technology – namely FLASH-like multi-media development tools – make the job of creating Web-based games much easier than before. They more efficiently increase the players' experience than any other type of material because the interactive immersion component has already been strongly developed for the players [7]. However, a good game-based educational material design is very complicated work; it should take into account the interactions from four perspectives: (1) the particular context in which learning takes place; (2) the characteristics of learners, (3) the internal representational world of the game, and (4) pedagogic consideration [5]. We discuss these perspectives below:

2.1 Pedagogic Considerations in Web-Based Educational Games

Pedagogic considerations include curricula objectives, pedagogic approach, learning activities, and the corresponding learning outcomes [5]. Computer games provide a learning-centered environment [12]. Learning is no longer a process of knowledge transfer from the expert to the novice. Instead, the learning process takes place naturally in the virtual world where players engage in the games. [13]. According to experiential theory on game-based learning, learners construct the knowledge themselves by interacting with the environment.

Table 1. Font sizes of headings. Table captions should always be positioned *above* the tables.

level	Knowledge taxonomy	Possible game styles
Low	competence	Possible game style
↓	knowledge	Game show competition, Flashcard type game, etc.
	comprehension	Simulation game
	application	Adventure games
	analysis	Role playing games, Detective games
	synthesis	Strategy games
High	evaluation	No games suitable

Bloom identified six levels of knowledge within the cognitive domain, from the simple recall or recognition of facts, at the lowest level, to increasingly more complex and abstract mental levels, with the highest order classified as evaluation. The taxonomy provided a useful structure that the teachers would be able to apply appropriate strategies in their test questions [2]. In Table 1 we try to combine the possible games styles suggested by Prensky [12] with Bloom's taxonomy of knowledge.

Siang & Rao [13] suggested seven levels in a hierarchy needs that game players demonstrate. At the bottom level, players are seeking information to understand the rules of game. Then they need to know how to gain control over the game. After that, they will expect more challenges (to meet esteem needs). The subsequent aesthetic need involves players demand for good graphics and visual effects, appropriate music, sound effects, and so forth. In game-playing, the aesthetic need is a higher ranking need than esteem needs. Therefore, a good game should be sufficiently challenging and match the player's skill levels [15]. Game players experience flow, or addiction to the game, only when the challenges offered match his/her skill [8]. The player performs the learning activities required by the games and focuses on playing in order to achieve the required learning outcomes [5].

A framework of pleasure by the anthropologist Lionel Tiger consists of four types of pleasure that motivate usage: physiological, social, psychological and ideological [1]. Physiological pleasure is derived from the sensory organs. It consists of pleasure connected with touch, taste, and smell as well as feelings of sexual and sensual pleasure. Social pleasure is derived from the company of others, such as having a conversation or being part of a group. Psychological pleasure is gained from accomplishing a task. Ideological pleasure is derived from the user's perception of the importance of the task itself. Ideological pleasure is only experienced by students taking important courses that are perceived to be highly difficult [6].

The main purpose of educational game is to enhance players' skills or knowledge. Game players in Web-based learning can easily obtain physiological pleasure through animations, sounds and other stimuli provided by the multimedia. The instructors who design the game with pedagogy should consider the players pleasure and their hierarchy needs which are satisfied by the context of the online multimedia learning platform.

2.2 Characteristics of University Students/Learners/Game Players

The new learning style of young people today demands a quick and enjoyable approach to learning [12]. The "new vs. old" tensions are: twitch speed vs. conventional speed, parallel processing vs. linear, graphics first vs. text first, random access vs. step by step, connected vs. stand alone, active vs. passive, play vs. work, payoff vs. patience, fantasy vs. reality, and technology as friend vs. technology as foe [10]. Therefore, game based e-learning should match the preference of the e-generation of university students. They are considered to have sufficient skills and background to use the Internet as well as play digital games.

2.3 Context

The context considerations in educational game design include the physical environment, equipment, technical support personnel, and so forth [3, 5]. At the point of technical view point, the FLASH-like software provides a cheap and easy way to develop Web-based educational games. The large bandwidth of Internet accessible in universities also provides an environment conducive to Web-based educational games. At the knowledge delivery process view point, the context must provide enabling factors to support student learning [5].

2.4 Internal Representational World of the Game Program Code

Issues regarding the mode of representation include choosing the appropriate tool and content supporting learning activities that match the level needed for fidelity, immersion, and realism [3]. The criterion of concentration implies that games should provide stimuli that quickly grab the players' attention and maintain their focus throughout the game [15]. Interfaces such as tutorials, online support, and feedback are important to a game's usability [15]. Players should be able to start playing the game without reading the user's manual. They should receive feedback on their progress toward their goals. Multimedia presentations encourage learners to engage in active learning by making mental connections between the story and structure of the problems. In accordance with the complexity of the game's storyline, the game can be labeled as well-structured or ill-structured. The importance of the storyline depends on the complexity of the game. Generally, the more complex the game is, the more important the storyline tends to be [8].

Video games not only present problem solving activities and storylines but also offer an effective internal representation that reinforces the players' augmentation skills in reading visual images, thinking, rule-discovery, language development, and triangulating divided attention. By mapping out possible gaming styles and curriculum content, learners can enjoy various learning activities while at the same time being entertained [12]. For example, facts can be presented through game show competitions, flashcard-type games, or action games; skills can be trained through persistent state games, role-playing games, adventure games, or detective games; judgment skills can be cultivated by role-playing games, multiplayer interaction adventure games, or strategy games.

3 The Three Layered Thinking Model of Game Design

Since the steps of designing a useful educational game are too complicated to be explicated through a cognitive process, we developed a three layered matrix model to analyze the stages of the design process (Fig. 1). The tasks of game design include determining the game style, game task, and game interface. But how to determine should base on the curriculum gaol. Thus, on the pedagogic level, the curriculum goals need to be translated into game goals. The players' previous skills and the knowledge enhanced also require included [5]. The criterion for selecting the game style is whether these styles match the goals of the game. The purpose of the game's tasks is to enhance the players' knowledge and skills through the provision of challenges. Game players in a Web-based learning environment obtain physiological pleasure from the multimedia material [1]. Meanwhile their psychological pleasure is gained from overcoming the challenges in the learning games. Good interface design helps players concentrate on the game. Learners perform the learning activities in the games in order to achieve the required learning outcomes while focusing upon playing [5]. Therefore, the achievements on game play can be concluded as pleasure, challenge, skill enhance and concentration.

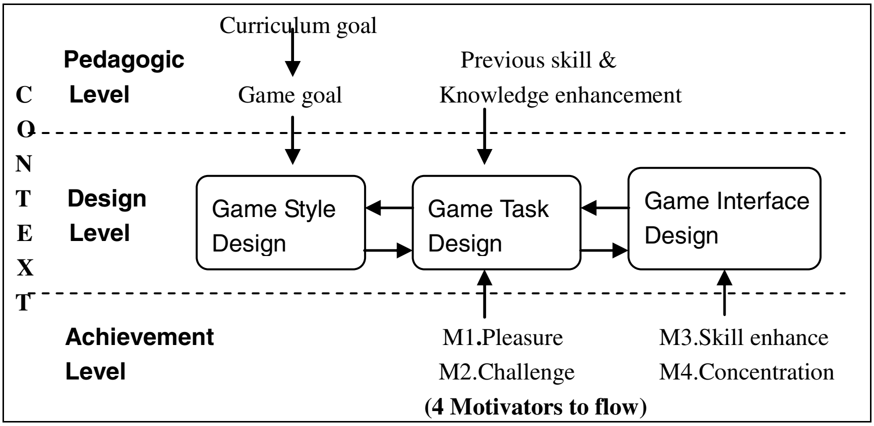

Fig. 1. Three Layered Thinking Model of Web-based Educational Game Design

4 Validating the Model

In order to explain how the above model is useful in developing of educational games, three games were evaluated. We illustrated the expert review results followed with the survey from the learners.

4.1 Profile of Learners/Students

The subjects consisted of 120 undergraduate students who had been taking an information literacy course provided to all students who are non-management information systems majors. Some 53% of the subjects were male while 47% were female; around 3% of the subjects were freshmen, 26% were sophomores, 37% were juniors and 34% were seniors.

4.2 Game Style, Task and Interface Design

The games were developed by a team of researchers and designers for the Web-based course "Introduction of Software Applications". The Web site is located at http://www.elearn.cc.nccu.edu.tw and is accessible with passwords. The first game was a simulation of how components are installed into a motherboard of a personal computer (PC), as shown in Figure 2 (a). Research has indicated that some novice users believed that the insides of a computer were bunches of wires connected together in a mass tangle. The purpose of this game was to increase students' understanding of the shape and position of all components inside the shell of a PC.

The second game was a diagnosis of the components required for a PC purchase. The purpose of this game was to increase students' understanding of how to buy a new PC based on their needs. Suggestions on the requirements of the necessary PC components were given as feedback to the learner after a series Q & A regarding the user's purpose, preference and budget. The third type of game was designed to enhance players' memory of operational procedures through stories. Many students are

Game1. Installation of mother board (a) **Game2.** Suggestions of PC Components (b) **Game3.** Manipulations of Windows XP (c)

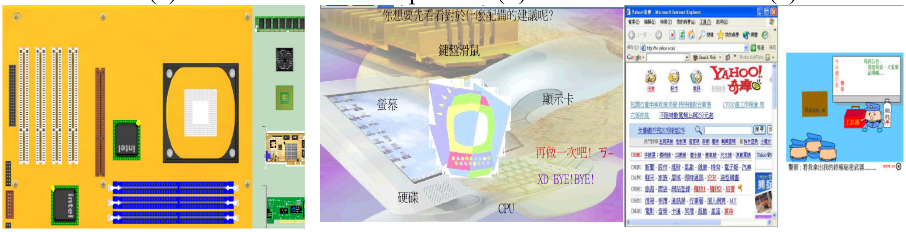

Fig. 2. Demonstration of game interfaces

interested in knowing more about problem-solving issues with regards to computer operating systems, including deleting cookies, rearranging hard disks, reinstalling software, and so forth. However, the steps involved in these tasks are difficult to remember for rookie users. The games were thus designed to associate the procedures with a play serial dotted with quiet animators and light, and humorous conversations on a battle against crimes in a big city. The “big city” is akin to the operating system (Window XP) in a computer. The “crimes” are problems with computer usage, such as a kidnapping of the home page. Each scene in the story is displayed on the right side while corresponding problem-solving procedures are shown in a screen on the left part, as demonstrated in Figure 2 (c). After the player performs the correct procedure, he/she can click on an “arrow” to continue reading the next scene.

4.3 Skill Enhancement Design

The following expert reviews were through subjective ratings. For each goal, all games were assigned a numerical value between one and five, indicating the extent to which the games supported that criterion. Values from one to five indicate “not at all,” “a little,” “average,” “good,” and “well done,” respectively.

Pedagogic considerations focus on whether the curriculum goals are attainable by means of game goals, and whether the game style matches the knowledge taxonomy. The goals of Game 1 and 3 were rates to fit better their respective curricula goals than Game 2 because skills in strategic thinking are more difficult than skills in memory or recognition. Based on Bloom’s taxonomy of knowledge, the strategic thinking involved in PC components combination (as targeted in Game 2) requires a higher level of knowledge than the other games. The pedagogic method in the game designs in this study was the experiential theory mentioned in [5] and [11]. The earliest, initial learning process in computer games is behavioral learning. Players learn by trial and error as well as stimulus associations. When the basic rules of a game are understood, players start to think cognitively about how they should respond to a new situation and actively update existing knowledge to fit the new things they are confronted with in the game environment [13]. According to suggestions from Prensky [12], simulation games provide content that help develop the player’s system of understanding, while adventure games can improve the user’s development skills. Therefore the match between knowledge and game style was rated to be good for Game 1 and 3. The puzzle game, which was the game style of Game 2, was suggested to fit best with the learning goal of strategic reasoning [12].

4.4 Challenge Design

The games create scenarios and provide challenges to invoke the learners' curiosity and keep them involved. Players immerse themselves in the game when the challenge provided by the game matches the skills they have [8]. If the challenge in the game is higher than the player's skill, he/she will become anxious. If the challenge of the game is beneath the skill level of the player, then the player will become bored. Both situations impede progress [8]. We evaluated challenges provided in the games according to how well these problems are structured and how closely they match the players' skills. There were fixed solutions and procedures in both the installation of a motherboard and the manipulation of Windows. The skill required in Game 1 was to recognize the positions of each component through trial and error. In the game that involves the manipulation of an operation system, the skill called for was to remember the sequence of procedures that solve a problem. As the games were offered in an introduction to computers course, we assumed that these challenges matched the players' skills. The problem provided in Game 2 was considered to be too easy in terms of how much it challenged players' skills.

4.5 Pleasure Design

All three games were single-player games that provide for interaction only with the software. There are two arguments concerning action-based drill and practice games such as Game 1. One point of view stipulates that in such games, players might simply keep on experimenting with actions until their scores improve. However, such behavior, based only on trial and error, may not bring about a higher level of intelligence [8]. On the other hand, the feedback delivered through rewards or punishments from the game indeed reinforces the stimuli and responses, and facilitates the learning of some behaviors [13]. The physiological pleasure comes from the graphics, sound, as well as the interaction with the systems. The psychological pleasure comes from positive feedback, such as score and/or applause. Both of the above satisfactions could encourage the player's engagement in playing. All components in Game 1 were designed to resemble the real objects as closely as possible. Therefore, the physiological pleasure of the game to be rated "good". Positive feedback is available when the computer "applauds" the player when he/she finishes the task of installation, so the psychological pleasure was rated "average".

Game 2 was a conversation-like diagnosis complete with a coloful interface. We rate the physiological pleasure as "average". All the players could finish the task no matter what their skills or backgrounds were. The game does not rate the player's performance. Therefore we see the psychological pleasure as lacking. Students probably garnered more pleasure from Game 3 due to its dramatic storyline, cartoonish characters and humorous dialogue. Therefore we rate the physiological pleasure of Game 3 as "well done". The psychological pleasure is assessed to be average because players can finish the task simply by following the computer's clear-cut directions.

4.6 Concentration Design

The context factors involved in the design of educational games included the physical environment, equipment, technical support personnel, and so forth [3, 5]. The level of concentration is determined by the stimuli and the workload the game provided. Storylines and activities are considered as the stimuli while heavy demands on the player's memory capacity are regarded as a high workload [15]. All the basic rules of playing these three games are comprehended by the players without the need for tutors to assist them [15]. The importance of the storyline to a game depends on the complexity of the game [8]. Game 3 used a serial of adventure story to help learners remember the procedures. The humorous stories were considered to help maintain players' concentration. Game 2 created several scenarios in terms of PC component combinations. The scenarios themselves served as a small story. A serial of questions and answers before the diagnosis in Game 2 created a discontinuous gap between the facts and strategic results. The overly complicated screen design that showed both the story and operation demo in Game 3 was also considered to be a factor hampering players' concentration.

4.7 Total Achievement on Educational Game

Four achievements on Web-based educational games were goal (M1), challenge (M2), concentration (M3), and pleasure (M4). Total achievements on educational game flow can be calculated as the average score on individual motivators (Si) multiplied by its weight (Wi) in the following formula:

$$\text{Total Motivation} = \sum_{i}^{type} Wi * Si \tag{1}$$

Game 2 and Game 3 were considered "good "for achieving players' experience flow.

4.8 Survey on Learners' Engagement

As suggested by [15], it is better to evaluate a game both by reviews of experts and by the players' engagement behaviors. The engagement data on games was collected through system log file and a survey on the players. The users' levels of engagement were measured in terms of the length of time they spent on the game and how

Table 2. Empirical Results on Learners' Engagement and Likeness

Game Content Evaluation Indicators	**Game1** Installation of Mother Broad	**Game2** Suggestion of Computer Purchase	**Game3** Manipulation of Windows XP
Frequency (Average numbers been played)	**3.52**	**2.49**	**3.5**
Average time spent (sec)	134.34	296.9	286.4
Estimated average time spent (sec)	120	240	260
Ratio of average/estimated average time	**1.12**	**1.23**	**1.10**

frequently they played the game. The empirical results of the measurements – the frequency of play, time spent, and subjective rating of interest – are summarized in Table 2. We found that learners who played Game 1 and 3 had higher frequency levels than those who played Game 2. Also, while there was a high level of interest generated from Game 3, this was not the case for Game 1. The empirical result is consistent with the results of our expert review.

5 Conclusions

Designing a Web-based educational game is a complicated task. One must consider numerous factors such as rules, goals, experience flow, interaction, problem solving, challenge, conflict, storyline, etc. Much effort exerted in the designing of educational games should also be targeted at achieving the curriculum goal through relevant learning theories, contexts and learners' characteristics. The primary intention of this paper is to present a three layered thinking model that makes designing and evaluating Web-based educational games less complicated and more effective. This model stresses the importance of focusing on the purposes in each step and their relationships to achieve of skill enhancement, challenge, concentration and pleasure.

An empirical study was conducted to evaluate three games using the model. Curriculum goals can be reached using different game styles, game tasks and interfaces that produce separate results in terms of the players' perceived challenge, concentration, pleasure and developed skills. Empirical results on the players' level of engagement are consistent with the expert's evaluation results. The weight average of the four elements of game results can indeed predict the players' engagement, while pleasure is verified to predict the subjective rating of interest.

Due to the constraints imposed by the budget and the learning platform, the games in the study were only one-player games. Currently, leisure, social games are very popular online. We expect that in the future, this paper's model can be further applied in the development of Web-based educational games with multiple users.

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Learning Kruskal's Algorithm, Prim's Algorithm and Dijkstra's Algorithm by Board Game

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Abstract. This paper describes the reasons about why it is beneficial to combine with graph theory and board game. Forbye, it also descants three graph theories: Dijkstra's, Prim's, and Kruskal's minimum spanning tree. Then it would describe the information about the board game we choose and how to combine the game with before-mentioned three graph theories. At last, we would account for the advantage of combining with these three graph theories and the game specifically.

1 Introduction

For computer sciences, graph theories are important. There are many computer science's concepts relate with graph theory, and many researchers try to combine these science to games. For example, we can connect the concept of network and Prim's minimum spanning tree [1], or link the graph and the concept of searching [2]. Therefore, learning and teaching graph theory much more efficiently aid learning computer sciences. About some knowledge in computer science, using graph theories assist in teaching is useful. It helps to describe some virtual concepts, like network connection. Some computer science, often combine with graph theories in class recently. There many kinds of concepts of graph theories, but we contact the concept of minimum spanning tree mostly. And, we choose minimum spanning tree theories as our target.

Accordingly, how to make student to learn graph theories more efficiently and boost the interest in learning for them is administer to learn computer sciences. In order to increase the interest in learning and absorbing knowledge, using board game to help learning is a good method.

Learning graph theories well help to learn computer sciences. By the reason, we combine the board game Ticket to Ride with three graph theories Dijkstra's, Prim's, and Kruskal's minimum spanning tree. Except some saving rules, we change and create some rules in the game. By the new board game, students can understand the graph theories more efficiently and can get interest in learning.

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2 Related Work

In the early centenary, games were just played for fun. The games, especially board games are. With the time goes, computers' knowledge and technologies are developing. So, computer science was becoming an important science. Accent on the materiality of board games, many researches tried to combine teaching computer sciences with playing board games. For example, Andre J. Henney and Johnson I. Agbinya used board game to explain the idea about mobile connection [3]. And Steve Goschnick and Sandrine Balbo linked programming to board games [4].

In these researchers' concepts, the most access to combine with computer sciences and board game is – shows the network or graph theory on board game. For example, Peter Komisarczuk and Ian Welch used board game to teach internet engineering [5]. Darren Lim shows the graph theory on the board game [1]. Using games can help teaching computer sciences much more efficiently. Especially teaching graph theory or network concepts on board games. It can use the materiality of board games to describe the virtual of graph theories and network well. In this paper, we try to explain the three of ideals of graph theories - Dijkstra's, Prim's, and Kruskal's minimum spanning tree on the board game Ticket to Ride.

In the follow sections, we will describe these: 1. The concept of minimum spanning tree theories: Dijkstra's, Prim's, and Kruskal's minimum spanning tree (section 2). 2. Related work (section 2). 3. The information about board game Ticket to Ride (section 3). 3. The design of combining graph theories and the board game Ticket to Ride (section 4). 4. Conclusion and evaluation about the board game in helping learning.

3 Brief Describe the Three Minimum Spanning Tree Theories We Use

Between many connected nodes, they are undirected graph. Spanning trees means all of the nodes connection. If we give the weight to every path from node to another node and sum of all paths' weight, the minimum spanning tree algorithms try to find the least sum [1, 6].

3.1 Dijkstra's Minimum Spanning Tree

It describes a concept of minimum spanning tree. The theory can be use in teaching network, like the paths of router and router [7]. It goes from a start node, than it will begin to run follow steps: 1.Finding the connected node. 2. Calculating the sum of start node to next node. 3. Choosing the least sum of node as start point next round and avoiding account for loop. It will cuckoo the three steps until finishing the spanning tree [1, 8].

3.2 Prim's Minimum Spanning Tree

Similar to Dijkstra's minimum spanning tree, the theory has a start node too. It can also use the same knowledge area in network. After choosing a start node, it finishes the minimum spanning tree by repeating the follow steps: 1.Finding the connected nodes. 2. Choosing the least weight of paths to next node, and avoiding account for loop [1, 9]. After repeating the two steps, a Prim's minimum spanning tree is created.

3.3 Kruskal's Minimum Spanning Tree

Unlike upper two theories of minimum spanning tree, the theory needn't any start node. The point of the theory are choosing the least paths and avoiding account for the loop. It finishes the minimum spanning tree by repeating two steps: 1.Choosing the least weight path. 2. Connecting the nodes and avoiding the loop [1, 10]. The concept can be used in network, too.

Fig. 1. Ticket to Ride Portugal Edition

4 What Is "Ticket to Ride"

This is a board game; it contains the city name and tracks from one city to another. The game has many kinds of maps like Europe, South America, and Portugal etc. An example is shown in Fig.1.

The main ideas of this game are: 1.Players can choose the mission about connects one city to another, and try to finish the mission to get points. 2. Players have to use their source in hand much more efficiently. 3. There are game plans in the game; players try to interrupt others finish their missions expect for finishing their missions. During playing the game, players get points by finishing missions or building the longest tracks. Player who gets the highest points is the winner. Altogether, this is a game needed chicanery.

5 Design of Combining Minimum Spanning Tree Theories and Ticket to Ride

In the section we fixed some rules based on original rules, and created a new edition of board game Ticket to Ride. The new edition of Ticket to ride is combined with the concept of board game Ticket to Ride and three minimum spanning tree theories: Dijkstra's, Prim's, and Kruskal's minimum spanning tree.

5.1 Necessary Properties of the Game

In this game, we need these things:

(1) Railway map (We use Portugal railway map as an example in Fig.1.)
(2) Each player has 45 railway carriages with its special color.
(3) Starting Point Card (It presents the start point of each player.)
(4) Ticket Card (It indicates the link from Starting point station to Destination station, and the score after the player completed the route.)
(5) Knowledge Card (It identifies which algorithm has to apply on the railway stations and the completed score. The related algorithms are Dijkstra's algorithm which is applied in shortest path algorithm, Prim's algorithm and Kruskal's algorithm which are used in minimum spanning tree.
(6) Railway Card (Each section railway of the map has a specific color which is composed of white, black, red, yellow, orange, blue, purple, green and full-color.)
(7) The Number of each color card (white, black, red, yellow, orange, blue, purple, green) are thirty five, and the number of full-color is fifteen.

5.2 The Limitation of This Game

There are the limitations of this game:

(1) Players range :2-3 players
(2) End conditions of single round game:
  a. When one of the players ran out of the 45 railway carriages
  b. When one of the players cannot put his/her railway carriages
  c. When one of the players reached scores over 150
(3) Completed conditions of the entire game: (A game consists of two single round games.)
  a. When one of the players reached scores over 300
  b. When one of the players completed all the three knowledge card missions which involved Dijkstra, Prim and Kruskal algorithms. The winner has to complete each knowledge card.

(4) All the players have to learn the related knowledge about the shortest path algorithm and minimum spanning tree.

5.3 Game Progress

In the new edition of Ticket to Ride, we fixed some rules based on original rules because of our ideal – combining the board game and three minimum spanning tree theories. The progress is likely the original game. The difference between new and old edition games is that we gave the new game an additional element. The element is the concept of start location and minimum spanning tree theories cards. First, players should cast a start point and knowledge card. Then, they should choose if they want them. After casting start point and knowledge cards, players begin to a single turn.

In the single turn, players can do three actions:

(1) Draw two of the railway cards or choose one which is opened directly.
(2) Draw three of the 3 ticket cards, and reserve the selected ticket.
(3) Re-cast new start point card and knowledge cards.
(4) Put the railway carriages on the map to establish the route. Players also can skip the step if there is no available condition.

In principle, the game will repeat these four steps until a player rich the end conditions of single round game. The game progress graph is shown in Fig.2.

5.4 Game Regulations

There are the descriptions of the game regulations.

(1) The station recorded in the starting point card has to match the stations in the knowledge card else the player cannot play the game (example is shown in Table 1).
(2) Regulations of drawing the railway card:
    a. Railway card color: white、black、red、yellow、orange、blue、purple、green、full-color.
    b. In the beginning of each round, the railway cards are divided into two piles. One is composed of five opened cards and the other one is covered pile of cards.
    c. When drawing the cards, each player can select two cards from the covered pile of cards else select the card from five opened cards. It means player can get the wanted card which is opened.
(3) Players can give up the knowledge card in hands, and player's score will be detected according to the card. Then the player proceeds game from pick up the starting point.
(4) After the player completed one knowledge card, player can decide if he/she will continue draw next knowledge card or not.
(5) Establish the player's railway routes:
    a. The color of the railway card and spaces of the map routes are matched, then the railway cards can occupy the routes of the railway map. The full-color card can occupy any color routes on the map. For example, there are three white

spaces on the route [BRAGANCA-BENAVENTE], the player can occupy the route with three railway cards combination. First one is three white railway cards; Second is two white and one full-color railway cards; Third is one white and two full-color railway cards; Fourth, three full-color railway cards. The other card combinations are useless.

b. Grey route is available for all the colors. For example, there are three grey spaces on the route [BRAGANCA-SALAMANCA], any kinds color of railway cards are acceptable, such as two orange and one red railway cards.
c. The quantity of the railway cards and spaces of the map routes are matched, then the railway cards can occupy the routes of the railway map.
d. If the route of the map is occupied by other players, this route cannot be used by others.

5.5 Score Rules

The score rules of this game are listed in the following:

(1) The player will gain 10 score if the player used the most railway carriages.
(2) If the ticket card is completed, the player will get the score on the card. On the country, the player did not complete the ticket card will deduct the score.
(3) The score of ticket card is calculated by the shortest path from starting point to destination. For instance, the route. For instance, the route, [VALENCA-VERIN] shortest path is 3 and the route [VALENCA-BRAGA] shortest path is 2, others are following the rules.
(4) Knowledge card score consists of two parts; first one is partial score when the player completed part of the answer route, second is completed score when the player completed all the answer routes. (example is shown in Table 2)

In order to encourage the player follow the correct algorithm, we give high scores for players. We give a sample of Dijkstra's algorithm in Table 2. When the player completed one edge of the answer route and the railway carriages establish order is exactly the same as the Dijkstra's algorithm, the player will get the score with three times of the spaces number of the edge. The edge from VALENCA to VERIN has 3 spaces of railway carriage; the gaining score is 3*3=9.

The completed score is based on the railway stations in the knowledge card. After players completed the correct order of the algorithm, then players get the completed score.

Table 1. Example of choosing start point card and knowledge card

The starting point card player owned	The recorded linked stations on the knowledge card	Result
VERIN	VALENCA, BRAGA, CHAVES, VILA REAL, BRAGANCA	Useless knowledge card
VERIN	VALENCA,BRAGA, CHAVES, **VERIN**, BRAGANCA	Usable knowledge card

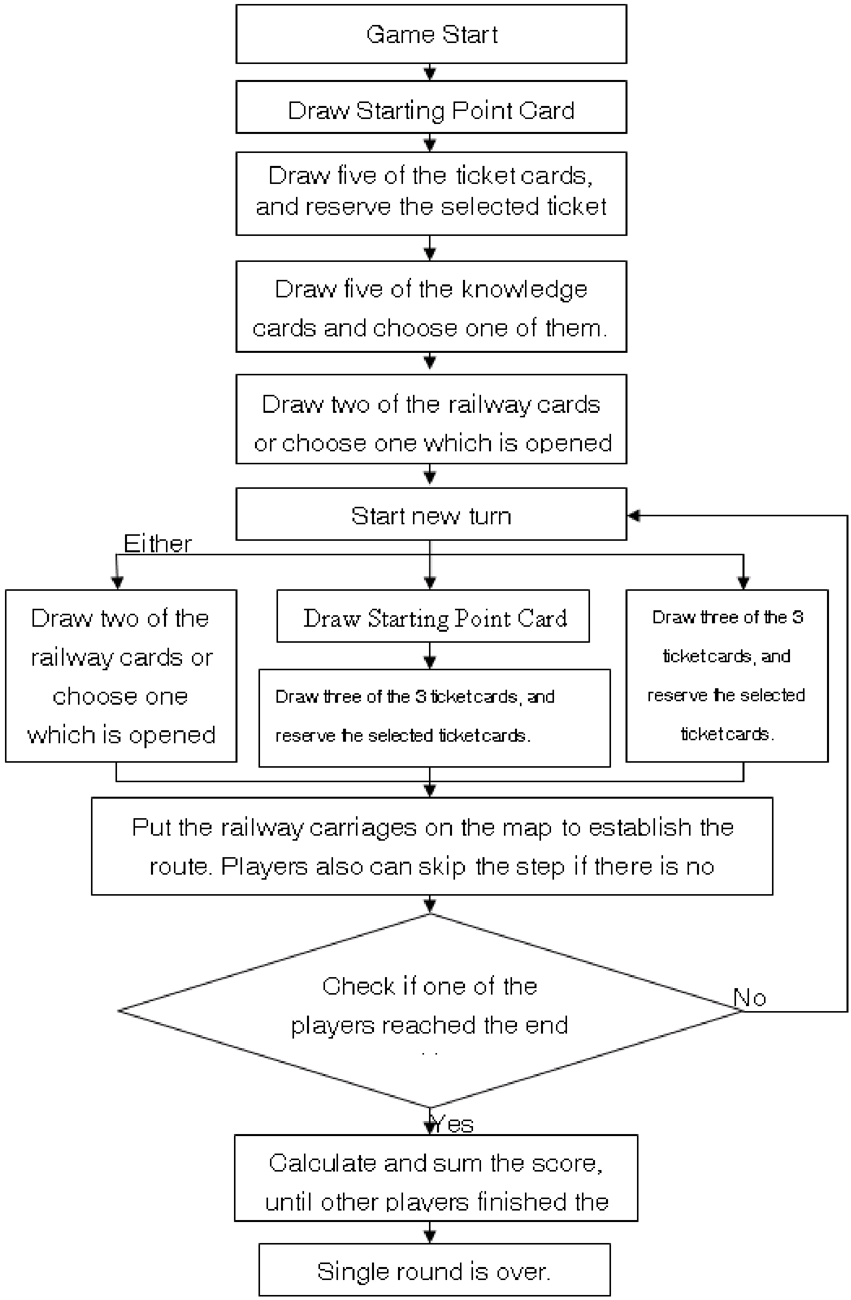

Fig. 2. Single round for each player

Table 2. Example of accomplish Knowledge cards and ticket cards

Connected Railway Stations	Knowledge	Partial Score	Completed Score
VALENCA,VERIN,BENAVENTE,BRAGANCA,CHAVES,BRAGA, PORTO	Dijkstra's algorithm	spaces number of the route*3	14
VALENCA,VERIN,BENAVENTE,BRAGANCA,CHAVES,BRAGA, PORTO	Prim's algorithm	spaces number of the route *2	14
VALENCA,VERIN,BENAVENTE,BRAGANCA,CHAVES,BRAGA	Prim's algorithm	spaces number of the route *2	12

Table 3. Comparison with traditional Education and Teaching combining board game

	Traditional Education	Teaching minimum spanning tree theories combining board game	Darren Lim 's theory
Efficiency in learning	Teachers' ability effect the level of efficiency in learning.	Students can clarify their learning problem with game.	Students can clarify their learning problem with game.
Interest in learning	Hard to let student interested in learning.	Easier to make students interested in learning.	Easier to make students interested in learning.
Students' feeling in learning spanning three theories.	Abstract	Easier to catch the theories	Easier to catch the theories
Prepare before learning	None	Students have to contact this kind of knowledge before.	Students have to contact this kind of knowledge before.
Usable computer science	All computer sciences	Graph theory	Programming, Data Structure, Graph Theory

6 Comparison

In this section, we compare this kind of teaching combining board game with traditional education and Darren Lim's theory [1] in several points of view in Table 3.

After the comparison, we can clearly find the advantage in teaching minimum spanning tree theories combining board game. These advantages are:

(1) Efficiently in learning: Students can use an existence to help them to learn, the minimum spanning tree theories are not abstracts, again.

(2) Interest in learning: Because of this tool is game, so students can learn knowledge with playing game. Anyway, playing is always funnier than sitting in the classroom.

On the other hand, teaching minimum spanning tree theories combining board game also have a weak point. Students have to know this kind knowledge first, then, they can use the game help learning, and Darren Lim's theory is, too.

Compare with Darren Lim's theory, we can find Darren Lim's theory can use in more computer science, but depth of implement, we have concreteness ideas.

We made an additional comparison table shown in Table 4. In Table 4, we compare our ideal with Darren Lim's theory in the points of view "how to implement", "usable range", and "if the ideal be computerized". We can dig out a characteristic in Darren Lim's theory. The characteristic is the theory can be use in widen range. In the other hand, our ideal is better in having a clear and definite way to implement it.

Table 4. Comparison with Darren Lim's theory

	Teaching minimum spanning tree theories combining board game	Darren Lim's theory
If the ideal be computerized?	On cybernation	No mention
How to teach these concepts?	Have clear and definite rules to express concepts	Abstract ideal and no detailed description
Usable range in computer science	Only in graph theory	Not only in graph theory, but also in data structure and programming

7 Conclusion

How to teach and learn the theories of graph is an important to teachers and students. And, how to express some abstract knowledge concepts is difficult. But there, we use game to express and help students to learn minimum spanning tree theories.

By this way, we believe that these minimum spanning tree concepts can be learned much more efficiently. If the idea – combining board game Ticket to Ride with minimum spanning tree theories can be cybernated, the speed of learning must be shorter and the efficiency would be higher.

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A Virtual Laboratory Platform Based on Integration of Java and Matlab*

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Abstract. Recently, it is a hot research to construct virtual laboratory (VL) in the modern remote education. This paper proposes a platform of VL based on the integration of Java and Matlab, which is called VL-JM. The VL-JM platform uses JMatLink to realize the seamless joint between Java and Matlab. Matlab is used for computing in the server, which improves the VL-JM platform simulation capability. In the VL-JM, simple and precise device components have been developed with the combination of JavaBeans components and Matlab. Furthermore, we develop the client with Java applet to make it be independent of operating system. This paper also introduces the design and implementation of VL-JM platform based on the integration of Java and Matlab in details. This paper discusses the realization of Java Matlab Proxy Server (JMPS) in detail, which is used for communicating between Beans components and Matlab. Taking digital communication virtual lab as an example, the communication process and the realization mechanism of the whole platform have been introduced and the validity of the VL-JM platform has been illustrated.

1 Introduction

The rapid development of communication technology and the Internet has brought up significant innovation in our life and study, and also the abundant information resources benefit everybody too. Meanwhile, everybody would like get more chance to obtain education, but there are lots of limitations, such as classroom and laboratory. Consequently, while considering the full use of the lab teaching resources, we must think about how we should use remote education through the Internet fully. We should take it into account and regard it as the very important research task in education. Generally, the remote education based on the Internet adopts the C/S model and users can connect with server and get the corresponding information.

For its convenience, safety and platform-independent, pure Java has been widely used in remote education system to develop virtual laboratory platform. But it is thought as complex that is used to develop all the laboratory components. Matlab is one of common computer process programs which can provide abundant digital

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image, digital signal process, simulation, artificial intelligence and other algorithm packets. It also has been widely applied in the emulation and real time control, especially in the communication fields. Meanwhile, it provides plentiful interfaces and can be called from many languages such as C/C++, Fortran and so on. So, Matlab has extensive prospect.

This paper puts forward a platform based on the integration of Java and Matlab, which fully takes advantages of Java and Matlab to design and realize the virtual lab.

2 Related Research

Nowadays, the web-based virtual experimental environment is one of the hot researches, especially in some colleges and academic institutes. Seen from its realization technologies, Java is the most popular technology in developing VL. There are also some other technologies including Quick Time VR, VRML, ActiveX, Flash and so forth.

Ref. [3] proposed a design of the virtual programming lab for online distance learning. It uses HTML and Java applet on the client side, and CGI and Java Servlet in the server side. Before running an experiment, users need to write their program codes in the client, the client sends the codes to the server. After receiving the request, the server invokes the corresponding language compiler, and then returns the result to the client. Ref. [4] introduces the design and implementation of biology virtual laboratory, in which most of components are implemented with JavaBeans, and the data description is realized in Extensible Markup Language (XML). Ref. [9] proposed the design model and implementing method of virtual computer networks lab which is based on NS2. In the lab, most of components are implemented with JavaBeans too. The design and implementation of digital signal processing virtual lab (DSPVL) based on components is discussed in Ref. [10], in which JavaBeans technology is used for developing all of the components.

At the same time, the research about VL platform is also a hot problem except for developing some virtual labs to fit for the needs of special courses. Ref. [2] introduces the architecture, features and some realization technologies of virtual laboratory platform in details. Its client is implemented with Java applet and equipment components are implemented with JavaBeans. Some specific apparatuses and device in it are programmed as components. Users can design the experiment process visually, and choose or create experimental device objects dynamically. Ref. [5] proposed a new architecture for web-based virtual laboratory with CORBA technology. In the architecture, the Java applet acts as the client tool and CORBA acts as the communication bridge among different objects. The integration of Java Bean, Matlab and COM/DCOM is implemented as computing tools on the server side. Matlab is used for computing in the server that enhances the simulation capability. But it is very difficult to be used because of its complicated technologies.

JMatLink [1] was developed by Stefan Muller, which is used as the interface to connect Java and Matlab. Functions in the Matlab can be called in Java, which will simplify the complexity of algorithm implemented with Java. Ref. [6] shows that Java and Matlab can communicate with each other through JMatLink and describes the integration of real-time hardware, a data analysis tool and web-based services. A web-based educational software package called RIO (Robotics Illustrative sOftware) is introduced in Ref. [7]. RIO integrates VRML and Matlab, the user interface consists of a Java applet along with VRML model, and the applet is capable of intercommunicating with Matlab in the server with JMatLink.

Using Java to implement some algorithm components is complex and inefficient in the development of VL, but there exists the same algorithm packets in Matlab. Therefore, we can invoke algorithms in Matlab to solve the problem that Java is hard to realize by integrating Java and Matlab. Although CORBA technology had solved the communication among different objects, it is so huge and complicated and slow in renovation of technology standard that it is not widely been used in practice.

This paper proposes a new virtual lab platform, which can implement the communication between Java objects and Matlab engine functions. The platform is constructed based on the integration of Java and Matlab. In this paper, we also discuss how to use the platform to develop the virtual lab of the digital communication and other courses labs supported by Matlab.

3 The Architecture of VL-JM Platform

The VL-JM platform, which is based on the integration of Java and Matlab, adopts C/S model to fulfill the design respectively from server and client. The client adopts Java applet technology to develop user interface for experiment, and JavaBeans component technology to develop virtual experiment device. Remote users can choose experimental components in the user interface, assemble experiment flow according to real experiment, and then run the experiment to get the results. The server mainly contains two parts. One is the virtual experiment devices, which are composed of component library and component register XML files; and the other is Java Matlab Proxy Server (JMPS) which processes the user requests and acts as a bridge between Java and Matlab.

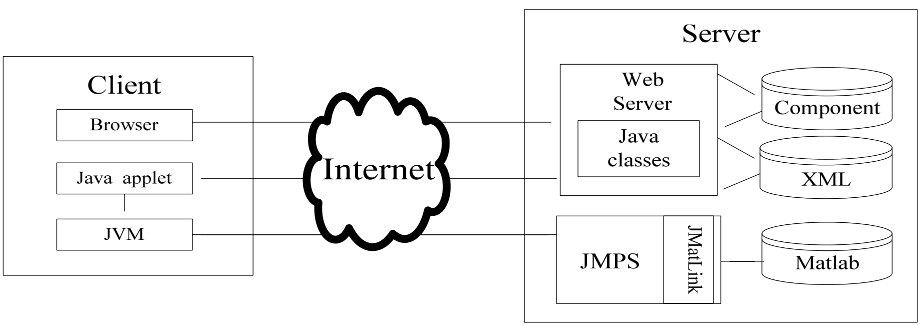

Fig. 1. The architecture of VL-JM Platform

The architecture of VL-JM platform is shown in Fig.1. The procedure for remote users to execute experiment is as follows:

(1) Users send requests to download the applet page from the remote server through browsers, which support JVM (Java Virtual Machine).

(2) The server analyses the XML files including registering components according to the requests sent by users, and sends these corresponding class files back to users.

(3) Users initialize user interface window after receiving these class files, and then assemble the experiment flow according to the experiment demand to do experiments.

(4) Users push the “run” button in the interface. Then each Bean is executed one by one according to the experiment flow. While there is an object which calls Matlab function in the Bean, the system will send the requests to the remote server in order to invoke Matlab function.

(5) The server invokes the Matlab function through JMatLink after detecting the users’ requests, and sends back the data processed by Matlab through JMPS.

(6) After these receiving data are processed by all components in the experiment flow, the final results can be obtained and displayed on the interface.

4 The Implementation of VL-JM Platform

According to function requirement in VL-JM platform, we adopt object-oriented method to design and implement. At the server, we have Java application as a proxy server to deal with the requests from remote multi-users for accessing Matlab and returning results. At the client, we utilize Java applet to develop the experiment interface window and experiment device components, which are independent of operating system. The implementation of platform is introduced in the following in detail.

4.1 The Implementation of Server

There are two main works in server. One is to distribute the experiment instrument components, and the other is used for listening to and responding to the requests from remote users. Functions in Matlab can be invoked to compute and then the results can also be sent back.

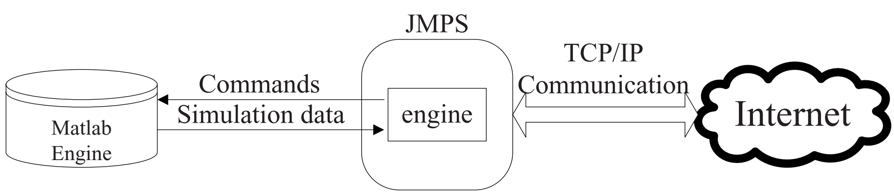

Fig. 2. Communication through JMPS

As shown in Fig.2, in order to invoke the Matlab functions and provide the communication among different objects we develop a Java application called Java Matlab Proxy Server (JMPS) in the server side. The engine object can be built by JMatLink library which contains a set of Java classes. The object plays a key role in communication between Java and Matlab and deals with the requests from remote multi-users.

The main functions of JMPS are as follows:

(1) Open, close Matlab computing engine, and to communicate with Matlab.

(2) Invoke Matlab engine functions after parsing the data stream from the remote components’ methods.

(3) Detect the clients' requests and return results.

To realize these functions of the JMPS, we utilize Java Socket and multi-thread technology to solve these problems which are involved in listening to remote clients' requests and multi-users access. A TCP/IP Socket connection is implemented between Bean component and JMPS. By using the connection, the results and the remote clients' requests can be transmitted in stream format. Once one request is accepted successfully, a new thread will be started to maintain the connection between the server and the client. Bean component holds a client socket and JMPS holds a server socket correspondingly. The definition of JMPS is shown in Fig.3.

```
public class JMPS extends Thread {
   … …
   public void run(){
   //get the data stream after detecting request from user
   streams=(String)getStreams();
   CallMatlab cm=new CallMatlab(); //build object
   parse(streams); //get sub string and value array
   result=cm.CallFunction(sub,value); //call Matlab and get result
   printStreams(); //output the data to client's Bean
   closeConnection();
   cm.closeEngine(); //close Matlab engine
   }
   … …
}
```

Fig. 3. Definition of JMPS

Native methods make it possible to use Matlab's computational engine inside the user's own Java applications, applets, and servlets as JMatLink connects Java and Matlab. JMatLink uses Java JNI technique to locate and call non-java methods. First of all, it compiles C/C++ source files, and then changes these files into Dynamic Link Library (DLL) and imports Matlab library functions so that these functions can be easily called. As a result, Matlab engine functions can be used from a Java program by implementing engine function calls in C language native methods. Detailed process of communication between JMPS and Matlab is shown in Fig. 4. JMPS start a

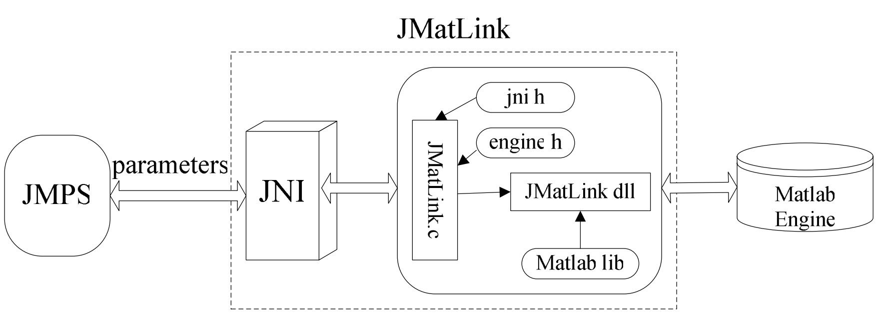

Fig. 4. Communication between JMPS and Matlab

thread when detecting a request from a component. Then the thread analyses the data stream from the component to obtain data to be processed and component information, which plays a role in locating and calling a certain function of Matlab. Finally, the thread sends the data into computing engine of Matlab. Such kind of realization is implemented by engine object which supports multi-users' calls. The thread executes method of the object and passes parameters in command line to Matlab for further processing and the results will back to clients.

4.2 The Implementation of Client

The main functions in client side include offering friendly experiment interface and assembling an experiment flow in the interface, adjusting parameters of the device, running the program according to the flow and displaying the results, dynamically registering the experiment components, saving the experiment flow and giving online prompts, etc.

In the process of designing user interface, we adopted pure Java technology to develop several classes. It mainly consists of MainWindow class, MainMenu class, ToolBar class, DeviceCarrier class, RegisterClassPane class and DeviceConnector class. The relation among them is shown in Fig. 5.

In the client, users could either choose the equipment components from the experiment device list, or add and register new components at local. Therefore, it is required that the components should be easily developed and have high efficient. According to these characteristics, we adopt the component technology during the development of equipment component in VL-JM platform. The JavaBeans technology, which binds Java technology and component technology, make the development of the Java program fast, easy and apt to maintain. All the devices in VL-JM platform are developed according to the JavaBeans standard. All components provide the external call interfaces. Its implementation is encapsulated in each Bean, so that the user could add their device components. The "get" and "set" methods in Beans component could provide access and modification of its attribution. In this way, the operation on setting and reading of the attribution of the experiment components could be achieved.

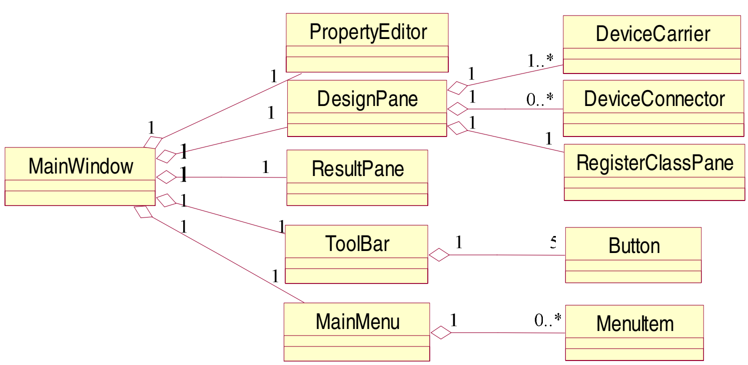

Fig. 5. User interface window class

Using the Beans component technology, users could dynamically choose the equipments, assemble experiment flow as well as set the parameters of the experiment. While the event response and communication approach could be utilized for the data interaction and communication between the components in VL-JM platform. Fig.6. demonstrates the pattern of creating Beans component in our VL platform.

```
public class NameOfClass {
  private type variable;//for internal usage, which makes the class
                          // encapsulated well
    public NameOfClass()  { … }//constructor initialize some variables
   /*method  in Bean component is used for invoking Matlab */
    public type NameOfMethod(){ … }
    public void setProperty(){ … }//set value of device component
    public type getProperty(){ … }//get value of device component
}
```

Fig. 6. Pattern of Beans component

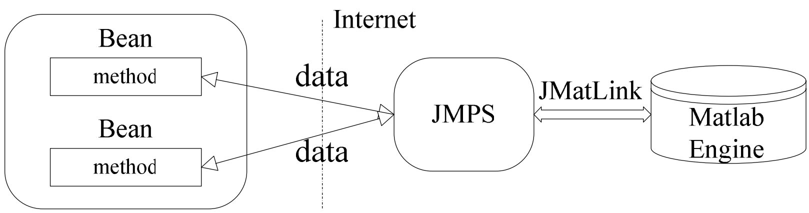

Fig. 7. Connection between components and Matlab

When writing source codes, according to the pattern of the component, we only need fulfil the algorithm, which achieves the equivalent functions of actual equipments, of accomplishing equipment facility by the Beans component methods. We adopt some relevant algorithms in Matlab to realize the corresponding functions. The VL-JM platform integrates the JMatLink call Matlab algorithms into the Bean components, which can get the results outputted by Matlab to the method of components through JMPS. The relationship of them is shown in Figure 7.

5 Digital Communication Virtual Laboratory

Digital communication is an elementary course for undergraduate in many specialities, in which experiments are essential. In order to provide an effective and interactive experiment environment with abundant instrument components in Internet, we developed and realized the digital communication virtual lab on VL-JM platform.

We take the low-pass filter experiment for example to introduce how to develop device components in the client and how the JMPS responds to user's requests and invokes functions in Matlab.

```
public class FIRLowFilter {
   ……
   /* Bean' s method is used to send request to call lowFilter method */
   public double[] lowPass(double[] value){
      output=new ObjectOutStream(client.getOutputStream());
      output.writeObject( "lowFilter" + "." +outputStr);
      output.flush();
      input=new ObjectInputSteam(client.getInputStream());
      inputStr=(String)input.readObject(); //get result return through JMS
      … … //parse
     }
  //displayData array will be prepared for interacting with next Bean
   return this.displayData;
   ……
}
```

Fig. 8. The part of low-pass filter component

```
public String lowFilter(double[] value){
   … …
   engine.engEvalString("y=fir1(n,0.2,'low')");
   coefficient = engine.engGetArray("y");
   engine.engEvalString("return=filter(coefficientb,1,value)");
   matrix = engine.engGetArray("return");
   … …
   return message;
}
```

Fig. 9. The implementation of calling functions in Matlab

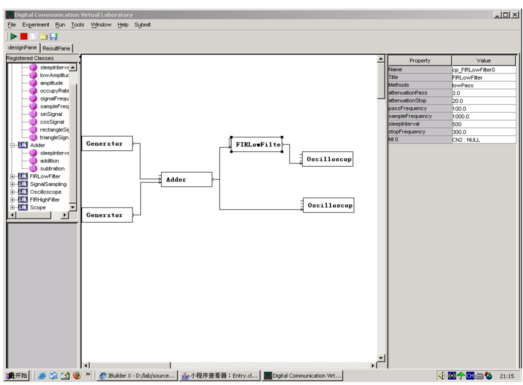

Fig. 10. Experimental interface window

In the client, the design and realized codes of the low-pass filter component is shown in Fig.8. In the method named lowPass, the double array is used for storing the data which is sent back after invoking Matlab function. The data in the array will be

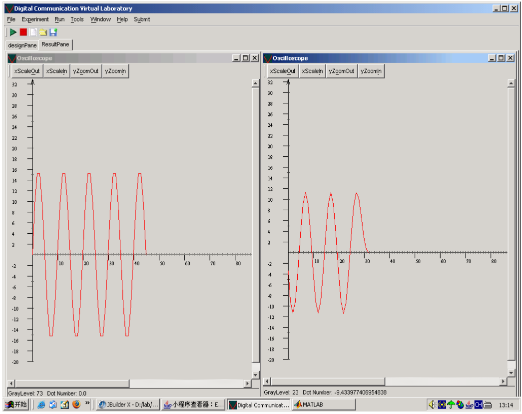

Fig. 11. Result of the experiment

processed and then be transmitted to the next components until it reaches the final one of the whole experiment flow. When users set the experiment flow and push the "run" button, the system will send a communication request based on TCP/IP and wait for the results after the component is executed.

In the server, JMPS detects the user's request and judges which method is called in Matlab from the request (e.g. lowFilter). Then it executes the lowFilter method embedded in the JMPS, which mainly uses "fir1" function and "filter" function in Matlab. After that, the result is sent back to remote users. The main code is show in Fig.9.

The procedure of experiment shown in Fig.10 is summarized as follows:

(1) Users apply for downloading the applet page through browser, and obtain the corresponding class files for the laboratory platform according to the response event on the page from the Server. Then the virtual machine in the client is run to initialize the window of the user interface.

(2) According to the experiment demand, users choose experiment device components including two Generators, one Adder, one FIRLowFilter and two Oscilloscopes in the left equipment list in the interface.

(3) Users add these device components into the experiment panel, and can modify the component attributes from the attribute list-box in the right in terms of their own demands. Then all components in the experiment panel are connected according to the experiment flow, which is shown in Fig.10.

(4) Users push the "run" button. The client checks the device components in the queue automatically, and organizes these components in terms of the experiment flow.

(5) According to the preset attributes in the component, two Generators generate 32 bytes signal data respectively, and send them to the Adder. The Adder component makes the two 32 bytes signal data overlapped and send the result to the FIRLowFilter component and one Oscilloscope component respectively. The Oscilloscope component displays the overlapped signal in the result panel. The FIRLowFilter component sends the data stream to the server to invoke "fir1" function and "filter" function in Matlab. The results of Matlab functions are sent back to the FIRLowFilter component. The

results of FIRLowFilter component are sent to another Oscilloscope component to display.

Users can compare the results of the Adder component with the result of the FIRLowFilter component in the two Oscilloscope components.

(6) Execute step (5) iteratively until users push “stop” button.

The experiment result is shown in Fig.11. The left frame is the signal of the Adder component, and the right frame is the signal processed by the FIRLowFilter component. In the experiment flow, we notice that the signals are changed according to the iteration of the step (5), which improves the effect of the experiment. Then user can get more knowledge about low-pass filter.

6 Conclusion

In view of the question existing in the design and development of present VL, this paper proposed the design and realization methods of laboratory platform based on the integration of Java and Matlab. The combination of Beans components and Matlab in the VL-JM platform enhanced the developing efficiency of components. The VL-JM platform has the following characteristics:

(1) Make the development of components efficient.
(2) Be independent-platform.
(3) Make it easy to construct one virtual laboratory.
(4) Have friendly user interface.
(5) Make the component reusable.

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Multi-agent Framework Support for Adaptive e-Learning

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Abstract. In the past years, agent technology is considered one of the most innovative technologies for the development of software systems. Meanwhile, following the rapid development of Internet, particularly web page interaction technology, web-based learning has become increasingly popular. However, there not yet has a perfect framework in e-learning system's software designing. This paper proposes a multi-agent framework to realize an adaptive e-learning system. Experimental results indicate that applying the proposed framework for personalized e-learning system is feasible and robust.

Keywords: Multi-agent; Adaptive e-learning; Web-based tutoring.

1 Introduction

In the past decades, the rapid growth of the internet has brought a great deal of changes in our educational environment. Internet and web rapid development has provided new mentality and method for e-learning. E-learning has a inherited merit like not limit by time, spatial and place in the traditional learning, learners may participate on-line study, on-line test, on-line discussion as well as on-line Q/A and so on. Otherwise it provides abundant, rich, colorful and an alternating interface between man and computer for study. It can stimulate learner's study interest, thus the goal of acquisition knowledge, self-renewal even knowledge innovation is achieved. The merit of e-learning not only lies in it's a very good content carrier could visit at any time, but also lies in it provides many exchanged channels allowed teachers and students to discussion. The emerging e-learning is reshaping the instructional community and provides tremendous cost savings for both instructors and learners[1,2,3].

But it lacks in interaction aspect, intelligence, personality, adaptability, simultaneously and returning feedback information not in time, its easy to misleading in learner's study process. Otherwise, it is not realize leaner's characteristics intelligently, it causes learner lose one's head when in front of the websites which filling lots of teaching information, and can not learning effectively. Therefore, how to enhance the e-learning intellectualized degree is our urgent work.

In recent years for achieved this goal, in the artificial intelligence domain, multi-agent technology provides a good opportunity. With the rapid development of AI(Artificial Intelligence),the agent technology is nearly mature. The agent has many

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characteristics, such as autonomy, proclivity, reactivity, sociality, collaboration, intelligence, and so on. Thus, in the agent environment, educational application focus on information searching, information organization, scheduled events response, problem solving, knowledge mining and regular service of internet. Hence, using agent technology, e-learning systems makes itself disadvantages up effectively[4]. In the real world, questions are extremely complex, individual agent function is extremely limited, generally, it is very difficult to complete the assigned task, and then, needs to organize many agents to form multi-agent system through suitable system structure to undertake tasks together, the multi-agent system could make up the insufficiency of single agent and its function surpass single agent[13].

MAS(Multi-Agent System) technology has impressively emerged as a new paradigm for software development[5]. As autonomous software components, agents can interact through a standard protocol and collaborate with each other to achieve common goals. MAS can help application designers to conceptualize solutions better: this paradigm may be more naturally suitable for certain types of applications; they can help improving code modularity and reusability; they can help hiding network, system and protocol heterogeneity. The features – autonomy, sociality, and communication possessed by agents make it easy to decompose a complex task into some simple ones and then assign them to individual agent that collaborate, negotiate and eventually achieve the common goal. Naturally, the agent-based software engineering paradigm is particularly suitable for developing various distributed systems because it could accelerate development with agent components and enhance modularity, speed, reliability, flexibility and reusability. At present, considerable research in agent technology applications for e-education has been conducted over the past few years.

The main contribution of this paper is to propose a multi-agent framework to realize an adaptive e-learning system. In the e-learning context, the indispensable functions are the diagnosis(assessment),online helping, adaptive navigation and courseware recommendation[6] and so on. In this framework, each function is undertaken by an intelligence agent.

This paper is organized as follows: Section 2 describes the system architecture of the adaptive e-learning system and the functions of each agent. In section 3, we give a experiment and evaluation of the system. Finally, we draw our conclusion in Section 4.

2 System Architecture

This section describes the system architecture, system components, and functions of each agent in the proposed personalized e-learning system. The system architecture of the adaptive e-learning system are outlined in Fig. 1.

2.1 System Architecture and Components

Here, an adaptive e-learning system based on multi-agent technology, which includes eight intelligent agents, four databases and two repositories are presented. The eight intelligent agents are learner interface agent, teacher/expert interface agent, diagnosis/assessment agent, adaptive navigation agent ,courseware recommendation agent, auto-reply agent, courseware/testing items management agent and database management agent, respectively; the four databases include learner account database, learner profile database, testing items database and teacher/expert account database; The two repositories include the courseware repository and answer document repository.

Learner interface agent aims at providing a flexible learning interface for learners to interact with the personalized e-learning system. The teacher/expert interface agent aims at providing a friendly management interface for teacher/expert to manage the courseware and testing items of the system[7, 8]. The function of database management agent is used to manage the four databases and the two repositories. All intelligent agents which need interacting with the four database or the two repositories must use the database management agent to manage data. The courseware/testing items management agent aims at managing the courseware and testing items of the adaptive e-learning. Teachers or experts can use the agent to create new testing items /course units, upload testing items/courseware to the testing items or courseware database and delete or modify testing items/courseware from the testing items or courseware database. The auto-reply agent has two functions, one is to answer learner's questions automatically, another is to organize and manage the answer document of the system. The diagnosis/assessment agent is the important agent in the system, which in charge of investigating the profile information of learner who first use the system, providing a final test while the learner finishes the whole learning process and storing these resulting information in the user profile database for personalized e-learning services. Moreover, the adaptive navigation agent is responsible for guiding the learner's learning process based on the learner's studying situation and storing learning records into the learner profile database. The

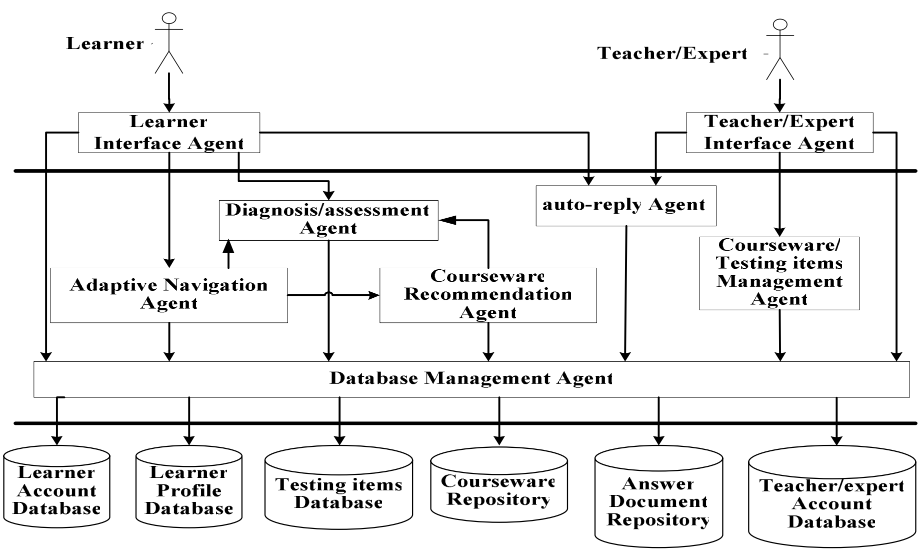

Fig. 1. The system architecture of the adaptive e-learning system

courseware recommendation agent is in charge of recommending a personalized learning courseware to learner according to learner's ability and courseware's difficulty. The system architecture is shown as Fig. 1.

2.2 Interface Design

The interface of the system includes two parts : learner interface and teacher\expert interface, which are managed by learner interface agent and teacher interface agent.

The learner interface agent provides a flexible learning interface to interact with learners, conveys the learners' feedback information and testing results to the diagnosis/assessment agent, receives the recommendation coursewares from the adaptive navigation agent,and then, displays the coursewares to the learners. Through the learner interface agent, learners can choose interesting course categories and units to study and use on-line helping to solve the encountered problems during the learning process. Learners can also enter appropriate keywords for searching the needed courseware through the system's search mechanism during learning process. If a learner visits the personalized learning system for the first time, he/she must register as a legal user by inputting his/her individual basic information, and then the learner interface agent stores these individual basic information to learner account database through the database management agent.

Teacher/Expert interface agent provides a friendly interface[15] to interact with teachers or experts. Through teacher interface agent, teachers or experts can upload, delete, or revise courseware and testing items stored in the courseware repository and testing items database. Teachers can also manager the answer document stored in answer document repository, give training cases to train the auto-reply agent for automatically answering students' questions.

2.3 Personalized Web-Based Tutoring

The personalized web-based tutoring module includes three agents: diagnosis/assessment agent, adaptive navigation agent and courseware recommendation agent. The three agents through a standard protocol, collaborate with each other to achieve personalized tutoring. After a beginner logs into, the diagnosis/assessment agent will give a questionary for collecting learner's profile information(learner's behaviors, interests, cognitive characteristics, knowledge level and ability) and store these profile information to learner profile database for providing personalized tutoring services, and then conveys learner's profile information to courseware recommendation agent and adaptive navigation agent. The courseware recommendation agent based on learner's profile information estimates learner ability, and then selects suitable difficulty levels courseware for learner[12]. Based on the learner's profile information and coursewares recommended by courseware recommendation agent, the adaptive navigation agent conduct personalized curriculum sequencing for learner[9], meanwhile, communicates with the learner interface agent to guide the learning contents according to the planned learning path for individual learner and the learning processes of individual learner are also recorded into the learner profile database for personalized tutoring. After learner finishes the entire courseware planed by the personalized tutoring system module, the adaptive navigation agent will notice the diagnosis/assessment agent to randomly generate a testing sheet to the learner for performing a post-test in order to evaluate learning performance. The generated testing sheet in a post-test will be transformed to learner interface agent, and then displayed to the learner. The post-test results are also provided to the learner for self-examination and stored into the learner profile database. So far, the learner finishes the entire learning process for a learning course unit.

2.4 On-Line Helping

If learners encounter problems during the learning process, their learning performances could be significantly devastated due to no instant aid. So, online helping system is very important for an adaptive e-learning system[10].In this multi-agent framework, the on-line aid function is undertaken by auto-reply agent. The auto-reply agent can automatically reply most of the questions submitted by the students with the answers provided by the teachers. If no feasible answer[11] can be found in the answer document repository, the agent will forward the questions to the teacher/expert interface agent, and then the auto-reply agent will remind and assist teacher in answering the question. Once the new answer is available, the system will send it to the learner via the learner interface agent. Moreover, the teachers can review all of the questions submitted by the learners and the answers replied by the systems with corresponding satisfaction degrees rated by the learners, which is helpful to the teacher in realizing the learning status of each learner and the performance of the system.

2.5 Courseware/Testing Items Management

The courseware/testing items management agent administers the details of maintaining the courseware repository and testing items database. The agent provides lots of robust functions for teachers to upload, delete, or revise the content of courseware in the courseware repository. Through the agent, experts can design testing items for learning content. Because all coursewares in the courseware repository have followed the standard of SCORM 1.2 (Sharable Content Object Reference Model) metadata information model (Advanced Distributed Learning)[14],the agent can exchange courseware with other e-learning systems.

3 Experiment and Evaluation

Based on the multi-agent framework, an adaptive e-learning system has been implemented. The proposed system is implemented on the platform of J2EE. Moreover, the genetic algorithm, data mining algorithm and machine learning are used to implement this system. Fig.2. is one of the learner's interface. To verify the system's effectiveness for the proposed personalized intelligent learning system, some high school students were invited to test this system. To evaluate learners' satisfaction degree for the proposed personalized e-learning system, a questionnaire which involves many questions distinguished six various question types(table1) were

Table 1. The six question types

Question type	Description
The satisfy of system services	To investigate whether learners satisfy the provided learner interface and course materials
Learning interests	To investigate whether learners are interested in using the proposed adaptive e-learning system for mathematical learning
learning mode	To investigate whether learners can accept the proposed learning mode with personalized tutoring
learning interction between teachers and learners	To investigate whether the proposed adaptive e-learning system affects learning interaction between teachers and learners
learning attitude	To investigate whether learners with computer use the proposed personalized e-learning system for learning at home
learning performance	To investigate whether the proposed personalized e-learning system can promote learners' learning performances and confidence

Fig. 2. The learner's interface

designed to measure whether the propose.There are totally 216 effective questionnaires filled out by learners who participated in this experiment. Among 216 effective questionnaires, 78% learners selected “strongly agreed” or “agreed” items,13% learners selected “neutrality” items, only 9% learners selected “strongly disagreed” or “disagreed” items. The investigation result illustrates that the multi-agent adaptive e-learning framework is high feasible and robustd e-learning system satisfied the real requirements of most learners.

4 Conclusions

This paper proposed a multi-agent framework for building adaptive e-learning system. The proposed architecture considered all indispensable functions which include diagnosis(assessment),online-helping, adaptive navigation and courseware recommendation, and so on, in the personalized e-learning system. This paper makes a critical contribution: proposed a multi-Agent framework to realize an adaptive e-learning system. The experiment also demonstrated that the system can efficiently and splendidly perform personalized web-based tutoring works. However, the project is still in its early stages; there are still a lot of works left to be done and there are still many open design and implementation issues. Additionally, in order to improve the system in terms of functionality and efficiency, some design aspects need further investigation.

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Construction of Project-Based Virtual Learning Community

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Abstract. With the further reform of education in our country, new teaching models spring out centered on learning. To meet students' needs for autonomous and constructive learning, it's urgent that besides appropriate resources and contexts, teachers have a relevant learning environment attached to new teaching models to aid teaching in class and realize students' autonomous learning. This paper, take project-based learning for example, mainly starts with definitions of PBL and project-based virtual learning community (abbrev. PBVLC), and expounds components of PBVLC. In the light of constructive perspective for learning environment components and web-based cooperative learning, this paper systematically scaffolds the model of PBVLC and develops it with technologies of ASP and Access.

Keywords: Project-based Learning (PBL); Virtual Learning Community (VLC); Project-based Virtual Learning Community (PBVLC).

1 Introduction

As knowledge innovation is our society's kernel feature, which needs a large quantity of creative talents, it is crucial for our country and people to cultivate creative talents to develop knowledge economy and improve competitiveness in the world. Secondly, in the times of IT represented by macromedia and network technologies, progress in compute science, especially births of macromedia and network technologies, makes changes in the models of various domains' operation and development, and changes in life style &learning style. With the aid of IT, people can more quickly, more accurately acquire and feedback more information. Depending on information delivery, science and technology, politics, economy and education, etc. develop faster. Therefore, it's necessary

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for people to exploit IT to acquire and process information. According to the features of modern society, reflecting on today's education in our country, we find out that current education is not suitable for modern society's development, and we must reform our education, in which introducing a series of new teaching models is an important innovation, which are quest-based learning, problem-based learning, resource-based learning, project-based learning and so on. This paper expounds project-based learning (PBL). See from teaching practices, PBL in traditional class has gradually showed limitations in IT as followed:

- a small learning community
- limited resources
- bad feedback and evaluation

Those limitations would be overcome in cyberspace. Herein, it's necessary to study project-based virtual learning community (abbrev. PBVLC).

At abroad, studies on PBL are definitions of PBL, underpinning theories of PBL, effectiveness of PBL and problems in implementing PBL. According the research review of PBL, the learning style of PBL tends to be applied to the programs (Alberge University, 1980s) , not to one chapter. Moreover, PBL is implemented against the true contexts of real life, not against the virtual contexts. This paper intends to design , develop and apply PBVLC.

2 Definitions of PBL and Project-Based Virtual Learning Community

According to definitions of PBL provided by experts at home and abroad, in general, PBL (project-based learning) is an innovative exploring learning model to solve a series of relevant problems in some time. It focuses on the central concepts and principles of a discipline, intends to motivate students to construct their own knowledge and culminates in realistic in products and abilities. Students take part in real-life projects to launch exploring learning. PBVLC (project-based virtual learning community) is a learning community on the line which forms a mutual teaching and learning process during studying a project.

3 Components of Project-Based Virtual Learning Community

According to the learning-oriented instructional system design(ISD) model, PBL starts with a driving project, provides a task and designs learning contexts, materials, strategies, cognitive tools, aids, task management, learning management and supervision etc. centered on the task which is decided by learning targets, learners, and contents. In the light of PBL in class and other learning models, PBVLC should include instructional components as the following (see Fig.1.), which construct an open and close system.

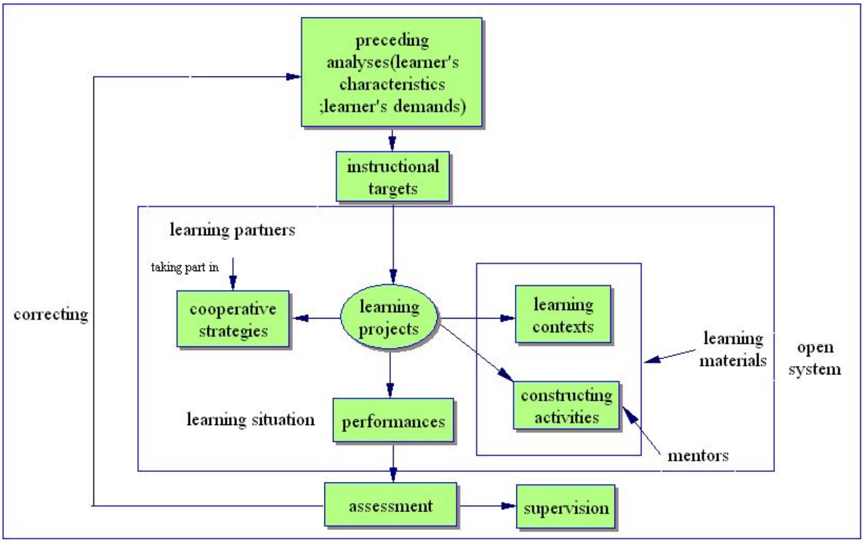

Fig. 1. Components of PBVLC

4 A Model of Project-Based Virtual Learning

PBVLC is centered on learning activities with the aid of teaching, which has mainly designed teaching and learning activities as followed: (see Fig.2.)

The model of PBVLC starts with student's registration before he or she logs in it at the first time. Students are advised to input their own basic information into the

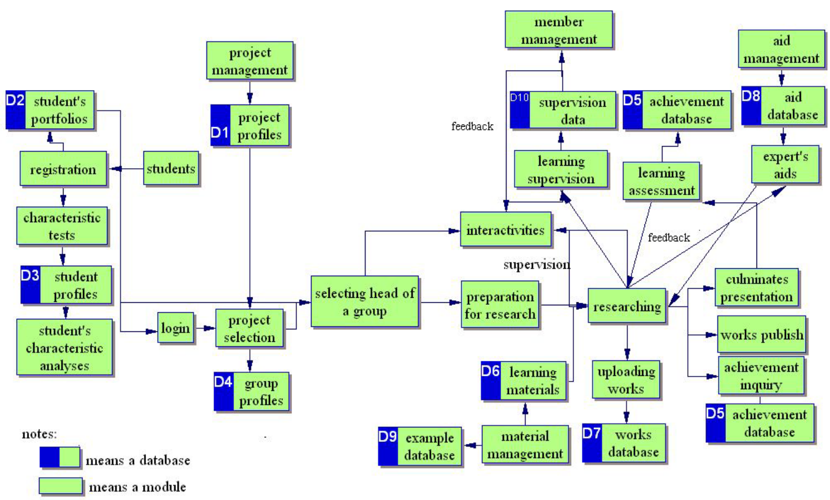

Fig. 2. The Model of PBVLC

database of student's portfolios. After that students have to accept characteristic tests including learning styles, information literacy, researching abilities and so on, and then output a database of student profiles. After registration, students can log in the system to learn. Firstly, each student will select a project from the database of project profiles and the database of group profiles will get an item of information about project selection. Students can seek for partners with the same interest on the line. When the project is selected by a preset number of students, they select head of their own group by voting. After that, learning partners of the project begin to prepare for research, included with signing out a project contract with their teachers, confirming their own tasks and writing the report for the selected project. After preparation, students begin to study. During studying, students need to be helped by online learning materials, experts and teachers offered by Aid Database. Meanwhile, in the course of researching, interactivities between students and teachers are to be fostered. Some information of interactivities will be collected by the module of learning supervision and be stored in the database of supervision. In the block of teachers, the number of student's login is showed by the module of person management. Teachers feedback the information of supervision database to the students by means of interactivity to supervise a student's learning. During the course of research, the group of a project will punctually upload their own works to the database of works observing the items of the project contract. Through the module of culminates presentation students presented their own works. Teachers will qualitatively evaluate student's performance of some time and feedback assessment to them. Finally, in the end of research, each project group will upload his works, each member of a group need to evaluate other member's PBL process, and teachers are required to evaluate the works of each group and each student's PBL process, the total grade is summed up by the computer. Such assessment is summative. The database of student's performance consists of two parts: PBL process and the final works. Furthermore, students can find out their own achievements by the module of achievement inquiry. Works honored with the top best can be published on the line to share with others.

5 Development of Project-Based Virtual Learning Community

The whole PBVLC, which uses ASP and ACCESS as developing tools, adopts B/S mode. In this paper, take learner's modules for example, the module of preceding analyses exploits online investigation on learner's characteristics, the one of interactivities is realized by means of BBS, chat-room and sending/getting message and the one of project selection, which is made up of project layout & selection, group constitution and project agreement etc., is completed by means of online databases. This system attaches important technologies to group constitution, research process, multimeta assessment and achievement inquiry. Of them,

5.1 How to Restrict the Number of a Group's Members

Firstly, teachers lay out data about research orientations in this phase. Secondly, learners spontaneously organize a group by means of BBS and others in the light of learner's characteristics. In general, a group consists of 4-6 members. Finally, teachers consult project topics with groups by means of BBS, chat-room and sending/getting message with regards to group's willings and lay out project topics with limited members. (The limitation is preset by teachers.). How to judge a group's members more than the limitation given is difficult and important in technology.

To overcome the difficulty, in designing database tables, the system presets the fields of member limitation called PNum and the number of members registered called RNum. When a member select the project, the system firstly judge whether RNum is larger than PNum. If so, the system will show cautions, or else, RNum automatically adds 1. The codes as followed:

```
<% …Judging whether the number of members is larger
than the Limitation……

if rsProject("RNum")=rsProject("PNum") then

          response.Write("the number of the group has
been larger than the limitation ,please reselect.")

          response.End()

else

rsProject("PNum")= rsProject("PNum")+1

rsProject.update

…%>
```

The flowchart of which followed by:

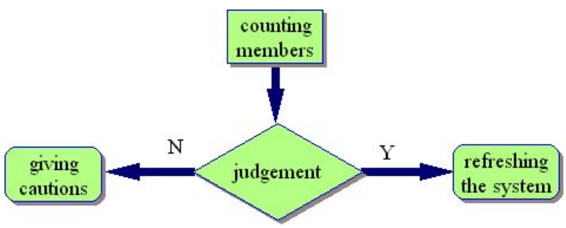

Fig. 3. Judging whether the number of members is larger than the Limitation

5.2 Important Techniques in the Module of Research

When learners has selected a project and constituted a group, they will enter the module of research (see figure 2), where learners will make good use of the situation given by PBVLC to cooperatively study. This module consists of drills, lectures, discussions, chats, records on a group's activities, interviews, investigations, reflections and aids. There are two difficulties in this module.

5.2.1 Techniques of Drills, Lectures, Interviews, Investigation

Drills and lectures are dynamic data of a project given by the system of PBVLC. However, interviews and investigations are main divisions of the research module. All the data of the four divisions are stored in the same database, which are distinguished from each other by the field of Type. When learners browse a webpage, the system will show one of them by judging the field of Type.

5.2.2 Techniques in the Module of Reflection

To meet learner's individual demands and make the reflection forms individualized and safe, not only do the reflection forms mainly employ the technology of eWebeditor, but also the fields of Length and Password is added to them (In which, Length is used for characters showed. If Length is 0, the form of reflection will be completely showed.). When learners input the password of the reflection form and submit, the system will execute encrypting in the use of md5 (which is only used to encrypt, not to decrypt.) For example,Strings will be encrypted as followed:

```
Dim strPlainText as String="Encrypt me!"
 Strings will be stored in the array as followed:
Dim hashedDataBytes as Byte()
Dim encoder as New UTF8Encoding()
To construct MD5CryptoService as followed:
Dim md5Hasher as New MD5CryptoServiceProvider()
To execute encrypting as followed:
hashedDataBytes =
md5Hasher.ComputerHash(encoder.GetBytes(strPlainText))
```

Judging from the examples as above, before encrypting a string, we must convert the string into an array at first, which will use GetBytes from Class UTF8Encoding to convert a string into an array and output the encrypted results from the array.

5.3 How to Sum Up Learner's Achievements

Assessments on PBL process, a group's works, online tests are implemented by learners themselves, partners and teachers. In general, assessments are divided into test evaluation, PBL process evaluation and performance evaluation. Learners use rubrics to make quantitative assessment over themselves and others. Teachers also use the same rubrics to make quantitative assessment over learners.

5.3.1 Assessment over the Process of PBL

In learning, partners of a group know about each other better, which makes assessment objective. At first, whether the student is evaluated by others and himself/herself, if not, the system will show the hyperlink of assessment (whose codes are "evalstudent.asp？userid=stuID") and come out the webpage of PBL process rubrics with the five grades of best, better, good, pass, bad showed by 5,4,3,2 and 1. Finally, the form is submitted and the program of evalstudentok.asp will execute grading.

```
<% … …
…………To connect a database and construct a muster…………
if not rs2.eof then’ whether he/she is evaluated
……’(IF he/she is evaluated, the system will show
her/his marks.)
Else
         sql="select * from evalsubitem"
set rs=server.CreateObject("Adodb.recordset")
           rs.open sql,conn,1,3
           usercent=0'(marks provided by users)
          while not rs.eof

         str=request.Form("eval"&rs("EvalSubId"))’(gett
ing data from users)
          usercent=usercent+cint(str)’(step is 5)
          rs.movenext:wend
          Subcent=Subcent+usercent
         rs1.movenext
         allcent=subcent
         set rs3=server.CreateObject("Adodb.recordset")
         sql3="select * from evalresult where user-
name='"&username&"' and fromuser-
name='"&session("username")&"'"
         rs3.open sql3,conn
         if  rs.eof then'(to insert results)
         if username=session("username") then
         zd=EvalSelf’ (marks from evaluation is written
to the field of EvalSelf)
         else
zd=EvalGroup’jmarks from partners in a group is written
to the field of EvalSelfj
end if
sqlstr="insert into evalresult (Produc-
tid,username,fromusername, "&zd&"  ) values  ("&session
("productid")&",'"& username & "','" & ses-
sion("username") & "'," & allcent &")"
```

conn.execute(sqlstr)’(marks is written to the database and the system gives data of success and results.)

end if ：end if ：end if

%>

The same technique is used to realize the function of assessment over PBL process given by teachers, which is somewhat different in rubric from by partners. Marks, which is from evaluation given by teachers, is written to the field of EvalTeacher. Meanwhile, during the course of assessment, the system will record who is evaluating or evaluated in order to judge who has evaluated or been evaluated. With regards to different criteria in evaluating works, the system is been programmed as the following.

```
<%
  …………to judge whether the teacher has evaluated the student………………
  'The following is to sum up achievements in works.
  Works achievements are equal to powers of criteria multiply marks and divide 5 which stands for five grades.'
  set rs1=conn.execute("select * from EvalEdusub ")
           if not  rs1.eof then
           while not rs1.eof
           usercent=request.Form("evaledu"&rs1("id"))
           percent=rs1("percent")
           thisnum=usercent*(percent/5)
           edunum=edunum+thisnum
           rs1.movenext
           wend
  %>
```

5.4 The Module of Achievement Inquiry

Only if teachers have announced when achievements can be inquired can students inquire about their own achievements made up of theory test and PBL achievements. Their powers vary with different programs and subjects, so the modules for teachers set up powers of some assessment components (i.e. See Table 1).

Table 1. Powers of Assessment Components

Power of theory test achievement	30%	
Powers of PBL(70%)	PBL Process(60%)	·Self-assessment(5%) ·Assessment from partners in a group (35%) ·assessment from teachers(60%)
	Works(40%)	·assessment from teachers(60%) ·assessment from other groups(40%)

Achievements summed up by the formulas as followed:

PBL achievement = achievement of PBL process *its power + works achievement* its power (1)

achievement of PBL process = self-assessment*its power + partner's assessment * its power + teacher's assessment * its power (2)

works achievement = teacher's assessment * its power + group's assessment * its power. (3)

final achievement = theory achievement * its power + PBL achievement * its power. (4)

Their codes as followed:

```
<%
……………………To acquire a power variable ………………………………
PBLcent=CDbl(evalself*pblself)/100+CDbl(evalother*pblot
her)/100+CDbl(evalth*pblth)/100 {evalth means evalua-
tion from a teacher}
          Wkcent=cdbl(wkst*wkst)/100+cdbl(wkth*wkth)/100
          cent=cdbl(pbl*(cdbl(pblcent*xx)/100+cdbl(wkcen
t*wk)/100)/100)+cdbl(llMark*ll)/100
………………………………………………………………………
%〉
```

6 Conclusion

The system of PBVLC has been exploited by the curriculum TV Program Production since 2005. Now the system has been used by 200 students. They used the system to complete online cooperation, brainstorming, interaction with teachers. The authors made a survey to 200 students. In that, 88 percent students think the system is better because of multi-meta assessment and brainstorm. However, 12 percent students cannot accommodate such a learning style because they think the assessment is too complicate, and the assessment has not been justice. In other words, the system is required to modify the rubrics of the assessment and confirm scientific rubrics.

As the system is developed appealing for modern educational concepts, now it's adopted by the curriculum Research Methods of Educational Technology and the curriculum Modern Educational Technology, which is a provincial fine course. The two curricula use it as cooperation and webquest. Besides, it has been adopted by Computer-based Education Society, whose website is http://www. accbe.com/pbl.

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Methodology for Supporting Novel Model of E-Learning Platform in Grid Architecture

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Abstract. It combines grid technology with E-Learning, present an E-Learning architecture based on grid technology to support learning novel mode. By using Grid Computing technology, this method aims to integrate those unrelated computers in schools to replace high level server as the teaching platforms of E-Learning. Thus, not only the computer sources in schools can be fully used and applied, and moreover, constantly sharing the computer sources from other schools or associations as well as the computing capacities. In this paper, a prototype of E-Learning platform using grid environment is proposed, built up using a number of open source E-Learning software in a heterogeneous environment. In the future, using grid technology on E-Learning might be a new scheme. We also expect the outcome and experiences of this research can provide reference to the schools that wish to develop E-Learning environment for saving the cost and time in developing a similar system.

1 Introduction

Grid technology was originally conceived to provide support for applications belonging to scientific domains. However, the grid is currently embarked on a maturation process derived from the definition of the Open Grid Services Architecture (OGSA) [1] which could allow the expansion of grid technology within new domains such as business and education. At present, education and collaboration are emerging as very important application fields of grid technologies. The use of grid technologies may enable access to large amounts of heterogeneous resources that can be employed for educational purposes. This new scenario is called E-Learning Grid or Learning Grid [2][3][4][5][6].

In recent years, with the rapid development in communication and network technologies, E-Learning has been popularized and become one of the most popular teaching methods in educational community. Along with the gradual improvements found in network bandwidth and quality, real-time transmission of high-quality video and audio has become possible and true reality. Because of these major transitions, conventional methods of school education have also followed this trend.

E-Learning utilizes electronic devices to assist the education or training process, taking advantage of the internet or any other communication channel to connect other devices, to deliver information and knowledge. This model of learning has many advantages with respect to traditional models: a better interaction between the learner and the learning resources he uses, i.e., the learning is not passive; Learning can happen anytime and anywhere, i.e., there are not boundaries tied to time and place; A

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tutor, or learner himself, is able to monitor the progress and to customize the learning experience basing on learner skills and preferences.

In E-Learning research, it is a crucial problem the support of learning in scalable, open, dynamic and heterogeneous environments. The scenario is a large scale and connected environment of Learning Management Systems, Learning Content Management Systems and virtual classroom systems of different organizations. Grid computing has emerged as an important new field, distinguished from conventional distributed computing by its focus on large-scale resource sharing, innovative applications and, in some cases, high-performance orientation [7]. Grid technology address issues related to access provisioning coordinated resource sharing and problem solving in dynamic, multi institutional virtual organization [8]. By adopting grid technology, it is possible a wide-scale learning resource sharing in heterogeneous and geographically distributed environments, the implementation of learning organizations in which different actors (teachers, learners), sharing a common target, are able to cooperate to obtain a result.

2 E-Learning Systems and Grid Computing

With the rapid growth of the Internet and digital technologies, the web has become a powerful, global, interactive, dynamic, economic, and democratic medium of learning and teaching at a distance [9]. E-Learning is the unifying term to describe the fields of online learning, web-based training, and technology-delivered instruction. Rosenberg[10] defines E-Learning have three fundamental criteria: a E-Learning is networked, which makes it capable of instant updating, storage/retrieval, distribution and sharing of instruction or information; It is delivered to the end-user via a computer using standard Internet technology; It focuses on the broadest view of learning – learning solutions that go beyond the traditional paradigms of training.

General E-Learning systems have four components: People, Authoring System, Run-Time System, and Learning Management System (LMS) [6]. People in these systems are the learners and authors, while others may include trainers and administrators. Authors (which may be teachers or instructional designers) create content, which is stored under the control of a LMS, and typically in a database. Existing content can be updated, and it can also be exchanged with other systems. A LMS is managed under the control of an administrator, and it interacts, with a run-time environment which is addressed by learners, who in turn may be coached by a trainer. These components of an E-Learning system can be logically and physically distributed.

In current incredibly complex world of computational power, very high speed machine processing capabilities, complex data storage methods, next-generation telecommunications, new generation operating systems and services, and extremely advanced networking services capabilities, we are entering a new era of computing-Grid Computing [11]. Grid computing has emerged as a framework for supporting complex compilations over large data sets. In general, grids enable the efficient sharing and management of computing resources for the purpose of performing large complex tasks [12].

Although many academies have now adopted E-Learning for teaching, the software and hardware facilities that the academies use are very different. It has become a cause of major difficulties in sharing the teaching resources with one another. The technique of Web Services can integrate the different information system within the

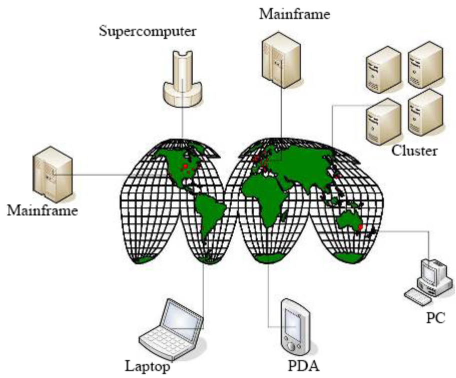

Fig. 1. The Grid computing infrastructure

Grid to solve the above mentioned problem. Therefore, the concept of this research is based on integrating Grid Computing with Web Services to build up an E-Learning platform [13]. Figure 1 shows the concept of grid computing.

3 Proposed E-Learning Grid Architecture

The architecture contains five layers from bottom to up, as shown in Figure 2 [14]. The infrastructure layer, at the lowest layer, supports basic networking environment,

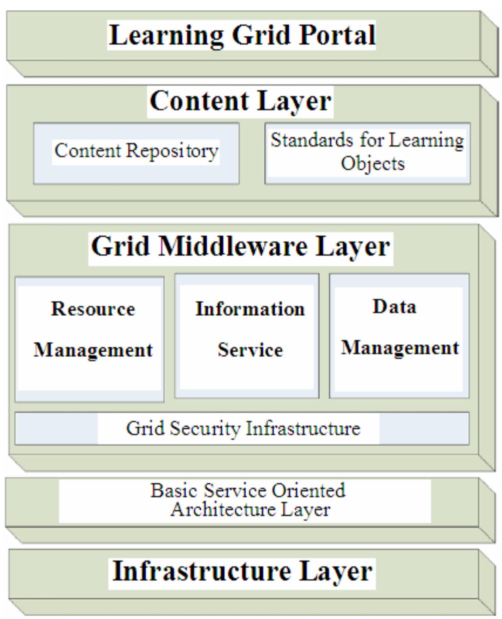

Fig. 2. An E-Learning Grid Architecture

including computing devices, networking and networking protocols etc. Secondly, the basic service oriented architecture for implementing the basic web services related protocols such as XML, UDDI/SOAP/WSDL etc. This layer provides the elementary connectivity, interoperation, reliability and flexibility for the layers on top of it. As next layer, the grid middleware layer is the core of the architecture where the basic grid problems such as distribution, dynamic, open and cross-organization are resolved. The content layer is on top of grid middleware layer to store all of learning contents in our platform. At last, the learning grid portal supports single user sign on the system. In next subsections, brief introduction of these layers will be discussed.

Grid Middleware Layer is a crucial layer to build a grid environment and should be on existing OGSA compliant middleware such as Globus Toolkit 4 (GT4). The Globus project provides open source software toolkit that can be used to build computational grids and grid-based applications [15]. It allows sharing of computing power, databases, and other resources securely across corporate, institutional and geographic boundaries without sacrificing local autonomy. It implements services for Security Services, Resource Management, Information Services and Data Management in the grid. The main functions of them are listed below.

(1) Security Services
(2) Resource Management
(3) Information Services
(4) Data Management

Content Layer is on top of grid middleware layer to store all of contents in our platform [16]. As above mentioned an E-Learning system needs a Learning Management System to store and manage its teaching content. However, every LMS platform runs its own learning materials, which cannot be exchanged with those of other LMSs. To deal with this problem, the U.S. government launched the Advanced Distributed Learning Initiative (ADL) [17] is unifying E-Learning specifications emerging from the international standards organizations into a single specification referred to as the Sharable Content Object Reference Model (SCORM). SCORM aims to establish a mechanism for repeated use and sharing of courseware as a way to reduce the time and cost of developing courseware and to make courseware reusable and acceptable to different LMSs.

Learning Gird Portal is the unified entry for all grid platform users. Users from different organizations who logon it could share learning resources without knowing where they come from. Moreover, the portal is responsible for assisting authenticated users when operating within the grid environment.

4 Optimization on Grid Portal Structure

In a grid organization, the grid portal allows communication between the outside world and the grid. The major function is to provide users with a web-based interface for the grid service and resources. To make the grid portal run more efficient way, we use the web mining technology to adjust its framework. To make it congregate users' needs. Web mining is a type of application of data mining and it is categorized into "web content mining" and "web usage mining". Web content mining deals with surveying the contents of the web and it is mainly applied to analyzing web contents and reinforcing web-searching capability, such as a search engine. Web usage mining mainly deals with analyzing the web users' browsing behavior through web log, so that the web administrator will become aware of the operation of the website before modifying the system, for the purpose of more efficient operation [18].

Web Usage Mining suggests analysis of user's browsing behavior through the web log. It enables the web administrator to be aware of the operation of the website before modifying the framework, for the purpose of more efficient operation. Its application comes as follows:

(1) Analysis of web flow.

In the web log, the title and size of a specific web and a specific access are duly registered and pattern for the web flow. In the [19] study, variation of web flow in each day of the week is registered in the web log. Analysis of it will become more applicable on the adjustment and planning of network bandwidth.

(2) Improvement of web accessibility.

By analyzing the web log, we have come to realize what popular websites and files are received more in an access rate. Consequently, we can place those files in the Web Proxy server or cache server. In the [20] study, we can analyze the web log and make a forecast of the popular web pages to decide on its priority of the pages in Cache.

(3) Analysis or forecast of browsing behavior.

This is a common subject being studied in Web Usage Mining. Robert Cooley et. al. [21] is one of the few experts that introduced the idea. Other studies aim to improve or propose new algorithmic methods [22] [23] for more efficient analysis. On the other hand, the web mining tool WUM [24] used in this study is theoretically based on aggregate tree, and MINT language that resembles SQL is used for analysis of the web before reaching to the patterns that we are interested in.

Data obtained through WUM analysis can be taken as a pattern, which comes from a kind of a rule. An example is that the browse from page A, page B to page C must follow a number of rules. To locate the most beneficial one, other methods are needed. In this case, we opt for the Greedy Algorithm.

Greedy Algorithm is simply understood as: When we have a number of options, we will usually select the most beneficial one at sight [25]. Figure 3 shows a simple route selection.

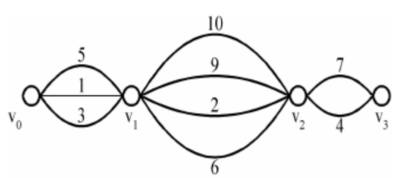

Fig. 3. A simple route selection

Suppose we are to choose the most popular route from V_0 to V_3, Greedy Algorithm would suggest 5 + 10 + 7 = 22, which is the common one. This can not be an easy job every time. The following Figure 4 explains why.

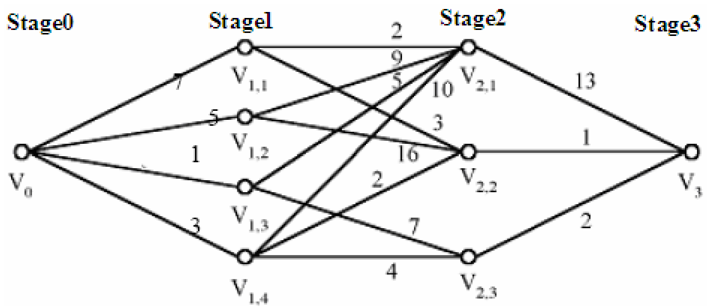

Fig. 4. A complex route selections

Then, by following the order Stage 0 →Stage1 →Stage2 →Stage3, we can look for the corresponding routes and add up to the count values before comparing both of the total count values of each routes at the same level and the maximum potential value of the next level. If both values are large, it indicates that we have located the best route and do not have to continue. In the following example.

$$Step1: V_0 \xrightarrow{7} V_{1.1} \xrightarrow{3} V_{2.2} \xrightarrow{1} V_3 = 11$$
$$Step2: V_0 \xrightarrow{7} V_{1.1} \xrightarrow{2} V_{2.1} \xrightarrow{13} V_3 = 22$$
$$Step3: V_0 \xrightarrow{5} V_{1.2} \xrightarrow{16} V_{2.2} \xrightarrow{1} V_3 = 22$$
$$Step4: V_0 \xrightarrow{5} V_{1.2} \xrightarrow{9} V_{2.1} \xrightarrow{13} V_3 = 27$$

When we realize that the fourth total count of 27 is higher than the $V_0 \rightarrow V_{1.2} \rightarrow V_{2.2} \rightarrow V_3$=22 at the same level and the maximum potential value of 3+10+13=26. At the next level, we can be sure that the most popular route is $V_0 \rightarrow V_{1.2} \rightarrow V_{2.1} \rightarrow V_3$ = 27. We have located the best route in the forth step. Now we can save the analysis result in the database for updating the web framework.

Finally, we add PHP commands to the web for regular reading of data and linkage in the database, while updating web hyperlinks as a way to adjust the web framework. The following shows a fragment of PHP command:

<p> % Firework1_name % </p>

Here, Firework1 _url stands for the website of a specific Web file name in the Web server, such as “Firework1.htm”. Firework1_name is a specific record in the database which stores the mining result.

This kind of web updating used to be conducted manually by reading the data first (ranking, for instance) before the administrator’s manual updating of hyperlink. From now on, all we have to do is trigger the automated updating system. The web will update its links by following the latest result of mining. Substitution of Web Usage Mining for web ranking will be more of an objective, as Mining result stands for “behavior” of all browsers on the web, not only ranking.

5 Conclusion and Future Works

At present, most E-Learning environment architectures use single computers or servers as their structural foundations. The innovative E-Learning architecture is presented, as it can solve current E-Learning platform problems. To make resources in the Learning Grid platform available to users, we have to setup a Grid Portal, which can monitor resources on the grid, use GridFTP to transmit data within the grid, and use the Proxy Manager to manage the CA in the Grid. Also, a prototype of E-Learning platform using grid technologies is proposed, built up using a number of open source Learning Management System in a heterogeneous environment. In the future we hope that instant messengers would be integrated as another portlet in our portal. We intend that this platform may enable people to process interactions and opinion exchanges through video and audio simultaneously, in situations such as training, teaching, conference and seminar, among others.

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Constructing a Multi-Monitor Displays System for Learning

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Abstract. This paper proposes a Multi-monitor Displays (MMD) System for assisting primary school students with their learning performance in music learning. The progress of computer technology has enabled an explosion in the visual ways of teaching presentation. In recent years, most educators present their instructional materials by using projectors primarily rather than chalkboards. Multimedia instruction is a good approach for learners to construct meaningful knowledge and to make referential connections between mental representations. This paper proposes a multi-monitor approach for constructing a multimedia aided learning system supported by some popular tools such as Microsoft PowerPoint, Microsoft Word, Microsoft Excel, and Adobe Acrobat Reader. Based on the Cognitive Theory of Multimedia Learning, this aided system is realized to combine and support verbal and pictorial forms. As a result, teachers can easily develop their teaching materials and present reference materials on two different monitors or screens. Our experiment reveals that by using the MMD system to simultaneously present musical notations and a listening map the results using multimedia presentation are superior to those of the conventional instruction methods when it comes to learning achievement and creative ability.

Keywords: Multimedia learning, Multi-monitor Displays, Music Learning, Pedagogical Issues.

1 Introduction

Music notation is a written symbol using a five-line staff, with notes placed on the staff to represent the relative duration and pitch of a sound. All music should be written as music notation for ease of reading, understanding, and playing [1]. However, music notation is comparatively abstract and not readily understood by pupils when they are unfamiliar with symbols and with the pitch of the notes [2]. Newman points out those children will be disturbed in volume and pitch [3]. Children believe that singing louder will produce a higher pitch. Therefore, teachers must teach student to distinguish the level of sound through some form of visual assist. Some students find that reading music is difficult. When the music appreciation instructional-activity comes to a high-level cognitive activity, such as timbre, dynamics, rhythm, melody, harmony,

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structure, and texture, pupils unfamiliar with musical notation often take only a timid step forward. This situation may limit students' music awareness and cognition, and even result in them no longer being interested in learning music.

In the development history of the artists, although music and painting are different, the creation of music and painting has been linked for a long time, and their artistic conceptions have some things in common. For example, in education, for painting assisted music teaching, Hair showed that pupils, from kindergarten to sixth grade that attend music class for 30 minutes a week, are superior to expressing only with the languages for the music element [4]. Cassidy took 68 university students as a sample, and found that students who major in music education can distinguish the position a melody is carried on better than students who do not major in music education because of their inadequate experience [5]. Gromko and Russell utilized the 'listening map' to teach, and found that this made it relatively easy to distinguish a pair of melodies from one another [6]. They also found that the listening map made it easy to distinguish the music elements and read the notes. Tan and Kelly stated that music can assist a student's creative and thinking ability while painting [7]. It seems that it improves their motivation and promotes the learning effect. Therefore, listening map is a valuable teaching aid for the music-listening lesson because it visually represents exactly where musical events take place making it easier for children to understand musical relationships.

Mednick was of the opinion that an individual will raise his/her creativity and produce something new related to his/her experience [8]. Mayer thought that it is helpful to arouse the creativity by presenting pictorial and textual information at the same time [9]. Better learning will occur when presenting words and pictures than words alone. The above findings inspired us to design the Multi-monitor Displays (MMD) system for presenting music notation and to design a listening map to connect at the same time the common visual and verbal materials used in assisting students with music learning. By showing the listening map (such as musical symbols and picture notations) to appear as music elements, teachers can select graphic representations that symbolize the musical features and notations in a visual format in order to enhance the learning of music elements.

2 Literature Review

2.1 Multiple Monitors

More display surface enlarges the amount of information that is visible to the user at any given moment, in addition to providing a more comfortable reading space. Most of users multitask today and feel that a single monitor offers a limited display surface [10]. Several screens allow for several documents to be easily presented simultaneously. Users can easily read several documents placed on different monitors. The topology of multi-monitors in software was defined by Microsoft, who called it a virtual screen. Windows 98, Windows 2000 and Windows XP all support multiple monitors on a single system. To use the multiple-monitor supporting feature, an AGP or PCI display adapter is needed for each monitor or a specific display adapter to drive two or more monitors.

The topology of multi-monitor in software was defined by Microsoft, which was called virtual screen [11]. Fig. 1 shows a possible arrangement of three monitors in software monitor topology [11]. Microsoft's Object Linking and Embedding (OLE) automation provides an easy way to use and control the contents and functionalities of an existing Windows program. By means of the OLE technology we can easily combine the functions of another program into our own application systems [12]. That is, our system will have some useful functions from other existing applications. OLE automation is a technology that is used by programmers to define the interface of Component Object Model (COM) objects [13]. This interface can be handled by any application that understands the interface description. The interface description is a detailed description of the names of methods and properties a COM object supports, together with the description of each argument a method holds. From this description, you can connect and control each method and property an object provides.

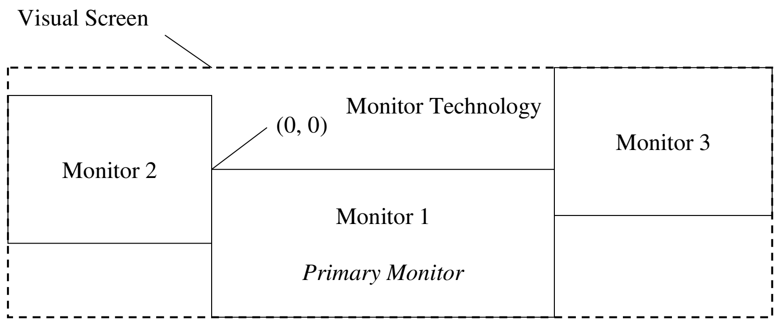

Fig. 1. A possible arrangement of three monitors

The OLE Automation includes a client and a server. The Automation client connects to the Automation server so that it can use the content and functionality supported by the Automation Server. Microsoft Office applications expose their functionalities as a set of objects. With OLE Automation, we can use the functionalities that Microsoft Office applications provide and we don't have to develop our own program with the same functionalities. That is, our application has the presentation capabilities of PowerPoint, and we use the OLE Automation to integrate the presentation functions provided by PowerPoint in our proposed system.

The Windows Hook function can be considered one of the most powerful features in the Windows system. With the Hook function you can catch windows messages, either in your own application or in other applications. The Windows Hook function is a message-handling mechanism for intercepting messages before they arrive at the target window and modify or discard them. There are a number of different types of Windows hooks available. Each type provides a different aspect of the message-handling mechanism.

2.2 Multimedia Learning

Multimedia learning provides multiple modalities of information for learners, including speech, printed text, static graphics, animation and video. It can offer many good forms to students. Mayer defined multimedia as the presentation of material using both visual and verbal [14] [16]. The Cognitive Theory of Multimedia Learning, proposed by Mayer, provides empirical guidelines that help instructional designers to promote meaningful learning. The theory is based on the following assumptions: dual channel, limited capacity, and active processing [15]. Words and pictures represent the teaching materials designed by instructional designers. Mayer defined words as teaching material presented in verbal form, such as using speech or printed text; and he defined pictures as teaching material presented in pictorial form, such as using static graphics or dynamic graphics. The Dual Coding Theory suggests that students learn best when both channels are processed together. For this reason, we hope to design a teaching-aided system that supports the verbal and pictorial form based on the multimedia formats while presenting and providing multiple multimedia formats.

3 The Structure of the MMD System

3.1 The MMD System Structure

Instructional materials may consist of various multimedia modalities supported by different authoring tools. For example, Microsoft Word supports texts and pictures; Microsoft PowerPoint supports texts, pictures, animations and videos. Therefore, instructional designers use several authoring tools to edit, modify, copy and paste the instructional materials at the same time. Here are several tools in common use: Microsoft PowerPoint, Microsoft Word, Microsoft Excel, Adobe Acrobat and Web Browser. The MMD system supports several multimedia formats such as PowerPoint, MS Word, Excel, PDF, HTML format, as well as images and videos. In this study we use the OLE Automation technology to handle the four existing tools and implement our own Web Browser, Picture Viewer and Video Viewer. The MMD system integrates the above seven multimedia formats to produce a vivid instructional presentation in a multi-monitor environment. This way, instructional designers can directly take advantage of the authoring functionalities supplied by the authoring tools. Fig. 2 shows the architecture of our proposed MMD system.

3.2 The Functions of the MMD Authoring Mode

There are two major parts in the authoring mode: Object Container and Multi-Monitor Manager. The Object Container is a physical container supported by the teaching-aided system. It provides an interface that connects and controls the contents and functions of existing windows applications, such as PowerPoint, WinWord, Excel, Acrobat, etc., by using the OLE technology. The Multi-Monitor Manager manages the functionalities related to multiple monitors, removes the redundant Windows taskbar items and controls how educators deploy the authoring tools or calls them back. Fig. 3 shows what happens when educators open two authoring tools by using the Open/Close Option in the MMD authoring mode.

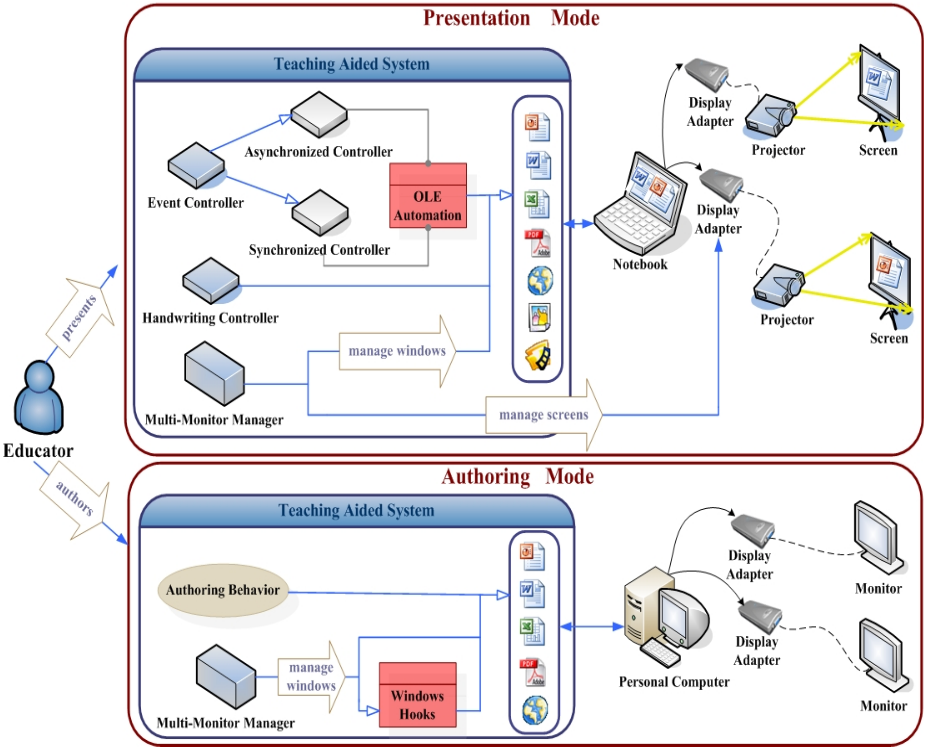

Fig. 2. The MMD system architecture

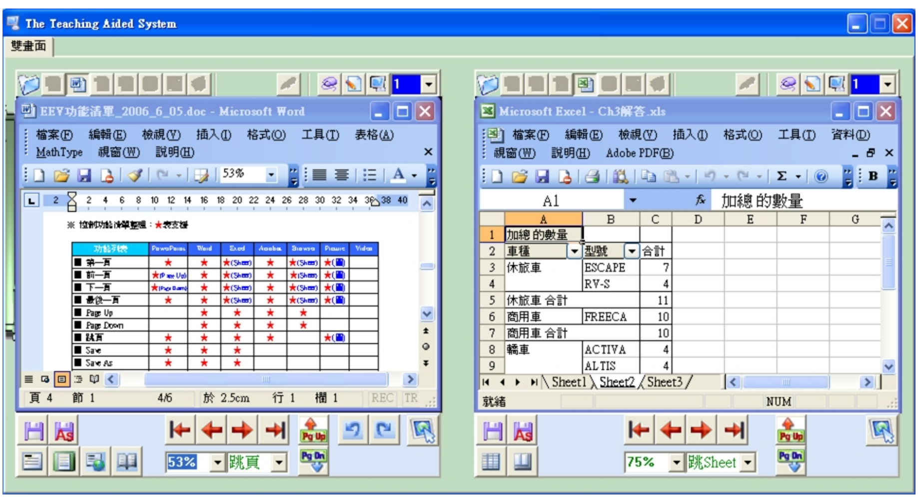

Fig. 3. The opened documents in the MMD authoring mode

The main functions of the MMD system are listed as follows:

Open/Close Option. To select which button will be pressed down so as to remind users to close the tool with the click of this button.

Monitor Selection. To select which monitor will be the used monitor in advance.

Windows Deployment. To select which tool will be the appropriate monitor according to the Monitor Selection button.

3.3 The Functions of the MMD Presentation Mode

In presentation mode, the Multi-Monitor Manager handles the ways to capture the thumbnails of projection screens, to identify the order of monitors and to switch the mouse cursor to other monitors. The mechanism of thumbnail will be executed automatically while educators click the presenting buttons. The Multi-Monitor Manager will detect which monitor educators select, and capture the image of appointed monitor with two frames per second. Each frame will be shrunk by using the Halftone stretching mode in order to fit the size of corresponding Object Container [17].

The multiple-monitor presentation consists of four major parts: Multi-Monitor Manager, Asynchronized Presentation, Synchronized Presentation and Handwriting Controller. The Multi-Monitor Manager shows thumbnails of the different projection screens, so as to identify the order of the monitors and to switch the mouse cursor to other monitors. The Multi-Monitor Manager can capture the thumbnail image of the projection screens in real time and displays them within the Object Containers. The Asynchronized Event Controller in the presentation mode handles a series of different events corresponding to the presentation tools. Educators can control these events by using the Asynchronized Event Controller, which applies the OLE Automation technology. The Synchronized Event Controller disables those synchronized events that are not supported by these tools. The Handwriting Controller will call the tool back to the primary monitor and capture the image of the primary monitor in real time, and then display successive fake images on the presentation projection screen.

4 Methods

The pilot for test their learning achievement and presentation the MMD system was carried out in a remote elementary school in the geographic center of Taiwan. All children at the school received music learning from a music teacher. The participants were 64 students (with a mean age of 9.6 years) selected from a population of 4th graders. The participants were randomly assigned to the experiment groups (n = 32) and the control group (n = 32). Generally, in remote elementary schools in Taiwan teachers have to teach Mandarin Chinese, Science, Mathematics, Social Studies, Music, and other subjects. Therefore, the teachers were not expert in each of the subjects taught, especially not Music.

4.1 Instructional Design

In this study, the experimental group adopted the MMD system to present the listening map to assist them in their music appreciation instruction. The teaching materials selected were mainly classical music such as ‘Fossiles’, ‘In a Persian Market’, and ‘In the Hall of the Mountain King’. The instructional strategies include discourse analysis, music appreciation, and multimedia presentation. First, the instructor plays the music and briefly introduces the composer’s life story, melody cause, and an analysis of the musical form structure, the theme, and the musical instrument. Second, the instructor plays the music and uses the MMD system to present the words and the pictures simultaneously, such as the music notation and the listening map, in order to reveal the characteristics of the music appreciation instruction for the experimental group. Finally, the instructor adopts eurhythmics, the playing of a musical instrument, drama, and creativity to perform a situated story. Students experience and express the heard music with moving their limbs, and connect the mental process of the thinking development when they are teaching [18]. Thus they show their own feeling in various Eurhythmic ways [19]. The experimental group used the MMD system during music appreciation so that the other visual auxiliary material, the ‘listening map’, could be presented simultaneously to help students learn and experience the music. The control group was treated similar to the experimental group, but did not use the MMD system to present the additional visual auxiliary materials. They are as follows.

4.2 Instruments

Learning achievement. The learning achievement in the study is students’ scores in the timbre, dynamics, rhythm, and melody [20]. The timbre is the essence of a sound produced by different musical instruments or a voice. Dynamics express the power of the sound. Rhythm is the length of musical notations. Melody expresses the level of the sound. In the test method students listen to 10 pieces of music, Saint-Saens, Bizet, …, and Dukas. Each piece of music lasts about 30 seconds, and tests if the subjects can distinguish the theme trend of the music, if they can hear which kind of musical instrument is playing, if the dynamics are stronger and stronger, weaker and weaker, or do not change, it they can distinguish if the music copper in the rhythm is long or short. Each music element has 10 points, for a total of 50 points. The higher the score the more the student has learned, and the lower the score the lower the learning achievement.

Multimedia presentation. According to Yamamoto’s creativity to rewrite, the multimedia presentation includes 7 items written in Chinese with fluency, flexibility, originality, and elaboration [18]. Fluency is the total produced about reacting smoothly or generating lots of ideas. Flexibility means classifying or thinking from different ways. Originality is to generate novel ideas or uniqueness reactions that others are unexpected. Elaboration increases the detail to build on existing ideas. It is the higher to score, the higher students' creativity achievement is. The answers are scored using a Likert type scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The internal consistency (Cronbach’s α) was .82.

4.3 Results

The learning achievement shows that the learning by the experimental group was more effective regarding timbre and melody than the control group, $t(62) = 2.388$; $p < .05$;

Table 1. Summary of Means (*M*), standard deviations (*SD*), and *t* value

Item I found that	Experimental Group		Control Group		t value
	M	SD	M	SD	
there was just the right amount of information on the screen.	3.31	0.82	3.19	0.69	0.658 *ns*
the texts and graphics presented were clear, structured and appealing.	3.66	0.83	3.22	0.75	2.215 *
the texts and graphics presented allowed me to easily identify the important information and key concepts.	3.47	0.80	3.56	0.62	-0.523 *ns*
the texts and graphics presented were helpful in learning the music elements.	3.66	0.75	3.25	0.92	1.946 *ns*
the presented texts and graphics help me to connect the knowledge that I have learned.	3.69	0.59	3.53	0.67	0.987 *ns*
the texts and graphics presented help me to better visualize the content.	3.72	0.77	3.31	0.64	2.285 *
the graphics and examples presented help me to pay attention to the subject.	3.41	0.71	3.28	0.99	0.579 *ns*
Total	24.91	3.17	23.34	2.94	2.047 *

$^{*}p$ <.05, $^{**}p$ <.01; *ns* = no significant

t(62) = 2.100; p < .05, respectively. However, they did not differ with the control group with respect to dynamics and rhythm, t(62) = 0.810; p > .05; t(62) = 0.361; p > .05, respectively. The experimental group (M = 23.31, SD = 4.22) did not significantly outperform the control group (M = 20.66, SD = 5.30.) in their learning achievement, t(62) = 2.219, p < .05. However, the average scores of the experimental group were slightly higher than the control one. They were able to learn more and correctly perceived having learned more. The results showed that using the MMD system to present the listening map can assist music learning and music appreciation and that it can effectively improve learning achievement in timbre and melody.

Table 1 shows the experimental group as being more effective in fluency and flexibility of presentation than the control group, t(62) = 3.007; p < .01; t(62) = 2.987; p < .01, respectively. However, they did not differ with respect to originality and elaboration, t(62) = 1.477; p > .05; t(62) = 1.154; p > .05, respectively. The experimental group (M = 43.38, SD = 5.42) significantly outperformed the control group (M = 40.00, SD = 5.25.) in the multimedia presentation showing, t(62) = 2.530, p < .05. The average scores of the experimental group were higher than the control group. The results also showed that combining multimedia presentation with visual materials can assist music learning and promote learning achievement. We found that students in the experimental group performed best in fluency and flexibility. The learners in the experimental group could build more mental connections between verbal and visual representations to be creative.

5 Conclusion

In this study we proposed the MMD system to assist pupils in their learning performance and increase their creativity during music learning. Multimedia learning offers a grand revolution on education - that is, a system for enhancing human learning. According to the multimedia principle [14], better learning occurs when presenting words and pictures than from words alone. The instructional materials consist of multiple modalities of information, including speech, on-screen text, static picture, animation or video. In this regard, an instructional designer requires various authoring tools that support multiple formats; similarly, a lecturer may use several presenting tools which provide distinct multimedia. The MMD system allows users to open distinct authoring tools simultaneously in order to edit, modify, copy and paste the instructional materials. The user can direct each authoring tool to the desired monitor or call them back into the system. The students combined the multimedia presentation with the music to realize their emotion that they imagined or wanted to express. It offered a chance for the students to create and represent, and to increase their cognitive degree of the music and the application of health operation. The results of the experiment in this study showed that the students accepted the listening map auxiliary music appreciation can achieve the music performance generally superior to traditional students. With a multi-monitor presentation, teachers can concentrate on the thumbnails of their projection screens without having to turn around to glance at the projection screens which are behind them. Moreover, the system acts as an integrated controller where most events can be triggered by using the aided system without moving the mouse cursor to the target presenting tools.

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Digital Content Development of Folklore Artifacts and Activities for Folklore Education

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Abstract. Digital preservation of museum artifacts has been widely promoted by governments around the world in recent years. However, the artifacts collected by national or local museums are not very exhaustive. Recently, the collected folklore artifacts accompanied with crafts in how to make them and skills and rituals in how to use them have been digitized in Taiwanese Folklore Museum. In order to supplement insufficiency of artifacts collected by the museum, folklore hobbyists are regularly invited to demonstrate their private collections. At the mean time, the task force of digital preservation team digitizes the artifacts for extending its contents. Another way to aggressively increase the number of digitized contents is to sign cooperation agreements with members of the folklore associations by giving services to digitize their personal collections. After having extended the digital contents, we expect that the website of Taiwanese Folklore Museum will become even more popular for teachers and students, especially in kindergartens and elementary schools, to extract and prepare useful materials for folklore education. In conclusion, the paper presents the digital contents which include folklore artifacts and folklore activities developed in Taiwan Folklore Museum. Additionally, other digital contents developed in other museums or personal collectors can be retrieved by using XML technique. The scheme supplements the insufficiency of national or local museums and provides inter-museum architecture for supporting more complete contents for folklore education.

1 Introduction

The importance of folklore can be manifested by Alan Jabbour's speech in the 100th anniversary of American Folklore Society, which stated that "folklore reflects on the

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ancestral missions that have shapes us, the inherited values that we reflect and must radiate into the future" [1]. The word "folklore" may refer to unsubstantiated beliefs, legends, and customs, currently existing among the common people [2] or substantiated artifacts, crafts, skills, and rituals, widely governing the living style of the common people [3].

In general, folklore refers to the society and culture tradition of the common people and the customs practiced and beliefs held by the vast majority of people in the cultural mainstream that they have inherited from their ancestors, including legends, stories, religious beliefs, festivals, ancestor worship, taboos, ceremonies, leisure activities, music, singing, dance and so forth [1]. As a result, the value of folk artifacts, crafts, skills, and rituals lies in their demonstration of popular conceptions, life wisdom and the ancestral legacy hidden within the culture. Their basic value lies in their tight intermeshing of spirituality, psychology, and social mores; and their social functions and symbolic cultural meanings lie largely in their artistic and historical worth. In a previous investigation, we had finished content development and digital preservation of the Taiwanese folklore artifacts [1].

Folklore objects and activities can be classified into four different types which include artifact, craft, skill, and ritual. In addition to folklore artifact, three types of folklore activities were added to make the folklore content and preservation more complete so that the spirits of folklore can be demonstrated more exhaustively [3,4].

Recently, digital content development with applications to the preservation of artifacts relating to the arts, languages, ecology, living styles, etc. has been studied and implemented worldwide [5,3]. Most of the digital contents emphasized artifacts rather than the craft in making or the skill in using these artifacts. For example, the craft in making puppets concerning wood sculpture, painting, clothing, and decoration, while the skill of using or playing the puppet in religious rituals regarding delicate finger operation, hand control, and arm and body movements. Besides, folklore and religious rituals have their spiritual meaning that step-by-step procedure embeds significant meaning for a people or a religion. Motivated by the investigations which showed that media richness facilitates learning of courses with high uncertainty and equivocality [6] and e-learning with interactive videos gains more learner satisfaction than non-interactive and traditional classroom learning [7], digital contents of crafts, skills, and rituals have been developed for the purpose of both digital preservation and online education [4]. The same concept was applied to digitize childcare standard operation procedures (SOPs) [8]. In contrast to general non-interactive e-learning and traditional classroom learning style, we proposed a metadata-based method for recording each step as a metadata record in which the title, description, associated digital media, and other related information are all included [4].

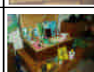
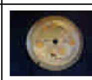
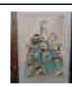
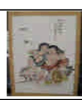
The artifacts collected by national or local museums are not very exhaustive. For example, there are only 1412 artifacts collected by Taiwanese Folklore Museum although it is a popular multi-function site with a crucial mission in the exhibition and preservation of representative folklore artifacts and an important site for folklore education. Table 1 shows the numbers and categories of visitors in the year of 2006.

In order to supplement insufficiency of artifacts collected by the museum, folklore hobbyists are regularly invited to demonstrate their private collections. At the mean time, the task force of digital preservation team of the museum digitizes the artifacts for extending its contents. Table 2 shows the exhibitions of the folklore artifacts collected by hobbyists and folk arts created by folklore artists at the Taiwan Folklore Museum from 2005 to 2007. Another way to aggressively increase the number of digitized contents is to sign cooperation agreements with members of the folklore associations by giving services to digitize their personal collections. We expect that after having extended the digital contents, the web site of Taiwanese Folklore Museum will become even more popular for teachers and students, especially in the kindergartens and primary schools, to extract and prepare useful materials for folklore education.

Table 1. Statistics of educational groups and persons who visited Taiwan Folklore Museum in 2006

School	Number of School	Number of Persons
University	14	364
High school	5	747
Junior high school	7	340
Primary school	37	2079
kindergarten	199	10988
Pre- kindergarten	66	2533

Table 2. Summary of culture and art exhibitions at Taiwan Folklore Museum from 2005 to 2007

Exhibition Name	Item	Example	Exhibition Name	item	Example
The Bride Wore Red	250		Hsiao Ren-neng's Collection and Carved Wooden Puppets	150	
Historical Documents from Old Taichung	150		Jade Auspicious Animals (for thwarting evil)	150	
Artifacts from When Grandma and Grandpa Were Young	300		Handicrafts Decorated Using Plant Dye and Indigo Blue	150	
Special Exhibition of a Collection of Cicada-shaped Jade Pieces	120		Wood-fired Ceramic Creations by Seven Artisans	100	
Carvings by Hsu Pei-ming	220		Ancient Taiwanese Religious Books and Paintings	200	
Paintings and Personal Letters by Contemporary Taiwan Artists	200		Special Exhibition of Dream of the Red Chamber-themed Art and Handicrafts	150	

2 Materials and Methods

The task force is consisted of multi-discipline scholars, including folklore specialists, archivists, and academic researchers majored in computer and information sciences. Their dimensions, originalities, functions, and other detailed descriptions were examined, investigated, and recorded by folklore specialists. Metadata based on the Dublin core were also constructed for compatible with international standard. Finally, a database system and a website were designed for providing general publics and researchers to browse and surrogate the digital contents.

2.1 Digitization of Folklore Artifacts

Pictures of the artifacts were taken by a professional photographer using a professional Hasselblad camera with 120mm positive films. Three infrared-synchronized spotted lamps, one was placed above the artifact and the other two at its left and right sides, were used to eliminate the shadow effect. The pictures were then digitized by a high-quality scanner with resolution as high as 600 dpi and stored in true-color format (TIFF) for further processing and future references. A commercial software package (Adobe Photoshop) was used to calibrate the color saturation and hue deviation caused by over- or under-exposure caused by differences in exposure characteristics among artifacts with great variety. In addition to the digital contents, paper-based documents were also prepared for supporting on-site demonstration and back-up. The artifacts were classified into ten categories according to their life styles and functions. Table 3 summarizes the categories and numbers of the artifacts collected in this museum. Figure 1 shows examples of the representative artifacts for ten categories.

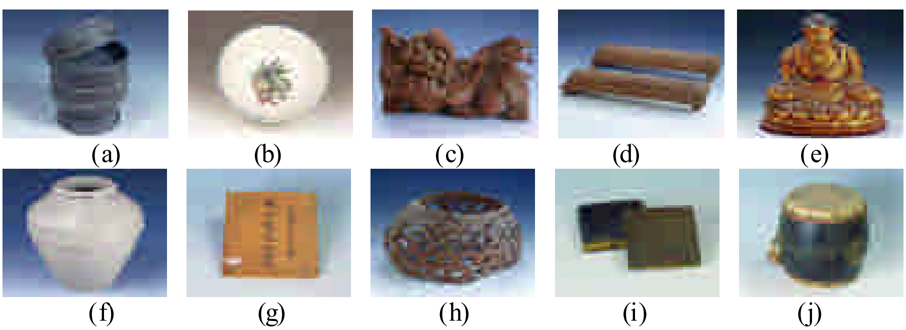


Fig. 1. Examples of folklore artifacts, in which the artifacts were classified into ten categories including (a) clothing and jewelry, (b) kitchenware and dinnerware, (c) furnishings, (d) transportation, (e) religion and religious ceremonies, (f) aborigines, (g) documents and deeds, (h) machinery and tools, (i) study, and (j) arts and recreation

2.2 Digitization of Folklore Activities

Step-by-step folklore activities were demonstrated practically by the folklore specialists invited to participate in this study and the actions were taken by a professional photographer using a digital camcorder with a resolution of 640x480 pixels. The text and oral description of a folklore activity were done by a folklorist who majors in this specific activity. Video clips of individual steps were obtained by using the video editing software to edit a video sequence and saved as the Microsoft wmv and Apple Quicktime formats. These video clips were then combined with other related information and recorded using metadata format compatible with the Dublin core standard. Metadata designed based on the Taiwanese folklore artifacts [3] were extended to include folklore crafts, skills, and rituals, in which the "Relation" element contains two quantifiers, i.e. "Has Part" and "Is Part Of", is used to interlink between the main (parent) metadata record and its children metadata of individual steps[9]. An example of step-by-step demonstration of bamboo weaving is described in Table 4. Each step in this table has a corresponding video segment. Additionally, a main (parent) metadata record is used to interlink with its related activity steps (children) by the "Relation" element proposed by the Dublin core, in which, as shown in Fig. 2, the element contains two Quantifiers; i.e., "Has Part" and "Is Part Of" for describing the sequential relation between the parent and children metadata records. Additionally, the Quantifier "Reference source" is applied for expressing its relationship with other artifacts or folklore activities. The "Has Part" Qualifier is used for the parent metadata record to relate to its children steps, while the "Is Part Of" for the child steps to trace back to their parent. With this mechanism, all the child steps can be tightly connected to their parent so that the ASP webpage design program can support flexible interaction between the users and the browsers for easy navigation. The Quantifier "Sub-Collection Type" was added to the Element "Type" in the metadata proposed in [3].

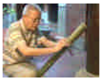
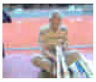
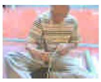
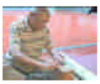
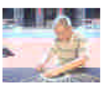
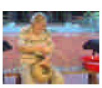
Table 3. Categories and Numbers of Collected Folklore Artifacts

Item	Category	Number
1	Clothing and Jewelry	353
2	Kitchenware and Dinnerware	242
3	Furnishings	232
4	Transportation	67
5	Arts and Recreation	81
6	Machinery and Tools	14
7	Religion and Religious Ceremonies	264
8	Study	96
9	Aborigines	31
10	Documents and Deeds	32
	Total	1412

2.3 Web Implementation with Xml for Data Exchange among Museums

A Microsoft SQL2000 server is built for handling database management and query. The web pages were designed using ASP.net. Figure 2 demonstrates the structure of the web site. As shown in this figure, functions including demonstration of digitized contents, member information, and blog function for information

Table 4. An example of step-by-step descriptions for bamboo weaving

Video	Step and Description
	**1. Scraping**: Place the edge of the blade on one of the joints of the bamboo and scrape it away moving the blade in a clockwise direction. Then ensuring that the top end of the bamboo is secure against something, scrape away the green bamboo veneer. Remember to scrape from top to bottom to prevent damaging the bamboo veneer.
	**2. Splitting into strips:** When splitting bamboo, place a knife in the middle of the bamboo and push down firmly. Now split the bamboo into strips into equal widths. Just how wide depends on the requirements of the project at hand. Sit when splitting the bamboo. The knife should be perpendicular to the bamboo; otherwise, the strips will be cut at an angle.
	**3. Splitting into thinner strips:** First, grasp one end of a strip of bamboo firmly between thumb and forefinger with the short end facing forward. Place blade on tip of bamboo. Make sure that blade is firmly on bamboo; otherwise, it might slip and cause injury. After the blade is firmly on bamboo, press down firmly with thumb. You can pull with your toes to split the bamboo.
	**4. Trimming width of bamboo strips:** First, place the blade of a knife on a worktable and set the width for the bamboo strips. Place a bamboo strip on the worktable where the width has been set. Press bamboo strip down as you draw backward to get the width you want.
	**5. Trimming thickness** of bamboo strips: First, place a bamboo strip, the width of which has already been trimmed, on the worktable. Press down on the bamboo strip with the splitter knife and draw the bamboo strip backward to get the thickness you want.
	**6. Round mouth weaving technique:** We'll use a carry basket as our example (see photo on right). When using the round mouth weaving technique for weaving a flower receptacle, the number of bamboo strips used is important, because if you use an incorrect number of bamboo strips, it will make it impossible to adjust the mouth when drawing it shut.
	**7. Weaving the bottom** See photo on right. Use either seven or nine bamboo strips. Make sure that your weave is symmetrical.
	**8. Drawing in the mouth** See photo on right. You can use four or five bamboo strips to make each bamboo cord when drawing in the edge of the basket's mouth. Be sure to go around in order when drawing the mouth or it won't be symmetrical.
	**9. Making the base:** See photo on right. The basket will be more stable when it stands if it is made with a base. First, insert bamboo strips, one at a time, into the bottom of the basket. Weave the bamboo strips one after another while pressing down on the last two.
	**10. Making the handle:** See photo on right. When making the basket handle, use upside-down "V" knots, the size of which is determined by the size and height of the basket, and plait the bamboo strips five times and adjust the size and arc of the handle to your liking.

Type	*Collection Type*	Folklore Artifact
	Sub Collection Type	Arts and Recreation
Title	**Budai Opera Puppet**	
Subject	*Classified Number*	AARPU_00
	Content	Hand Puppet Theater
	Situation and Function	Traditional Hand Puppet Theater has a very classical and refined flavor about it. It has seven major characters, including students, females, clowns, monks/nuns, children, miscellaneous and beasts
Relation	*Has Part*	
	Is Part Of	
	Reference Source	CACPU_00

Reference Relation

Type	*Collection Type*	Folklore Craft
	Sub Collection Type	Artistic Carving
Title	**Taiwanese Hand Puppet Theater-The craft of making the puppet head**	
Subject	*Classified Number*	CACPU_00
	Content	Hand Puppet Theater
	Situation and Function	The head of the puppet is important as it gives it life and personality. The types of heads can be divided overall into "san gu" (lit. three bones) and "wu hsing" (lit. five forms). San gu refers to the brow, cheeks, and jaw bone, while wu hsing refers to the two eyes, two nostrils, and mouth. San gu and wu hsing endow the puppet it's own aesthetic beauty, personality, and emotions and feelings.
Relation	***Has Part***	CACPU_01, CACPU_02, CACPU_03, CACPU_04, CACPU_05, CACPU_06, CACPU_07, CACPU_08, CACPU_09, CACPU_10
	Is Part Of	
	Reference Source	**AARPU_00**

Is Part Of **Has Part** **Sequential Relation** **Is Part Of** … … **Is Part Of** **Has Part**

Type	*Collection Type*	Folklore Craft
	Sub Collection Type	Artistic Carving
Title	**Selecting wooden blanks**	
Subject	*Classified Number*	CACPU_01
Relation	*Has Part*	
	Is Part Of	**CACPU_00**

Type	*Collection Type*	Folklore Craft
	Sub Collection Type	Artistic Carving
Title	**Applying varnish and hair application**	
Subject	*Classified Number*	CACPU_10
Relation	*Has Part*	
	Is Part Of	**CACPU_00**

Has Part

Type	*Collection Type*	Folklore Craft
	Sub Collection Type	Artistic Carving
Title	**Sculpting work**	
Subject	*Classified Number*	CACPU_02
Relation	*Has Part*	
	Is Part Of	**CACPU_00**

Fig. 2. A metadata example for implementation of sequential and reference relations

exchange among collectors and general citizens are embedded in the website. The web-based system is implemented under the protocol of XML which is an emerging standard for a variety of interface types in distributed environments in general as well as in digital contents in particular. Basically, XML is a way of structuring

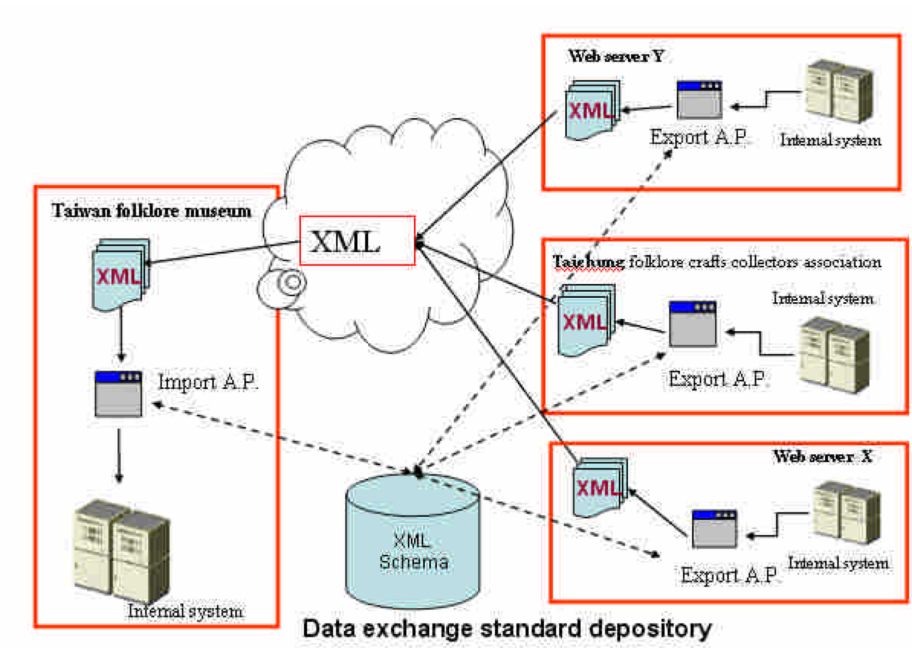
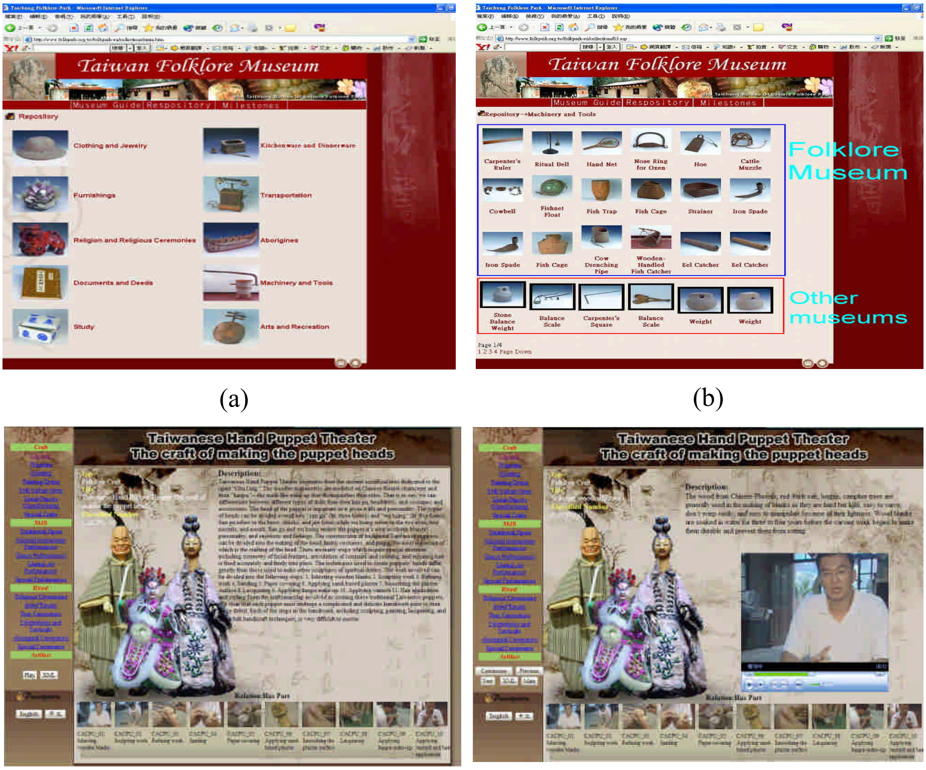


Fig. 3. The architecture for information interchange using XML among museums

information and sending it from one component of software to another. Its syntax is relative simple to define a data format. XML include a family of technologies that can be leveraged to build highly extensible and interoperable software solutions. In this study, XML is used for exchange digital contents between different museums. For example, when a user is browsing the digital contents in Museum A, the digital content of an artifact which is not preserved in this museum can be retrieved by asking Museum B to send an XML page containing all the related information of the artifact. Fig. 3 demonstrates the architecture enables information interchange using XML among different museums.

3 Results

Figure 4 shows the homepage of the website supporting the digital preservation of folklore artifacts and activities. For each craft, skill, or ritual, a step-by-step video demonstration accompanied with either Chinese or English description can be selected. Table 5 demonstrates several examples of folklore activities digitized with video format. Figure 5 and Fig. 6 demonstrate the homepage of a partner museum and its digital contents of folklore artifacts collected by hobbyists and a folklore craft demonstrated by a folk artists, respectively.



(a) (b) (c) (d)

Fig. 4. Home page of the Taiwanese folklore museum for displaying (a) folklore artifact and (b) examples of the artifacts classified as the machinery and tools category shown on a web page, (c) an example of folklore activity, and (d) one of the steps

Table 5. Examples of various folklore activities

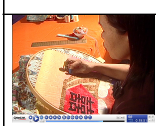
 (a) Dough figurines	 (b) Bamboo utensil carving	 (c) Gongs and drums performance	 (d) Puppet show performance	 (e) Chinese traditional music performance	 (f) Bamboo weaving
 (g) Piece together the cloth	 (h) Nanguan performances	 (i) Art cultivated in a pot	 (j) Pottery	 (k) Top spinning performances	 (l) Puppet head carving

Fig. 5. (a) Main web page of the website; (b) Blog page for one hobbyist; (c) examples of a hobbyist's collection; and (d) description of a collected artifact

Fig. 6. (a) Web page for displaying main (parent) metadata record of bamboo weaving and the related web pages for showing child metadata records including (a) Step 1, (b) Step 2, and (c) Step 12, respectively

4 Discussion and Conclusion

Folklore is believed to be an endangered, marginalized, or misunderstood field. Folk artists are honored to study and inherit the skills building upon earlier generation [9]. In this system, we propose an information exchange platform allowing folk artists and folklore hobbyists to exchange information regarding their own created or collected folklore artifacts and knowledge. The digitized contents contained in the platform complement the insufficiency of folklore artifacts collected in Taiwan Folklore Museum. Additionally, hobbyists and professional folk artists of the folklore association have the potential to serve as folklore educators for preparing introductory materials and answering questions regarding their private areas of creation and collection. It is believed that a folklore learning platform containing digitized contents of artifacts and written information and knowledge folk arts is stimulating and interesting in motivating students to learn.

Each artifact collected in folklore museums and folklore hobbyists has its own story regarding religion, myth, folklore legend, ethnography, or anthropology. These materials and information are embedded in the learning system. After having learned deeply about our own folklore or culture, we can understand more about other cultures [9], which in turn can prevent conflicts among different peoples [2]. Further system development will focus on constructing stories, usages, and backgrounds of the artifacts to enhance learners' impression and to promote their learning effect. Additionally, problem-based learning method will be added to this system. Learners are expected to complete the first-stage learning (as story background learning), and then to follow problem-based sub-system to build their complete folklore knowledge.

When more senses are involved in the learning process, a greater impression is made and the longer the information stays with the learners [10,11]. An enriched environment with multi-sensory creates a thicker cortex within the brain, more dendrite branching, more growth of spinal nervous, and larger cell bodies that lead to cells that communicate better. Fauth [12] and Jensen [11] indicated that people retain 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they see and hear at the same time, 70% of what they hear, see, and say, and 90% of what they hear, see, say, and do. Jensen [11] also noted that most people learn many things at the same time due to the abilities of their brains to process concurrently vast amounts of information, emotion, and awareness. Einstein stated that he felt an idea first, and then experienced it through visual and kinesthetic images, before he was able to put the idea into words. Diamond [15] demonstrated that enriching the learning environment changes the structure and ability of the brain's cerebral cortex. All the above psychological and educational theory and studies support interactive learning to be a more effective method for training of practical skills. The Website is believed to be a useful tool in enhancing teaching and learning. Web- based interactive learning has lead to a new learning style, by migrating from teacher-centered to student-centered.

In conclusion, the paper presents the digital contents which include folklore artifacts and folklore activities developed in Taiwan Folklore Museum. Additionally, other digital contents developed in other museums or personal collectors can be retrieved by using XML technique. The scheme supplements the insufficiency of the national or local museums and provides inter-museum architecture for supporting more complete contents for folklore education.

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Automated Chinese Handwriting Error Detection Using Attributed Relational Graph Matching

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Abstract. Due to the complex shapes and various writing styles of Chinese characters, it is a challenge to automatically detect the errors in people's handwriting. In this paper, we use attributed relational graph to represent a Chinese character. To model the spatial relationships between the strokes in a Chinese character, a refined interval relationship that considers more granular levels is proposed. A novel interval neighborhood graph is also proposed to compute the distances among the refined interval relationships. Error-tolerant graph matching is used to locate the stroke production errors, sequence error as well as the spatial relationship errors. We also propose a pruning strategy in order to speed up the graph matching. Experiment results show that our proposed method outperforms existing approaches in terms of accuracy as well as its ability to handle more kinds of handwriting errors in less computational time.

Keywords: Chinese handwriting error detection, attributed relational graph, stroke spatial relationship error, stroke spatial relationship error, error-tolerant graph matching.

1 Introduction

A Chinese character is an ideogram composed of many strokes. The correct handwriting should follow the correct position, proportion and order of each stroke. Law *et al.* [1] shows the following handwriting errors children may often make: 1) stroke production errors that include missing, extra, broken, and concatenated strokes; 2) stroke sequence errors. Besides, there exist other handwriting errors such as spatial relationship errors resulting from problems in the relative length or position between strokes. When a student makes a handwriting mistake, he/she often does not even realize it. It is thus essential for the student to receive feedback about his/her handwriting in order to correct any mistakes.

Traditionally, the teacher can help the student find out their handwriting errors in class however the teacher's available time for each student is limited. As a result, we are motivated to build a Chinese handwriting education system for assisting the teacher when the teacher is absent. In this system, a student can first write a Chinese

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character by following a template character from teacher then the system can automatically check the handwriting and give feedback to indicate whether and where there are any errors.

The existing handwriting education systems can be divided into two categories. The first one is the view-only system. The student can see how a Chinese character should be written but they cannot practice handwriting through the system [2, 3]. The other category allows the student to practice handwriting and gives some feedback to indicate if there are errors in their handwriting. These systems can be further divided into four main streams. The first one is focused on locating the production errors [4, 5, 6]. The second stream can only evaluate the stroke sequence errors [7]. The third stream can detect the spatial relationship error among strokes [8]. The last one is the combination of the previous types. In [9] the system can find out both the stroke production and sequence errors but without considering the spatial relationship errors. As a result, we are motivated to explore a method that can identify the stroke sequence, production and spatial relationship errors at the same time.

In this paper, we propose a method that can not only identify the stroke production errors and sequence error but also the spatial relationship errors between strokes given an input online Chinese handwriting. This is achieved by using the attributed relational graph (ARG) matching. Attributed relational graph is a powerful tool to represent the relational structure of a pattern. It has been used in 2D recognition [10, 11] as well as Chinese handwriting education [6]. In our application, the Chinese character is represented by a complete ARG. The nodes in the ARG are used to describe the strokes of the character and the edges denote the relations between any two strokes. As the relations between the Chinese characters are rather complex, we propose to extend the existing interval relationship to refine its granularity. The optimal detailed matching between the two ARGs is the mapping between corresponding strokes. In order to find this detailed matching, the error-tolerant graph matching [13, 14] is used with the graph edit operations: deletion, insertion, substitution, merging and splitting of the nodes and the edges. A* algorithm is applied to perform the state-space searching of such a graph matching. The resulting operations can reflect the graph distortions. On the other hand the operation of the edges can show the spatial relationship between strokes. However, we should not ignore the computational complexity of graph matching thus we propose a pruning strategy to reduce the matching time.

The main contributions of this paper is as follows: 1) we propose an algorithm that can analyze an input online Chinese handwriting and determine stroke production error, stroke sequence error and stroke spatial relationship error at the same time; 2) we define a refined interval relationship to model the spatial relationship between strokes and extend the interval neighborhood graph to obtain the distance measures for the refined interval relationships; 3) we propose a pruning strategy in order to reduce the state-space searching time while we apply the error-tolerant graph matching. The remainder of this paper is organized as follows: In Section 2, the proposed ARG matching method incorporating the spatial relationships is described. Experiments and results are discussed in Section 3. Conclusions and future work are provided in Section 4.

2 Our Proposed Method

2.1 Overview

The flowchart of our method is illustrated in Figure 1. First, the sample handwriting inputted by the student and the template character with which the student should follow are both represented as ARGs. Then the error-tolerant graph matching is applied on the two ARGs in order to find out the stroke production and sequence error in the sample handwriting. Afterwards, the post processing can detect the stroke relationship error. Finally the feedback that locates all the errors is provided to the student.

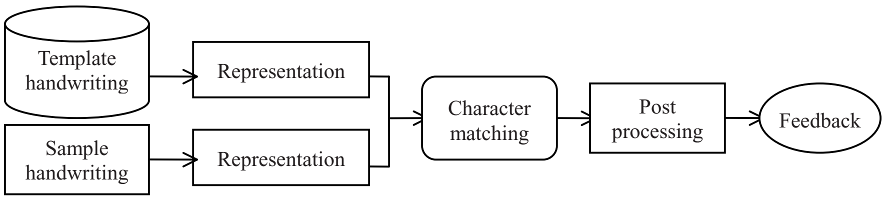
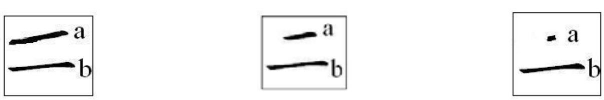


Fig. 1. Flowchart of our method

2.2 Spatial Relationship in Chinese Character

A Chinese character consists of many strokes that form a particular structure unique to that Chinese character. The spatial relationship between strokes is one important factor in determining whether a student's Chinese handwriting is written correctly. In object recognition, people have studied the spatial relationship between objects. Allen firstly shows 13 interval relationships in [15] and the spatial relationships between objects have been described in [16, 17].Nevertheless, it is not sufficient to use these interval relationships to fully describe the spatial relationship between strokes. This can be illustrated by the example in Figure 2. The strokes in Figure 2(a), (b) and (c) all have the same 'during *d*' relation as defined in Allen's interval relationship meaning that the duration of stroke *a* is within the duration of stroke *b*. However, only Figure 2(b) shows the standard handwriting of this character. The handwritings in Figure 2(a) and (c) are non-standard because stroke *a* in Figure 2(a) is too long whereas the one in Figure 2(c) is too short.



(a) Non-standard handwriting (b) Standard handwriting (c) Non-standard handwriting

Fig. 2. Example of spatial relationships in Chinese character

As illustrated in Figure 2, it can be observed that the relationship between the strokes is not only the topological relationship but also the relative distance between the strokes. A more granular definition of the interval relationship is able to distinguish among the three cases in Figure 2. In particular, we propose to further refine the interval relationship into three levels (*f, m, l*) by considering the distance information. The refined interval relationships of the strokes in Figure 2(a), (b) and (c) become '*dl*', '*dm*' and '*df*' respectively. The refined relationship with three additional levels based on the distance can also be applied to other existing interval relationships. The resulting refined relationships are summarized in Figure 3.

Relation	Symbol	Symbol for inverse	Example
a before b	<f	>l	
	<m	>m	
	<l	>f	
a meets b	m	mi	
a overlaps b	of	oil	
	om	oim	
	ol	oif	
a equals b	=	=	
a starts b	sf	sif	
	sm	sim	
	sl	sil	
a during b	df	dif	
	dm	dim	
	dl	dil	
a finishes b	ff	fif	
	fm	fim	
	fl	fil	

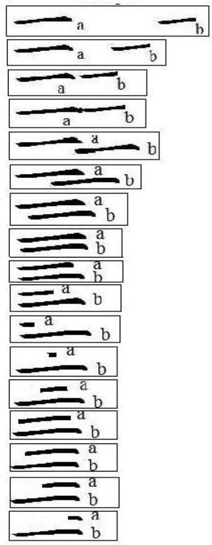


Fig. 3. Refined interval relationships with more granular levels

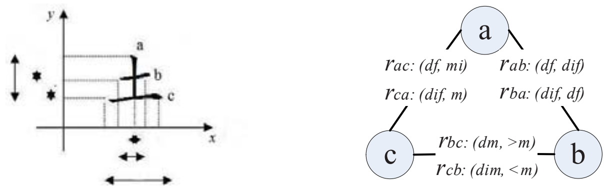
2.3 Complete ARG Representation of Chinese Character

ARG was first described in [10] to represent the structure information of a pattern as $g=(V,E,\alpha,\beta)$. In our application, the set of nodes V describe the strokes of the Chinese character, and the set of edges E describes the relationships between any two strokes as defined in Figure 3. The ARG representation is given as follows.

Nodes in the ARG. Each node stores the x and y coordinates of a stroke. The node labeling function $\alpha : V \rightarrow L_V$ returns n data points for each stroke [6].

Edges in the ARG. Each edge stores the relation of the two nodes (strokes) which are connected by this edge. The edge labeling function $\beta : E \rightarrow L_E$ returns (μ, λ) where μ, λ are the refined interval relationship along the x-axis and y-axis respectively.

As an example, a Chinese character and its stroke spatial relationships are shown in Figure 4(a). The ARG representation of this character is shown in Figure 4(b). The strokes *a, b* and *c* in the character are represented by the nodes *a, b* and *c* in the ARG. The term r_{s1s2} is the relationship between strokes $s1$ and $s2$, and $s1, s2 \in (a,b,c), s1 \neq s2$.



(a) A Chinese character (b) Corresponding ARG

Fig. 4. ARG representation of a Chinese character

In this example, r_{ac} is denoted by *(df ,mi)*, r_{ab} is denoted by (*df, dif*), and r_{bc} is denoted by *(dm,>m)*. Note that the r_{ca} is formed simply by taking the inverse of each component of the relationship used to represent r_{ac} and is denoted by *(dif, m).*

2.4 Error-Tolerant Graph Matching

As illustrated in Figure 1, the input (sample) handwriting is represented as an ARG $g_1=(V_1,E_1,\alpha_1,\beta_1)$ and the template handwriting is represented as another ARG $g_2=(V_2,E_2,\alpha_2,\beta_2)$. In order to decide whether the two ARGs have some differences, we find an error–tolerant graph matching from g_1 to g_2 which is a transformation denoted by the function f [13, 14].This function f consists of many edit operations performed on both nodes and edges. The node operations have been defined by the authors in [6] with *node substitution*, *merging*, *splitting*, *deletion* and *insertion*. On the other hand, we extend the work in [6] by adding the edge operations defined as follows: 1) *edge substitution* implying that both nodes sharing this edge are correct; 2) *edge deletion* implying that one of the nodes/both nodes sharing this edge is an extra or broken stroke; 3) *edge insertion* implying that one of the node/both nodes sharing this edge is a missing or concatenated stroke.

Edge substitution. The cost for the edge substitution is the matching cost between an edge in the sample character and an edge in the template. We use *Rt* to denote the set of edges in the template and *Rs* to denote the set of edges in the sample. Note that an edge represents the spatial relationship between two strokes in a handwriting. The *i*-th template edge Rt_i can be denoted by $(\mu t_i, \lambda t_i)$ and the *j*-th sample edge Rs_j can be denoted by $(\mu s_j, \lambda s_j)$. The dissimilarity between $(\mu t_i, \lambda t_i)$ and $(\mu s_j, \lambda s_j)$ is defined as $D(Rt_i, Rs_j)$ which is derived from the idea of the interval neighborhood graph [16]. Two interval relationships are neighbors, if they can be transformed into one another by continuous deformation (shortening, lengthening, and moving) [17]. We construct a new interval neighborhood graph in Figure 5 which considers our proposed refined relationship with three levels *(f, m, l)* in each relationship defined in Figure 3. Note that the three levels with the same interval relationship are close to each other in the refined interval neighborhood graph since they can be transformed from one to another by shortening or lengthening the distance between the two strokes.

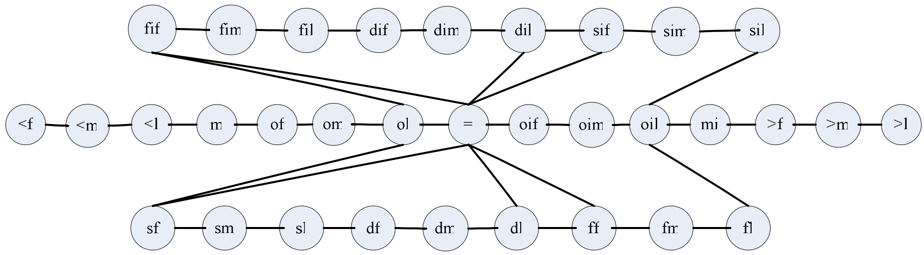


Fig. 5. The refined interval neighborhood graph

The distance between two interval relationships μt_i,and μs_j or the distance between λt_i and λs_j is defined as the topological distance between the two relationships, i.e., the length of the shortest path from μt_i to μs_j or from λt_i to λs_j in the interval neighborhood graph. The final spatial relationship distance $D(Rt_i, Rs_j)$is:

$$C_{sub}^{e} = C(Rs_i \rightarrow Rt_j) = D(Rt_i, Rs_j) = \sqrt{D(\mu t_i, \mu s_j)^2 + D(\lambda t_i, \lambda s_j)^2} \tag{1}$$

Edge deletion. It is used together with the node deletion operation. If some extra nodes need to be removed by using the node deletion, then the corresponding edge should also be removed by the edge deletion.

Edge insertion. It is similar to the edge deletion, but it is used together with the node insertion operation. If some missing nodes need to be added by using the node insertion, then the corresponding edge should also be added by the edge insertion.

The graph edit distance defining the overall cost for transforming from the ARG g_1 to ARG g_2 using the function *f* is given as follows:

$$Cost(f, g_1, g_2) = C_{node}(f, g_1, g_2) + C_{edge}(f, g_1, g_2) \tag{2}$$

where C_{node} is the node edit distance and C_{edge} is the edge edit distance.

$$C_{node}(f, g_1, g_2) = \sum C_{sub}^{n} + \sum C_{mer}^{n} + \sum C_{spl}^{n} + \sum C_{del}^{n} + \sum C_{ins}^{n} \tag{3}$$

where C_{sub}^{n}, $C_{mer}^{n}, C_{spl}^{n}, C_{del}^{n}, C_{ins}^{n}$ are the costs of node substitution, merging, splitting, deletion and insertion respectively.

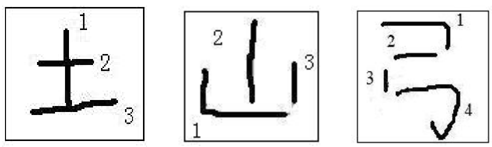
$$C_{edge}(f, g_1, g_2) = \sum C_{sub}^{e} + \sum C_{del}^{e} + \sum C_{ins}^{e} \tag{4}$$

where C_{sub}^{e} , C_{del}^{e}, C_{ins}^{e} are edge substitution, deletion and insertion costs respectively.

There are many possible sequences of edit operations that can transform from g_1 to g_2. It is impractical to perform exhaustive search to find the optimal matching that minimizes the overall graph edit distance. As a result, the A* algorithm which is a state-space search strategy is employed to identify the optimal ARG matching [6].

2.5 Pruning Strategy

In the handwriting education system, students always want to get an immediate feedback. The computational time of the graph matching thus should not be too high. By using the edit operations like merging and splitting, the searching space of our problem is increased. We need to consider all the possibilities for the nodes to be merged or split. However, actually not all of the nodes need to be merged. For example, in Figure 6(a) strokes 2 and 3 are horizontal strokes. In addition, in Figure 6(b) stroke 2 is enclosed in stroke 1, and in Figure 6(c) strokes 1 and 4 are far from each other. Strokes with such spatial relationships can never be broken strokes so there is no need to consider merging them. As a result, we are motivated to examine the properties of the spatial relationships in order to determine under which conditions there is no need to perform the merging operation. This will lead to a reduced set of candidate nodes which in turn can reduce the searching space for the graph matching.



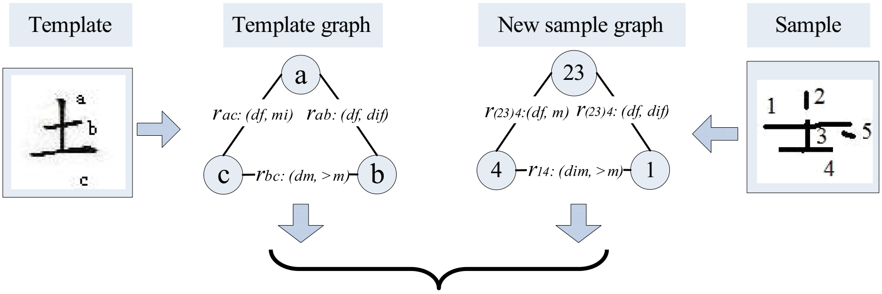
(a) (b) (c)

Fig. 6. Examples of Chinese character handwriting

By analyzing those relationships we can discover the following rule: if the two nodes have the relationship, both along x-axis and y-axis, which can be found in the set *{<f, <m, om, ol, fif, fim, dim, dil, sif, sim, sf, sm, dm, dl, ff, fm, oif, oim, >m, >l}*, then there is no need to merge those two nodes. For example, in Figure 6(a) the relationship between strokes 2 and 3 is *(dil, >m)*, while both *dil* and *>m* are in the set which we had mentioned above, so there is no need to merge strokes 2 and 3; in Figure 6(b) the relationship between strokes 1 and 2 is *(dm, ol)*; in Figure 6(c) the relationship between strokes 1 and 4 is *(ol, >l)*. Each time when we consider about the merge/split operation of two strokes we should check whether their relationship is in the relationship set above. If it is, there is no need to do the merge operation. If not, the merging operation is performed on the two nodes.

2.6 Post-processing for Detecting Spatial Relationship Errors

After the ARG matching we can get a mapping from the sample ARG to the template ARG showing the stroke correspondence between the sample character and the template character. For the example in Figure 7, after applying the resulting edit operations, the stroke correspondence between the sample and the template is: 1-*a*; 2,3-*b*;4-*c* (5 is extra stroke in sample). We can then obtain a new graph to represent the sample graph as shown in Figure 7. The edges in the graph can describe the spatial relations between the nodes (strokes). In Figure 7, there is a difference between the spatial relationships r_{bc} and r_{14}. In particular, the spatial relationship along the x-axis for r_{bc} is *dm* and the spatial relationship along the x-axis for r_{14} is *dim*. It can be found from Figure 5 that it takes at least 4 steps to get from the *dm* node to the *dim* node thus the spatial relationship distance between r_{bc} and r_{14} is 4. Since this is quite a large distance, we can conclude that the spatial relationship between strokes 1 and 4 is incorrect compared with the corresponding template strokes *b* and *c*.



	r_{ac}-$r_{(23)4}$	r_{ab}-$r_{(23)1}$	r_{bc}-r_{14}
$D(\mu t_i, \mu s_i)$	0	0	4
$D(\lambda t_i, \lambda s_i)$	0	0	0

Fig. 7. Matching of spatial relationships

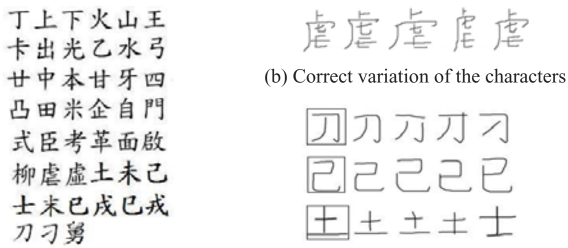
2.7 Feedback for Revealing Handwriting Errors

After the character matching and post processing, we can already locate the student's handwriting errors including stroke sequence, production and spatial relationship errors. First, the character matching can reveal the stroke correspondence which is used to detect the stroke sequence and production errors. If the matched strokes in the sample are not in the same writing sequence as in the template, then there is stroke sequence error and our system can notify the student which strokes are written in the wrong sequence. The graph edit operations in Section 2.4 reveal any stroke production errors and our system can notify the student which strokes have such problems. On the other hand, the result from the post processing described in Section 2.6 can identify and locate the spatial relationship error. Our system is thus able to handle multiple handwriting errors, i.e., stroke sequence, production and spatial relationship errors at the same time.

3 Experimental Results

3.1 Dataset

In our experiment, 44 Chinese characters shown in Figure 8(a) are written by different people and we get 1247 various Chinese handwriting samples. The number of strokes for those characters ranges from 2 to 13. The purpose of our system is to help children and foreigners to learn writing Chinese characters. In the first stage, we will ask them to start with some simple characters consisted of few strokes. We are in the process of collecting more complex characters to expand our dataset.



(a) Character used in the dataset

(b) Correct variation of the characters

(c) Wrong variation of the characters

Fig. 8. The dataset

Different people may write the same character in different ways resulting in many variations of the characters. In Figure 8(b), the handwritings have some variations due to the user writing style which is acceptable. However, in Figure 8(c), it can be seen that the variations of the handwritings are so large that either they are considered as handwriting errors. Some handwritings are even transformed into a completely different character despite the similarity of their appearance. Our algorithm aims to identify these kinds of variations and notify the student about the problems.

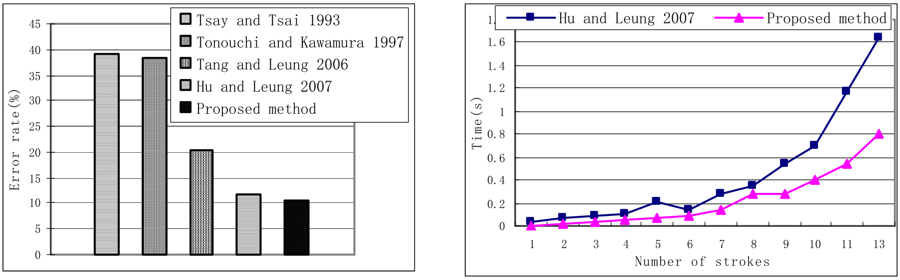
Some of the people's handwritings contain stroke production errors and spatial relationship errors. We manually check those error types to obtain the ground truth information. Our algorithm is then applied to identify handwriting errors and check its accuracy using the ground truth information.

3.2 Results and Discussions

We compare our proposed method to some of the existing methods on detecting different kinds of handwriting errors.

Stroke production error. We have compared our proposed method with four existing methods: Tsay and Tsai [4], Tonouchi and Kawamura [5], Tang and Leung [9] and Hu and Leung [6]. The methods in [4] and [5] are based on string matching which is sequence dependent. If the student input character has a different stroke sequence from the template, these methods may fail to find the matching. Tang and Leung [9] proposed a system that allows students to practice handwriting freely, and it can check both the stroke sequence error and stroke production errors simultaneously. However it relies heavily on some threshold values to determine the potential production errors. Hu and Leung [6] applied graph matching to find the stroke production errors, but without considering the sequence error and spatial relationship errors. On the other hand, our current proposed method is able to identify all three kinds of handwriting errors with less computational time. The performance of finding stroke production errors is shown in Figure 9(a). Figure 10(a) shows some examples of the production errors that can be well identified by our method.

Stroke relationship error. In Figure 8(b), the first character in each row is the template character, and the others are variations of users' handwritings. The last column in Figure 8(b) shows some handwritings that resemble the template character but in fact they represent completely different characters. Those Chinese characters almost



(a) Performance of finding stroke production errors

(b) Comparison computational time

Fig. 9. Performance comparison

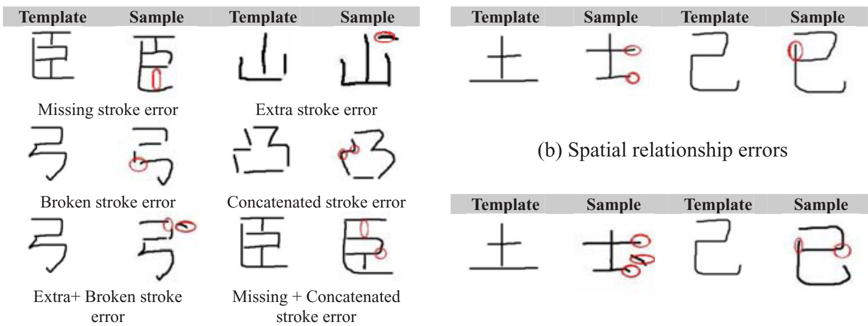


Fig. 10. Handwriting errors that can be identified by our proposed approach

have the same shape as the corresponding template character, with only one or two strokes that are different in relative length or position showing spatial relationship errors. We compared our method to the existing method in [8]. This method first finds the features of a given Chinese character by rewriting the character many times in the training step. After the training, they can get an invariant feature of the given character. The difference can be obtained by comparing the input character with the given character. The disadvantage of this approach is that when the teacher wants to add a new character to the system, the new character must be trained many times at the back-end before it can be used at the front-end. In our proposed method, when the teacher wants to add a new character, he/she only needs to write the character once and then the character is stored in the database. Figure 10(b) shows the spatial relationship errors that can only handled by our method. Figure 10(c) shows some of the complex cases with both production errors and spatial relationship errors in the handwriting.

Stroke sequence error. After the ARG matching we can determine a stroke correspondence of the template and student input characters. The standard stroke sequence of the template is already known in the database. Hence, the stroke sequence can be easily verified based on the stroke correspondence.

Computational complexity. We apply our pruning strategy to the graph matching, and compare the computational time with the existing method in [6]. The method in [6] also makes use of graph matching to find out the difference between the template and sample but without applying the pruning strategy. From Figure 9(a), it can be observed that the performance of finding stroke production errors for the method with and without pruning is similar. However, our proposed method is faster than the one in [6] as illustrated in Figure 9(b).

The results show that our method can handle more kinds of handwriting errors such as stroke production errors, spatial relationship errors and stroke sequence error compared with existing methods. While our method can locate more kinds of handwriting errors with less computational time, the accuracy of our approach also outperforms existing methods.

4 Conclusion

In this paper we have used the attributed relational graph to represent a Chinese handwriting character incorporating the spatial relationship information between strokes. A refined interval relationship with more granular levels is proposed to model the Chinese characters. A novel interval neighborhood graph is also proposed to compute the distances among the refined interval relationships. A pruning strategy is adopted to assist the A* algorithm in searching for the optimal matching and lowering the computational complexity. The experiments show that our proposal can handle more kinds of handwriting errors than existing methods with less computational time. To further improve the performance of our method, future work may focus on improving the current definition of relationship by combining the relationship along x-axis and y-axis to form a new relationship, and find a more computationally efficient pruning strategy based on the new relationship.

Acknowledgments

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A New Chinese Speech Synthesis Method Apply in Chinese Poetry Learning

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Abstract. This paper describes a new Chinese speech synthesis method apply in Chinese poetry teaching and learning, which focus on the prosody of syllables and words in Chinese poetry. As the word is a key semantic unit for Chinese poetry, we concentrate on Chinese word prosody and propose a speech synthesis method, which consider the appearance with the essence of human voice, use the homomorphism analysis over the time domain analysis to make the synthesized speech between syllables in a Chinese word sounds more natural. The prosody model of the method, however comply with the reading rules of Chinese poetry, make the user to learn Chinese poetry more convenient from the acoustic perception level.

Keywords: Chinese poetry, Speech Synthesis, PSOLA, homomorphism.

1 Introduction

China is a poetry country, she had reached her golden age in Tang dynasty and Song dynasty. The Chinese poetry is a quintessence of Chinese culture. In modern education the poetry teaching and learning is still play an import role.

To learn Chinese poetry reciting is the first step, and then comprehension. Generally we recite things by our eyes or ears. Though we often get knowledge from the visual perception level, the sounding perception level can't be ignored. Sometimes we reading out loudly when we learn the poetry, actually it affects our brain through our ears.

The Chinese Text To Speech (hereafter call TTS) technology can translate Chinese text stored in computer into speech voices that can played through the sound devices. Thus the Chinese TTS technology can help users to learn the Chinese poetry more convenient, more efficient and to make the Chinese poetry teaching more vivid.

In the following, we will give the prosody feature of Chinese poetry in section 2, and then present the synthesis speech prosody model in section3, and the new speech synthesis method in section 4, followed with the experiment and conclusion in section 5.

2 The Prosody Feature of the Chinese Poetry

Take a Tang poetry "床前明月光, 疑是地上霜. 举头望明月, 低头思故乡." as example. It will be segmented into "床前/明月光/, 疑是/地上霜/. 举头/望/明月/, 低头/

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思 / 故 乡 /.” and the Mandarin Chinese phonetics is spell as “chuang2qian2/ ming2yue4guang1/, yi2shi4/ di4shang4shuang1/, ju3tou2/ wang4/ ming2yue4/, di1tou2/ si1/ gu4xiang1/ .”, in which the number represents the syllable tone. Here we call one Chinese character as a syllable.

The Chinese poetry format is strict neatly, it is often made of four or eight sentences which including five or seven syllables. The poetry gives abundant information in such limited words, so a character or a word can be explained into several associate meanings. Then the poetry often takes one syllable or one word as its reading unit.

The poetry reading mood is a little different from the news broadcasting statements mood as usual, it is slower. Thus the rhythm of a word including monosyllable is made to a more prominent position and the prosody of them becomes the key prosody of Chinese poetry.

We concentrate on the prosody between adjacent syllables in one word in Chinese poetry and propose a prosody module in section 3.2 and section 3.3.

3 The Chinese Poetry Prosody Model

The Chinese poetry prosody mainly includes three levels, the syllable prosody, the word prosody and the sentence prosody.

3.1 The Syllable Prosody

The pitch and duration are two important features in syllable prosody. It is well known that Chinese is a tonal language, the tone represent the pitch in physics. The tone is exits on certain duration. There are four lexical tones including tone1, tone2, tone3 and tone4 in Mandarin Chinese. Chinese phonetist Yuanren Zhao had introduced a method called five-grade tone-marking [1] to describe the Chinese tones. It gives the corresponding tone type for each lexical tone which conveys the pitch changing trends on certain duration of one syllable. As figure 1 show, it divides the vertical pitch axis into five

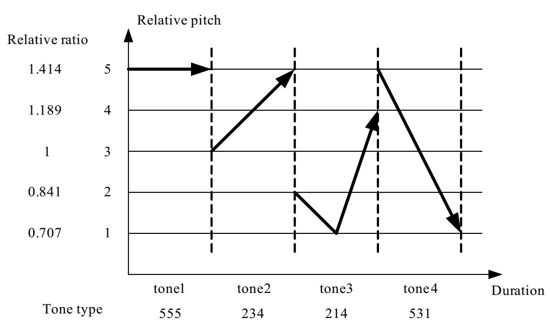

Fig. 1. Five-grade tone-marking

levels. The ratio between each adjacent level is $2^{1/4}$. The five levels is a relative value. If we set level3's value equals 1, the level2's value can be calculated as 0.841 etc. Then the tone1's tone type is defined as "555" which means the relative pitch value at the start time, middle time and end time point on the duration of syllable, and we concatenate the adjacent pitch point with a line. In the same way tone2's tone type is defined as "345", tone3 as "214" and tone4 as "531". Once we give an absolute average pitch value of the syllable and a certain duration, we can calculate its pitch value of any time point in the duration by the module.

3.2 The Word Prosody

The word prosody mainly includes tone changing and coarticulation [2].

Chinese word tone prosody is based on its character's tone. In continuous speech the syllable tones type maybe changed and no longer equal to its basic tone type. For example, the word "慷慨" in spelling is "kang1kai3" whose tone combination is "1-3" and original tone type combination is "555-214", but the tone type will be changed into "555-21" which makes it sounds more natural by our Mandarin Chinese pronunciation custom. We have experimented on all kinds of Chinese tone combinations and then give out the changed tone type combinations as table 1 shows.

Table 1. Tone Changing

tone i-tone j	1st tonetype	2nd tonetype	tone i-tone j	1st tone type	2nd tone type
tone1-tone1	555	444	tone3-tone1	311	444
tone1-tone2	555	234	tone3-tone2	311	124
tone1-tone3	555	21	tone3-tone3	234	21
tone1-tone4	555	531	tone3-tone4	211	531
tone1-tone0	555	21	tone3-tone0	311	31
tone2-tone1	234	444	tone4-tone1	531	333
tone2-tone2	345	345	tone4-tone2	531	234
tone2-tone3	345	21	tone4-tone3	531	21
tone2-tone4	234	531	tone4-tone4	531	531
tone2-tone0	345	31	tone4-tone0	531	31

The second feature of word prosody is coarticulation. Coarticulation is a phenomenon happened when one syllable pronounce by the end with another syllable is about to start pronounce in a word, the latter syllable's pronouncing way will affect the former one's.

How human voice produces? The principle is the airflow comes from our lung and through the glottis, if the vocal chords vibrate then the vowel formed, or else the consonant formed. And the airflow continues to get through the vocal tract, which is constituted of the oral cavity, the nasal cavity etc. then change into the voice. According to the different vocal tract form, the airflow becomes into different speeches. Thus we see the vocal tract parameters decide a certain voice.

for example, the syllable "一" will be read as "yi1". The vocal tract will keep still when pronounce the phoneme "i", but in word "一个" whose spelling is "yi1ge4", at the end of the pronunciation of phoneme "i" the vocal tract is ready to change to fit the phoneme "g". So the pronunciation of "i" will be different from the single "i" in a word when another syllable is come with it.

The new speech synthesis method this paper present is to make the synthesized speech presents the affection produced by the coarticulation in the word.

3.3 The Sentence Prosody

Firstly we take a look at the prosody of words in a sentence. Here we have to introduce a concept called "pitch resetting", it is comparative with the "pitch continuous" which means the latter syllable's start pitch is equal to the previous one's end pitch in a word.

A sentence can divided into several words, the first syllable's start pitch in each words will reset to a certain pitch, but in the word the syllable's pitch is vary continuous. We call it "pitch resetting". Pitch resetting often happens when we exchange breath during reading. We often take a word, a phrase or a short sentence as a breath exchanging unit. As shown in figure 2, the sentence "系列报道感受二零零四今天播出" is segmented as spelling sequence "xi4lie4bao4dao4/ gan3shou4er4ling2ling2si4/ jin1tian1bo1chu1/ ". The sentence is composed by three phrase, from the figure 2 we see at the first syllable of each phrase the pitch is reset to certain value. We can decide the pitch reset prosody boundary when we do Chinese word segmentation in Text proceeding.

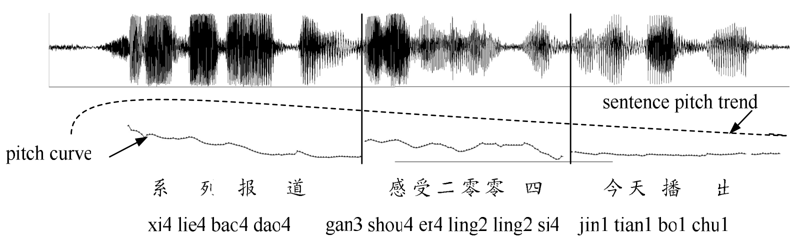

Fig. 2. Chinese sentence prosody

Another feature of sentence prosody is whole sentence's pitch trends. In statement sentences the pitch trend is declining. This trend overlaps on every syllable in the sentence. So when pitch resetting occurs in a statement sentence the "definite pitch" will a little lower than it last time was.

Consider the Chinese poetry's reading feature; we assume the pitch resetting happens in a single syllable's end or a single word's end.

4 The Speech Synthesis Method

The TTS system mainly including three parts: text processing module, prosody module and speech synthesis module. In speech synthesis module, what kind of speech synthesis algorithm should be chosen is most important. As it is an important part of the TTS system, we make a close look at it.

4.1 Speech Synthesis Algorithm

This paper addresses a new speech synthesis method which takes the time-domain waveform editing algorithm as basic speech synthesis algorithm and overlaps the vocal cepstrum parameters which get from homomorphism analysis on the adjacent syllables in a word to smooth the speech transition affections. The waveform editing synthesis whose advantage is rapid for process and vocal tract parametric synthesis whose advantage is flexible for adjustment as it is considering the essence of the sounds.

4.1.1 The Voice Database

Because the waveform editing algorithm is our basic algorithm, the voice database is needed to store all the elementary waveforms. The voice database mainly stores the synthesis elements.

The choice of the base synthesis element not only decides the quality of the final speech but also relative to the limit of the hardware storage ability. So many Chinese TTS systems choose syllables, words or phrases, even sentences as the base synthesis element, which lead to a big voice database. Our approach is taking initial consonant and simple/compound vowel as basic elements according to the reference [3]. Thus the storage of voice database is cut down to several hundreds of KB meanwhile maintains a fairly equal level of voice quality.

4.1.2 PSOLA Algorithm

E.Moulines and F.Charpentier found a speech synthesis algorithm based on time domain waveform modification called PSOLA (Pitch Synchronous Overlap Add) [4]. It is being widely used nowadays. To know more detail about PSOLA algorithm please see the reference [5] and [6].

The PSOLA algorithm ensure the waveform and the spectrum persist smooth and continuous when the speech signal being modified. It works by three steps. As shown in figure 3. Firstly make a transform on a small segment of the original time domain waveform, whose duration is about 2 times of the pitch period, we call the transformed speech signal as short time temporary signal. Then modify the temporary signal. At last rebuild the time domain waveform from the modified temporary signal. So we can do the modifications in step 2 to synthesis the speech we required.

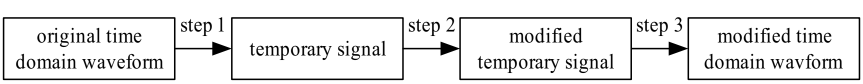

Fig. 3. Main steps in PSOLA algorithm

For example, if we want to synthesize a syllable of 400ms, but the corresponding syllable in voice database is 200ms, then we can process it as shown in figure 4.

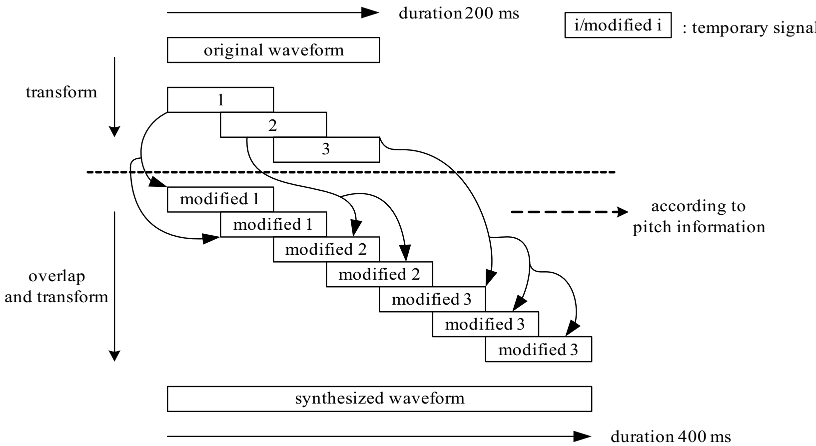

Fig. 4. PSOLA synthesis procedures

Firstly calculate how many temporary signals there should be in 400ms duration and calculate all the temporary signals of the original syllable's waveform, then according to the pitch information, find the temporary signals which about to be synthesized should equal with which ones in the original's and arrange them on the duration line, finally overlap them to produce the synthesized speech.

4.1.3 Concept of Cepstrum

We called time-domain signal sequence $\hat{x}(n)$ as the complex cepstrum of signal sequence $x(n)$. The $\hat{x}(n)$ is calculated by formula 1.

$$\hat{x}(n) = Z^{-1}[\ln[Z[x(n)]]] \,, \tag{1}$$

take the real part of $\hat{x}(n)$ as $c(n)$, we called $c(n)$ the cepstrum and $c(n)$ is calculated by formula 2.

$$c(n) = Z^{-1}[\ln | Z[x(n)|] \,. \tag{2}$$

4.1.4 Homomorphism Analysis to Get the Vocal Tract Cepstrum Parameters

The time domain speech signal $x(n)$ is the convolution of speech source signal $e(n)$ and vocal tract signal $v(n)$ in a simple digital speech model. We have known that vocal tract contains the most important information of the speech, thus we want to separate the vocal tract signal and modify it in order to produce the speech we need.

There is no good way to separate $v(n)$ from $x(n)$ in time domain, but the homomorphism analysis is helpful. In homomorphism analysis, do Z transform on both sides of the equation 3.

$$x(n) = e(n) * v(n) \ . \tag{3}$$

The convolution is changed into product and we get the equation 4.

$$X(k) = E(k)V(k) \ . \tag{4}$$

Do logarithm operation on both sides of the equation, then we change the product operation into linear operation and get the equation 5.

$$\ln(X(k)) = \ln(E(k)) + \ln(V(k)) \ . \tag{5}$$

Make it as equation 6.

$$\hat{X}(k) = \hat{E}(k) + \hat{V}(k) \ . \tag{6}$$

Do Z^{-1} transform, the equation change into equation 7.

$$\hat{x}(n) = \hat{e}(n) + \hat{v}(n) \ . \tag{7}$$

Now we can get the vocal tract cepstrum parameter $\hat{v}(n)$ by an linear filter. After we modified the vocal tract cepstrum parameter, the converse operation can be used to make the cepstrum domain signal $\hat{v}(n)$ back to time domain signal $v(n)$.

4.1.5 Vocal Tract Cepstrum Parameter Speech Synthesis

When dealing with the adjacent syllables in one word during the speech synthesis, we could synthesize the speech through adding the latter syllable's vocal tract cepstrum parameters into the former syllable.

In the step 2 of PSOLA algorithm, after the temporary signal to be synthesized is calculated we take the last *k* temporary signal's vocal tract cepstrum parameters of the first syllable and the first *k* temporary signal's vocal tract cepstrum parameters of the second syllable with a linear operation, the operation result as the first syllable's last *k* temporary signal's new vocal tract cepstrum parameters. Finally transform the cepstrum parameters and temporary signal back to time domain then we get the synthesized speech. The linear operation method is shown in formula 8. The linear coefficient is determined according to the reference [7].

$$\begin{bmatrix} \tilde{v}_{f1} \\ \tilde{v}_{f2} \\ \vdots \\ \tilde{v}_{f25} \end{bmatrix}_k = \begin{bmatrix} v_{f1} \\ v_{f2} \\ \vdots \\ v_{f25} \end{bmatrix} \times \left[1 - \sin(\frac{\pi k}{2K}) \right] + \begin{bmatrix} v_{b1} \\ v_{b2} \\ \vdots \\ v_{b25} \end{bmatrix} \times \sin(\frac{\pi k}{2K}) \ , \tag{8}$$

In formula 8, $\widetilde{v}_{fi}$ is the first syllable's modified vocal tract cepstrum, v_{fi} is the first syllable's original vocal tract cepstrum, v_{bi} is the second syllable's original vocal tract cepstrum.

Thus we resolve the affection between the adjacent syllables.

4.2 The Programming Implementation

The method this paper mention is implement under VC.net framework with C++ languages.

The Figure 5 shows the logic procedure of the Chinese TTS system, When the Chinese poetry text is input into the TTS system we can predict the basic duration, pitch of the syllable and then sentence mood, and then do words segmentation to mark the boundaries of pitch resetting, the next step is synthesize the speech with the consonants, vowels, tones which has been analyzed already by PSOLA algorithm, meanwhile to adjust the prosody of the adjacent syllables in one word with vocal tract cepstrum parameter synthesis algorithm, and finally get the synthesized speech.

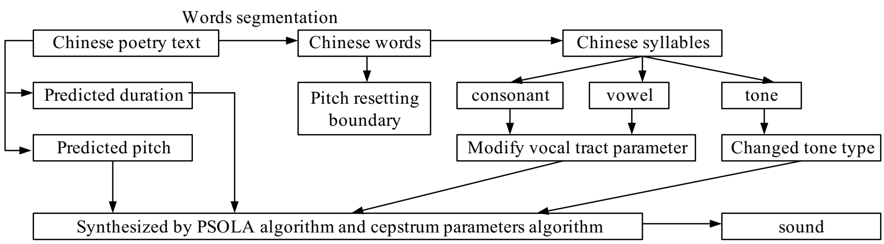

Fig. 5. The logic flow of TTS system

The final user interface including the waveform which is synthesized by the system is shown in Figure 6.

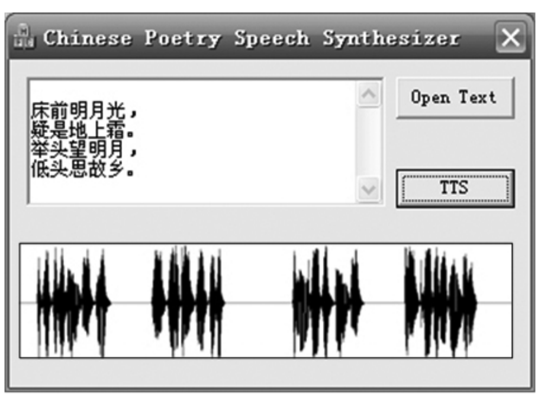

Fig. 6. User interface

5 Experiment and Conclusion

Figure 7 shows the waveform of Chinese word "明月" which spell as "ming2yue4" synthesized by PSOLA algorithm only and synthesized by vocal tract cepstrum parameter algorithm overlap on PSOLA algorithm. From the waveform we can see the waveforms between two syllables are different. To test the quality of the word speech sounds produced by the method this paper presents, 30 words were selected. The experimental results showed that the speech synthesized by the new method sounds more natural.

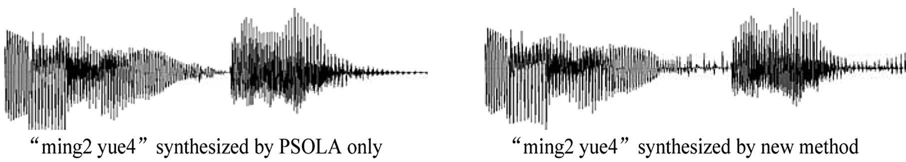

Fig. 7. Word's waveforms synthesized by different methods

The quality of the sentence speech sounds produced by the method the paper presents is tested by 30 selected sentences and 8 different people. The experimental results also showed that the speech synthesized by the new method sounds more natural and adapt to the prosody of Chinese poetry. Take the sentence "举头/望/明月" whose spelling is "ju3tou2/wang4/ming2yue4" as example, its waveforms and pitch curves synthesized by two method are shown in figure 8. It is obvious to find that the pitch curve of the speech synthesized by the new method has a gradually decline trend which is more adapted to the Chinese poetry prosody.

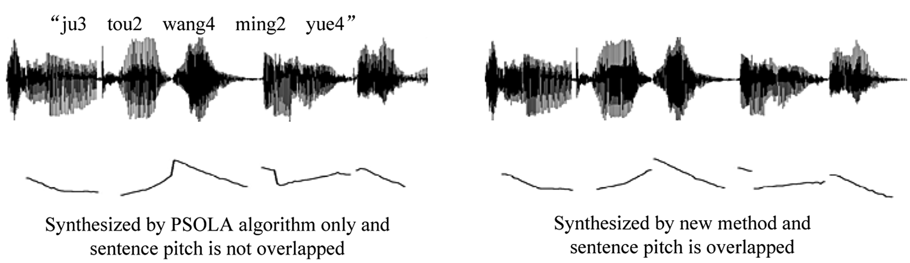

Fig. 8. Sentence speech synthesized by different methods

This paper analyzes the feature of Chinese poetry, and addresses a new method for Chinese speech synthesis which happens to adapted to Chinese poetry's prosody. The method takes advantages of two basic algorithms, and improves the quality of the synthesized Chinese poetry speech. We can apply the new method of Chinese speech synthesis in our Chinese poetry teaching and learning, because it provides us a more convenient way. Learning Chinese poetry needs reciting, and the reciting needs more listening, we can reproduction the audio stream of the Chinese poetry through the TTS engine. It only needs to store a few characters which take a small storage spaces on our electronic devices, but provide colorful, varied sounds to us. As the network and wireless technology is developing, it certainly will provide more supports for the Chinese poetry speech learning.

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Comparing the Impact of Two Different Designs for Online Discussion

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Abstract. This study examined the impact of two different designs of online discussion on student participation in the discussions and the type of learning that was generated. The results showed that when students were given an opportunity to respond to each other with the instructor mostly absent in the discussion process until the end of the discussions, they would visit the discussion forums more frequently. They were also more likely to pose follow-up questions for their classmates and engage in meaningful inquires. On the other hand, when the instructor posted frequently in the discussion forums, students would respond to him instead of their peers, and the discussions were seldom carried forth in much depth.

Keywords: Online discussion; instructional design.

1 Introduction

Most instructors of online courses require their students to participate in some sort of online discussions as part of their learning experience. Since online teaching has only been recently introduced in higher education, online instructors have few models to follow in setting up discussions for the students. As a result, instructors may design the discussions in different ways, which could lead to very different learning experiences and outcomes for the students.

1.1 Theoretical Rationale for Online Discussion

The use of student discussion in an online course is often justified on the learning theory of constructivism, especially social constructivism. According to constructivism when a concept is connected with a learner's personal experience in an authentic context, learning is more likely to occur [1], [2]. Interaction between different learners is considered important, since it makes it possible for a learner to see how a concept or idea applies to different circumstances [3]. According to Hemetsberger and Reinhardt [4], knowledge-building at the collective level consists in "the advancement and collective elaboration of conceptual artifacts" (p. 190). Dennen and Wieland [5] proposed that when analyzing whether discussion supports learning, one needs to look for learning evidence within a collection of messages instead of examining them in isolation.

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Unlike discussion in a face to face class, discussion in an online environment is often asynchronic [6]. The online instructor and the students do not have to log into the course website at the same time in order to carry on the discussion. As a result, the students have sufficient time to think before responding to a question in a discussion forum [7]. Asynchronic discussion also tends to reduce the participation anxiety of shy students. Possibly for such reasons, online discussions are perceived by instructors as more substantive than discussions in a regular classroom [6].

1.2 Designs for Online Discussion

Although online discussion has the potential to generate collective learning for the students, it does not mean that such learning will easily take place in every online setting [8], [9], [2]. According to Dennen and Wieland [5], students may “nominally fulfill class discussion requirements by posting, but fail to engage more deeply with their classmates by reading and responding to their messages in a thoughtful and reflective manner” (p. 281). In order for learning to take place, an instructor needs to design the discussions in a way that makes such learning possible.

There are different ways in which discussions in an online class may be designed. Some online instructors may let students choose their discussion topics, whereas the majority of instructors like to develop the topics for their students. Even if an instructor is responsible for developing the discussion topic, there are different kinds of topics that may be used. It was found that discussion topics that require students to relate to their experiences are more likely to engage students in the discussions [5], [10].

A related decision in the design of online discussion is the role of an instructor [2], [11]. The instructor has the option to be heavily involved in the discussions, by responding to every student’s comments, or remain as an observant during the process, providing little input until the end of the discussion. It was generally believed that students can have successful online discussions without much intervention from the instructor [5], [10]. According to Dennen [9], when there was considerable presence of the instructor, students would choose to respond to the instructor instead of their peers. In a study by [11], it was reported that the frequency of postings by online instructors had significantly negative correlations with the frequency and length of student postings. The study also found that students tended to consider instructors who were active in posting as more enthusiastic and more knowledgeable, especially if instructors provided postings towards or at the end of the discussions. According to the study, the timing of instructor postings did not have a significant impact on student participations in the online discussions.

1.3 Purpose of Study

This study compared two ways of designing the discussion forums in an online class for teacher candidates. The purpose was to find out if requiring students to respond to one another with little intervention from the instructor would lead to increased student participation and more significant student learning, as compared to a design that required students to directly respond to the original discussion topic followed by an instructor response.

2 Method

This study used a mixed method of quantitative and qualitative inquires. The quantitative approach was used to collect data regarding the extent of instructor and student participation in online discussions. The participation data include: 1) the number of times the students and the instructor visited each discussion forum; 2) the number of times posted a message in a discussion forum; and 3) the number of words for each posted message.

The qualitative approach was utilized to examine both the process and product of the discussions associated with the two designs. To obtain the qualitative data, the researcher chose two discussion forums that used the same topic and similar instructions and compared the discussions in these two forums in terms of: 1) the degree of interactivity between the students; 2) the opportunity for students to raise thought-provoking questions; and 3) the evidence of collective learning for students.

2.1 Context of Study

The data for the study came from two online course sections taught by the researcher in Fall 2007 and Spring 2008 in a Midwestern state university in the U.S. The course was “Educational Measurement and Evaluation,” a two credit hour class designed for both undergraduate education majors and graduate students seeking their initial teacher certification through an alternative route. The course was offered completely online using the Blackboard course management system. In both sections of the course, there were 24 active students. There were altogether 14 lessons in the course, with each lesson covered in a week. The data of this study were based on the discussions for the first six lessons in both semesters. There were a total of 12 discussion topics from each semester that were examined, with two topics for each lesson. The topics and instructions for discussions are provided in the Appendix.

As an instructor of the course, the researcher had access to the course statistics function of the Blackboard to obtain the number of times students visited each discussion forum and the number of times they responded in each forum. The researcher also had access to a collection function in each discussion forum that simplified the process of calculating the length and viewing the content of each posting.

2.2 Subjects of Study

In the Fall 2007 section, the students were instructed to either directly respond to the instructor’s question, or respond to each other. The instructor responded to most students’ messages if they were posted by the Thursday deadline. In the Spring 2008 section, the students were asked to respond to their previous respondent only. The instructor waited until the end of the discussion before providing a summary that included comments on some of the ideas students shared and answers to any unanswered questions. The discussion topics from the two sections were worded in a similar way (Appendix).

3 Results

The online version of the volume will be available in LNCS Online. Members of institutes subscribing to the Lecture Notes in Computer Science series have access to all the pdfs of all the online publications. Non-subscribers can only read as far as the abstracts. If they try to go beyond this point, they are automatically asked, whether they would like to order the pdf, and are given instructions as to how to do so.

Please note that, if your email address is given in your paper, it will also be included in the meta data of the online version.

Table 1. A Summary of Online Discussion Participations by the Students

Fall 2007				Spring 2008			
Topics	Accesses	Messages	Words per message	Topics	Accesses	Messages	Words per message
Lesson 1							
About me	477	32	83	High stakes test	714	32	200
Assessment topic	488	36	70	Benefit of assess. know.	537	28	130
Lesson 2							
Reliability	405	34	126	Test reliability	481	24	111
True score	449	33	54	True score	523	17	215
Lesson 3							
Validity example	346	31	113	Test validity	717	35	101
Test validation	363	30	116	Test validation	490	25	95
Lesson 4							
Test bias	354	32	107	Biased assess.	344	28	140
Test accommod.	240	28	99	Test accommod.	415	35	117
Lesson 5							
Cognitive Level	306	28	76	Cognitive level	522	30	146
Affective/ Psychomotor	278	26	93	Affective/ psychomotor	564	30	121
Lesson 6							
Guideline for item construction	201	26	113	Guideline for selected response item	314	25	125
Type of test item	175	27	106	Selected response item	314	26	106
Average	340	30	96	Average	495	28	134

3.1 Student Participation

A summary of quantitative data regarding student participation in the online discussions is provided in Table 1. The data shows that the students in the online course visited each forum on an average of 340 times in Fall 2007, and 495 times in Spring 2008, an increase of 46% over the previous semester. There was an average of 30 messages per discussion topic provided by students in Fall 2007, and about the same number (an average of 28) of student messages in Spring 2008. The average number of words a student used in a posted message was 96 in the fall semester, and 134 in the spring, an increase of 40% over the previous semester.

Table 2. A Summary of Online Discussion Participations by the Instructor

Fall 2007				Spring 2008			
Topics	Accesses	Messages	Words per message	Topics	Accesses	Messages	Words per message
Lesson 1							
About me	66	6	34	High stakes test	72	4	100
Assessment topic	145	21	14	Benefit of assess. know.	43	2	124
Lesson 2							
Reliability	184	24	11	Test reliability	22	1	373
True score	196	24	10	True score	32	3	95
Lesson 3							
Validity example	119	19	34	Test validity	20	1	145
Test validation	194	23	32	Test validation	16	1	424
Lesson 4							
Test bias	96	18	28	Biased assess.	14	1	411
Test accommod.	85	20	16	Test accommod.	13	1	460
Lesson 5							
Cognitive Level	121	22	15	Cognitive level	29	2	169
Affective/ psychomotor	122	21	12	Affective/ psychomotor	30	2	221
Lesson 6							
Guideline for item construction	73	21	12	Guideline for selected response item	6	1	244
Type of test item	66	21	19	Selected response item	5	1	239
Average	122	20	20	Average	25	2	250

3.2 Instructor Involvement

The involvement of the instructor in terms of the number of visits to the discussion forums, the number of messages, and the number of words per message is summarized in Table 2. The instructor visited each forum on an average of 122 times in Fall 2007 and 25 times in Spring 2008. Given that there were 24 students in each semester, the instructor visited each student's postings about five times in the Fall semester, and only once per student in the Spring semester. The average number of messages posted by the instructor for each discussion topic also dropped significantly, from 20 in the Fall to 2 in the spring. On the other hand, the average number of words used by the instructor per message increased drastically, from an average of 20 words per message in the Fall 2007 semester, to an average of 250 words per message in the Spring 2008 semester. The sharp increase in the words reflected the fact that the instructor used relatively brief comments to each student in the Fall semester and much detailed feedback at the end of the discussions in the Spring semester. The total number of words the instructor used for each discussion forum averaged 400 for the Fall semester and 500 for the Spring semester.

3.3 Student Interactivity

Aside from the quantitative data, the content of the discussion forums was examined to compare the potential impact of the discussion designs. One difference that was relatively easy to identify was the extent of interactivity between the students. Although there was some interactivity in the Fall semester, it was only discernible in 5 out of the 30 messages students posted in response to the topic of test validation. Overall, the postings in that semester's discussion board read more like a dialogue between each individual student and the instructor, with each student responding to the message originally posted by the instructor, and the instructor following the response with a brief comment on the merit of the student's response. In contrast, in the Spring semester, each student was required to respond to the previous post. It was evident from the postings that each student had read at least the previous post before providing any response in the forum. Many messages included acknowledgment of several postings that were provided earlier.

3.4 Opportunities for Questions

Related to the difference of interactivity is the opportunity for students to raise meaningful questions. In the Spring section, there was sufficient evidence of students asking their fellow students to clarify their positions or challenge them to a new perspective. For instance, in the discussion forum on the topic of test accommodation, a student mentioned a friend of hers who needed accommodation due to dyslexia. She observed that test accommodations were important, but should be only provided on a case by case basis. Another student followed up by drawing attention to potential issues with test accommodations, even when the provision of accommodations was justified in this case:

> Did she say whether or not the reader's voice intonation, eye contact, or body language ever helped her get the right answer, or maybe even misguided her to a wrong answer? I ask this because I would be concerned about an added advantage or disadvantage to the tester.

In another post, a student questioned the benefit of accommodating students in testing over the long term:

> I have questions about whether or not students benefit in the long run by having exams read to them when they are poor readers… I question the wisdom in constantly reading exams to students. Students will learn that they have no need to try harder…

There were five instances where such thought provoking questions were asked regarding test accommodation in the Spring section. In contrast, no such question was found in a corresponding forum in the Fall section. Instead, most of the messages posted in the semester were attempts to answer the instructor's original question without raising any further questions for either the instructor or the rest of the class.

3.5 Evidence of New Learning

Not only was there a difference in the opportunity to raise thoughtful questions, there was also a difference in the opportunity for students to engage in meaningful inquires that would provide for them insights or new perspectives. Such opportunities were rare in the discussions in the Fall semester, where the conversations were mostly restricted to those between the instructor and an individual student. A typical response by the instructor to a student's post on the topic of test validation was: "I think that would be a great idea to validate a test, by giving it to students in another grade!" Although the instructor's comments were often worded in a constructive way, seldom did the conversation between the instructor and the student proceed much further.

Occasionally, a conversation might occur among the students themselves in the Fall section. For instance, the following is a message pertaining to the topic of test validation:

> Since I am the only teacher for my area of instruction, it makes it difficult to have another teacher review the exam; however, your post got me thinking that there are a few other instructors in the local area, some with many years [of] experience and they could be a great resource in developing my program. Thanks.

This message suggests that a previous post brought to the attention of this student the idea of using peers at another location to review her test. However, the idea was new to the student and needed to be tested out in the field. It is possible that some other students in the class had relevant experience and could provide valuable feedback to this student. Unfortunately, this conversation was not followed up in the Fall semester.

Such follow-ups, however, were common in the Spring section of the course. For instance, one student responded to a previous post by suggesting a new idea for pre-testing when validating a test:

> I believe the pre-test is a good idea, but why does it need to be a test? Another good way to test if the students know the material could be by a game, such as a relay game, or different things like that. This material you cover in the game would be related to what the test is going to be like and then if the students have [a] question they are more than welcome to ask… Adding in some fun and action will allow the students to be more involved and feel more comfortable on the material.

The message that immediately followed this post provided additional support for an alternative pre-test, as well as reflecting upon other ideas for test validation:

> I completely agree that the "pre-test" does not have to be an actual test. Making it a test penalizes the students for not knowing information that they may have never been exposed to, and [it is inappropriate] since you're mostly using it to assess what they do and don't know in order to better plan your curriculum…

The first post introduced the idea of using a game as an alternative pre-test and suggested that this approach would help with student motivation. The second post added to this argument from a different perspective, by suggesting that providing an alternative pre-test was not only useful but also very necessary. Such posts constituted evidence that new learning had occurred among the students, as a result of the follow-ups of messages made possible by the interactions of the students in the Spring semester.

4 Conclusions and Discussions

This study examined the impact of two different designs of online discussion on student participation in the discussions and the type of learning that was generated. The results showed that when students were given an opportunity to respond to each other with the instructor mostly absent in the discussion process until the end of the discussions, they would visit the discussion forums more frequently. They were also more likely to pose follow-up questions for their classmates and engage in meaningful inquires. On the other hand, when the instructor posted frequently in the discussion forums, students would respond to him instead of their peers, and the discussions were seldom carried forth in much depth.

The findings confirmed what was reported in the research literature regarding the negative relationship between instructor involvement and student participation in online discussions [11]. Although the instructor may need to provide more detailed feedback at the end of the discussion, the release from making frequent visits and posts in the forum would save the instructor valuable time. When online discussion is designed in this way, an instructor no longer has to invest in as much time as is generally assumed. This does not mean that the instructor should stop monitoring the discussion process. Regular instructor visits of the discussion forum are still needed so that the instructor may help when a discussion gets stalled. This study also highlighted the importance of interaction between students in online discussions [5]. Although there is a distinction between interaction and engagement in collective learning, when interaction is made possible, there is more opportunity for students to engage in collective inquiry and benefit from it.

The results of the study were based on the discussions from the first six weeks of two online classes. They need to be validated with studies that utilize data on a larger scale. In addition, the learning outcomes were examined through content analysis. Future research may focus on outcomes measured through the student perspectives, in terms of how much learning and what type of learning have resulted in association with the two discussion designs. The learning outcomes may also be measured in more objective terms, such as exam results. Besides student learning outcomes, a comparison of the two discussion designs may also need an examination of student satisfaction of the processes.

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Appendix: Topics and Instructions for Discussion

	Fall 2007		*Spring 2008*
Topics	Instructions for Discussions	Topics	Instructions for Discussions
About me	Please tell us who you are, what is your background, and what is your favorite hobby.	High stakes testing	What is your thought on high stakes testing? Please also introduce yourself.
Assessment topic	What is an assessment topic you are most interested in and want to learn more about? Why?	Benefit of assessment knowledge	What do you think is the most important benefit for a teacher to know about assessment?
Reliability	In your opinion, how much and in what specific ways should a teacher care about the reliability of an assessment device?	Test reliability	What type of test reliability do you think is most useful to a teacher? Why?
True score	Give another name for "true score". Explain in what way it resembles the concept of true score. Make sure you don't use one someone has already mentioned.	True score	In what way do you think the concept of true score is helpful to a teacher?
Validity example	Give an example of a test that you think is particularly valid or invalid. Explain why you think it is valid or invalid.	Test validity	Why do you think a teacher needs to understand the test concept of validity?
Test validation	Suppose you developed a new test that will be used as the final exam for a course you are teaching. Briefly mention the subject area and the grade level of the test. Discuss what informal method may be used to prove the validity of the test.	Test validation	If you developed a test and want to get a rough idea if the test is valid, what may be a method you can use to find this out without having to do any calculations?
Test bias	Have you come across any test that is biased?If so, what makes the test biased?	Biased assessment	Have you come across any assessment that you think is biased? If so, in what way do you think it is biased?
Test accom-modation	Do you perceive a need to use test accommodation for any students in your classes? Why? If so, what test accom-modation will you most likely use?	Test accom-modation	Do you perceive a need to use test accommodations for any students in your class? If so, what accommodations will you most likely use? What student characteristics warrant accommodations?
Cognitive level	Please construct a test question and specify the cognitive level of the question. Discuss if this is an appropriate level for your students.	Cognitive level	Please think of a test question or a performance activity and determine the most likely cognitive level for the question or activity. Discuss if this is an appropriate level for your students.

Affective or psycho-motor domain	Please give an example of an assessment item that may be used to assess student learning in the affective or psychomotor domain. Discuss whether it is necessary to have such assessment in your class.	Affective or psycho-motor assessment	Please give an example of an assessment item or activity that may be used to assess student learning in the affective or psychomotor domain. Discuss if it is. appropriate to have such assessment in your area of teaching
Guideline for item construct-ion	Out of the various guidelines for writing test items, which guideline is most helpful to you? Please use an example to explain.	Guideline for selected response item	Out of the various guidelines for writing selected response test items, which one do you find most helpful? Please use an example to explain.
Type of test item	Out of the various types of test items, which one do you think will be the most useful to you in your area of teaching? Please use an example to illustrate.	Selected response item type	Out of the various types of selected response test items, which one do you think will be the most useful to your area of teaching? Please use an example to explain.

A Sociogram Analysis on Group Interaction in an Online Discussion Forum

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Abstract. Group interaction reveals how group members communicate each other when they are working for a group task. The purposes for analysing group interaction are to know how students engaged in the group learning activities and what kinds of social networks are built. 23 students enrol a course and they are organised into 5 groups in this study. Each group has to complete two tasks in a group discussion forum which is offered by WebCL system (an online learning environment). The messages in the discussion forums posted by students in these 5 groups are analysed through sociogram and the results illustrate the characteristics of group interaction in this course.

Keywords: Group Interaction, Online Learning Environment, a Sociogram Analysis, Online Discussion Forum.

1 Introduction

Online discussion forum is an increasingly common use of new information and communication technologies in education[1]. Students are engaging in the discussion forums through communication each other, which can enhance learning outcomes, e.g. increasing motivation and engagement in the learning task, deeper levels of understanding, increasing metacognition, the development of higher-order thinking skills and divergent thinking have been shown to result from the adoption of conversational modes of learning[2][3][4]. Numerous research have been explored how to analyse discussion forums, such as Thomas examines students' learning outcomes and the pattern of interaction within an online discussion forum and the findings demonstrate that the typical nonlinear branching structure of online discussion may be insufficient for the realisation of truly conversational modes of learning[1]. Guzdial and Turns claim that simply making a discussion forum available does not mean that will be used effectively to enable learning[5]. Brace-Govan proposes a Moderators' Matrix for giving moderators a framework through which to sort information about learning activity [6]. When students are organised into online discussion forums, they are normally assigned into different groups as 4, 5 or 6 people. Webb's series research find group interaction is positively related to achievement[7][8][9][10], because interaction may help group members understand the material better, develop new perspectives, and construct more elaborate cognitive understanding[11]. We argue that the status of group interaction could help us understand students' learning behaviour in this social

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environment. In this paper, group interaction in an online discussion forum is going to be analysed through sociogram. The findings of this research would help us know more about group members' learning behaviours when they participated in the discussion forums.

2 Method

2.1 Sociogram

A sociogram is a diagrammatic representation of the valences and degrees of attractiveness and acceptance of each individual ra ted according to the interpersonal interactions between and among members of a group[12]. It is a schematic rendering of communication patterns in a group[13]. In the diagram of a sociogram, the cycle points represent group members in a learning group. The "centre" is used for describing group task. When group member communicates with "centre", the line will not have arrow on it. If an interaction is taken place between different group members, an arrow will be added on the line and it represents the direction of the interaction. The number on the line is used for indicating the times of the interaction between group members. If the message is sent by one learner, the number will be added closer to her/him.

2.2 Participants

23 third-year undergraduate students who came from School of Information Technology in Education, South China Normal University participated in the research. They were organized into 5 groups. 3 groups included 5 students, and 2 groups consisted of 4 students. Most of them had experiences of online group learning. They enrolled in a course – "Computer in Education" running in a blended learning environment for 10 weeks. The students had been participated in 8 sessions face-to-face lecturing and 2 online group tasks. The group interaction taken place in those 5 groups when students engaged in 2 online group tasks was analysed through sociogram.

2.3 Online Learning Environment

Online learning environment in this research is WebCL which is a web 2.0-based learning system and was developed by Educational Engineering Laboratory (EEL), Beijing Normal University (BNU), China. WebCL system includes six main modules, i.e. "my bookstore, my class, resources centre, communication centre, instructional management centre, and system management". Many facilities are offered in WebCL system, such as managing groups, discussion forums, blogging, lecturing, tasks planner, online chatting, managing learning resources, online survey, role playing, and publishing learning productions.

Each group had its own discussion forum in WebCL and group members can post their contributions to their task in it. Group discussion forum is a group private space in which other person who does not belong to the group cannot join them. Before the products of their group work have been done, they cannot be opened to the public. The interface of group discussion forum is showed in Figure 1.

Fig. 1. The interface of group discussion forum

2.4 Data Collection

Data in this research were collected from group discussion forum in WebCL. The postings in the discussion forum included two sessions produced by students when they were working for the group task one and two. The data also included two categories based on group task accordingly. When a posting was analysed, it needed to be identified who posted it, its purpose, and communication target. The results were used for a sociogram analysis.

3 Data Analysis

3.1 Interaction within Group One

Group interaction within group one of the group task one is presented in Figure 2.

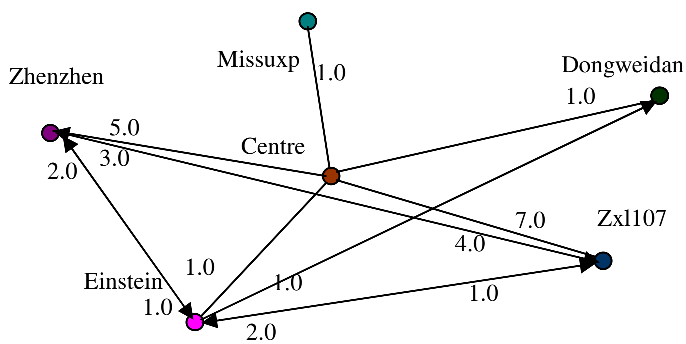

Fig. 2. The interactions within the group one for the first group task

The total number of messages posted for the group task one was 29 and the average number of postings was 5.8. Mr. Zxl107 posted 12 messages to other 2 persons and the centre of the group. Miss Zhenzhen posted 10 messages to other 2 persons and the centre of the group. Mr. Einstein posted 5 messages to other 3 persons and the centre of the group. Mr. Dongweidan posted 1 message to the centre of the group. Mr. Missuxp posted only 1 message to the centre of the group.

The number of messages to the group centre was 14 (48.3%). The result reveals that almost the half messages were posted to the group task. It means that the half of the interaction was taken place among group centre and participants, rather than among participants.

Einstein was the best active student in group one because he communicated with other 3 persons. Zhenzhen and Zxl107 were the second active students because they interacted with other 2 students. Dongweidan was the third active student. During the interaction process, he communicated with other 1 student. Missuxp was the weakest active student and no other students communicated with him. Figure 2 demonstrates that 93.1% messages were sent by 3 most active students posting. Other 2 students only contributed their group 6.9%.

Group interaction for the group task two in group one is described in Figure 3.

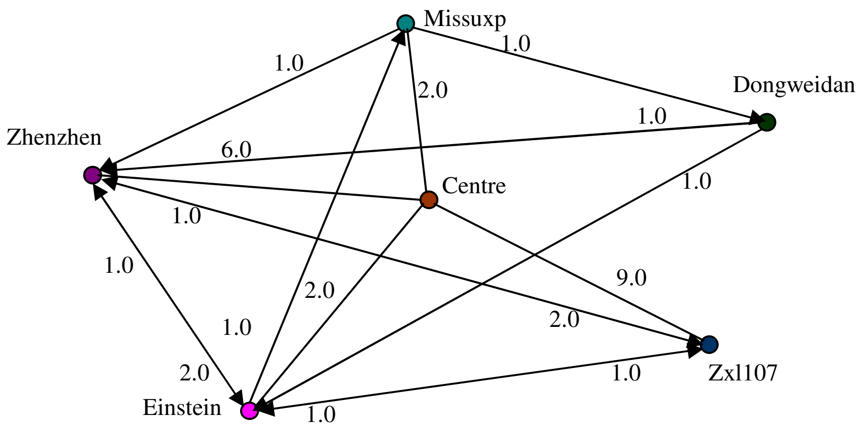

Fig. 3. The interactions within the group one for the second group task

Total number of the messages posted by students for the group task two was 32 and average number of postings was 6.4. This number was a little bit bigger than the number of the messages for the first group task. Mr. Zxl107 posted 12 messages for the second group task. Miss Zhezhen posted 8 messages to the group. Mr. Einstein contributed 6 messages to the group work. Mr. Missuxp posted 4 messages to the group. Mr. Dongweidan posted 2 messages to group.

The number of messages to the group centre was 19 (59.4%). It demonstrates that more than half messages were posted to the group task, rather than for interaction among different participants.

Miss Zhenzhen and Mr. Einstein were the best active students because they interacted with other 4 students. Mr. Missuxp was the second active student because he communicated with other 3 students. Mr. Zxl107 and Mr. Dongweidan were the third active students who interacted with other 2 students.

The number of messages for the group task two was increased (29 vs. 32), which reveals that group interaction was more active. The number of messages posted by 3 students for the group task two (Mr. Zxl107, Miss Zhenzhe, and Mr. Einstein) was reduced (81.25% vs. 18.75%), and it demonstrates that the interaction was much more average. The number of the messages to the group centre for the group task two was increased (48.3% vs. 59.4%), which illustrates that the interaction among students was less active.

3.2 Interaction within Group Two

The interaction within group two for the group task one is described in Figure 4.

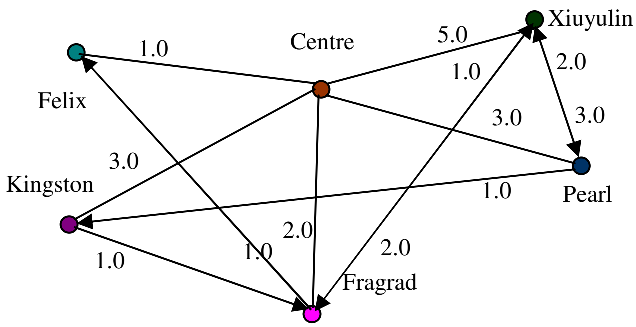

Fig. 4. The interaction within group two for the first group task

The total number of the messages posted by students for the group task one was 25 and the average number of the postings was 5. Mr. Xiuyulin posted 8 messages (32%), Miss Pearl posted 7 messages (28%), Mr. Fragrad contributed 5 messages (20%), and Mr. Kingston posted 4 messages (16%). According to their postings, these four students were most active. Mr. Felix was less active because he only posted 1 message to the group and receives 1 message from Mr. Fragrad. 2 students posted messages were less than the average number.

The number of messages to the group centre was 13 (52%). It demonstrates that less than half messages were for the interaction among participants.

Mr. Fragrad interacted with other 3 students and he was the most active student in the group. Miss Peral, Mr. Xiuyulin, and Mr. Kingston were the second active students. Each of them interacted with the other 2 students. Mr. Felix was the weakest active student in the group and only 1 student interacted with him.

The interaction within group two for the group task two is presented in Figure 5. The total number of the messages posted by students for the group task two was 42 and the average number of the messages was 8.4. Miss Pearl posted 11 messages (26.2%). Mr. Xiuyulin posted 10 messages (23.8%). Mr. Fragrad posted 9 messages

(21.4%). The number of messages was posted by Mr. Kingston was just less than the average number (8). These four students posted the most messages (90.1%) for the group task. Comparing with the number of the messages in the group task one, it was more average in the second group task.

The number of messages to the group centre was 17 (40.5%), which means more than half messages were used for communicating between or among participants. This number indicates that students were more active for the group task two.

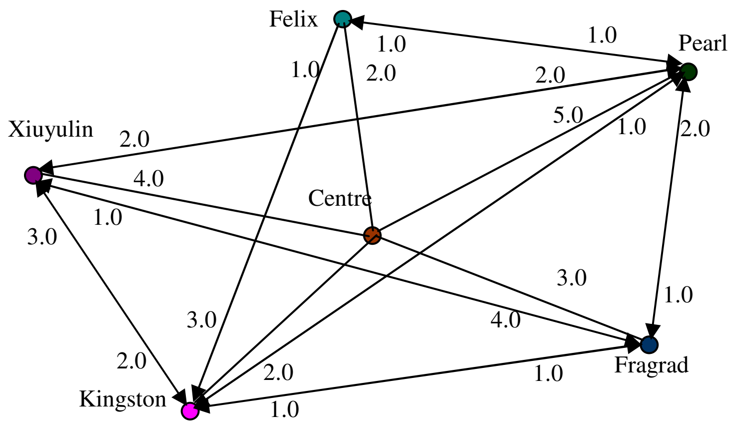

Fig. 5. The interaction within group two for the second task

Miss Pearl and Mr. Kingston were the most active students within the group, because they interacted with other 4 students. However, Miss Pearl posted 7 messages for interacting with other students. Mr. Kingston just posted 5 messages. Therefore, Miss Pearl was the best active student. Mr. Kinston was the second most active student in the group. Mr. Xiuyulin and Mr. Fragrad were the third most active students. Mr. Felix was the less active student in the group.

The increased number of messages for the group task two (25 vs. 42) illustrates that the interaction was much more active. The reduced number of messages to the group centre for the group task two (52% vs. 40.5%) reveals that the interaction between or among students was much more active. The reduced number of messages posted by three most active students (Mr. Fragrad, Miss Pearl, and Xiuyulin) for the second group task (80% vs. 71.4%) demonstrates that the interaction was more average.

3.3 Interaction within Group Three

The interaction within group three for the group task one is described in Figure 6.

Only 3 students were within this group. The total number of the messages for the first group task was 15 and the average number of the messages was 5. Mr. Byronspm posted 6 messages (40%), Miss Gigi posted 5 messages (33.3%), and Miss Tina posted 4 messages (26.7%). The messages were posted by them were average. According to the number of their postings, Mr. Byronspm was most active student.

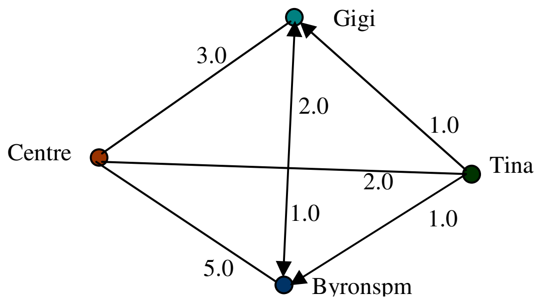

Fig. 6. The interaction in group three for the first group task

The number of messages to the group centre was 10 (66.7%), which means that most messages were posted for the group task, rather than for the communication between or among participants.

The interaction within group three for the group task two is presented in Figure 7.

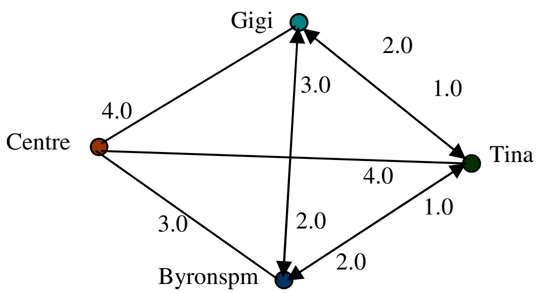

Fig. 7. The interaction in group three for the second group task

The total number of postings for the second task was 21 and the average number of the messages was 7. Miss Gigi posted 9 messages (42.9%), Mr. Byronspm posted 7 messages (33.3%), and Miss Tina posted 6 messages (28.6%). According to their postings, Miss Gigi was most active student.

The number of the messages to the group centre was 11 (52.4%), which means more than half messages were posted for the group task, rather than for the communication between or among participants.

The increased number of the messages for the group task two (15 vs. 21) demonstrates that the interaction for the group task two was more active. The reduced number of the messages to the group centre (66.7% vs. 52.4%) reveals that the interaction between or among students was more active.

3.4 Interaction within Group Four

The interaction within group four for the group task one is presented in Figure 8.

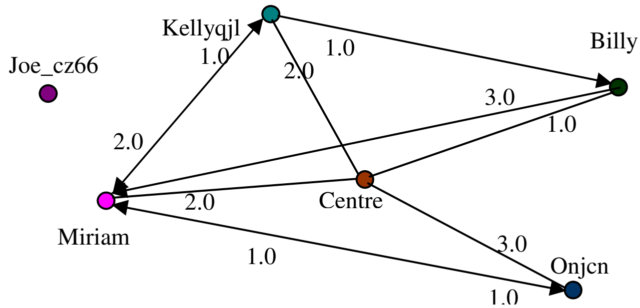

Fig. 8. The interaction within group four for the first group task

The total number of the postings for the first group task was 21 and the average number of the messages was 4.2. Mr. Onjcn posted 8 messages (38.1%). This number was the biggest one that might be considered he was the most active student. Miss Miriam posted 5 messages (23.8%). Miss Kellyqjl and Mr. Billy were equally posting 4 messages (19.1%). The postings were posted by these four students. Mr. Joe_cn66 contributed nil messages to the group.

The number of messages to the group centre was 10 (47.6%), which means that more than half number messages contributed to the communication between or among participants.

The interaction within group four for the group task two is presented in Figure 9.

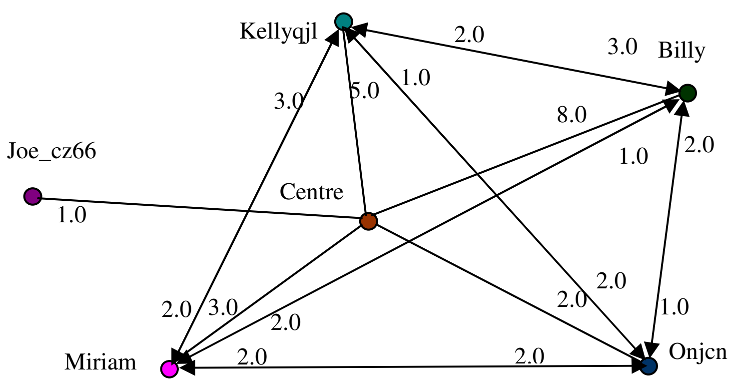

Fig. 9. The interaction within group four for the second group task

The total number of the postings for the second group task was 42 and the average number of the messages was 8.4. Analysing the number of students' postings, Mr. Billy posted 14 messages (33.3%), Miss Kellyqjl posted 11 messages (26.2%), Miss Miriam contributed 9 messages (21.4%), and Mr. Onjcn posted 7 messages (16.7%). These four students posted 97.6% message of group postings. Mr. Joe_cz66 only posted only 1 message (2.4%). Mr. Billy was most active student.

The number of messages to the group centre was 18 (42.9%), which means that more than half number of interaction was taken place among participants. Total number of messages within the group four for the group task two was increased (21 vs. 42), which reveals that the interaction was much more active. The number of the postings to the group centre was reduced to 42.9% from 47.6%, which demonstrates that students' interaction was more active.

3.5 Interaction within Group Five

Figure 10 describes the interaction within the group five for the group task one.

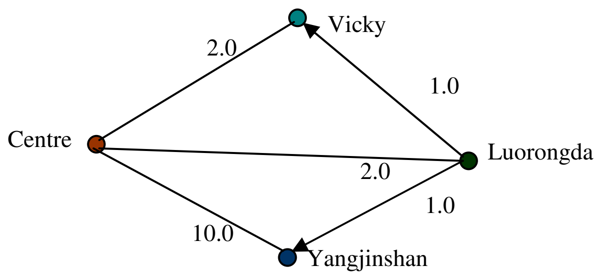

Fig. 10. The interactions within the group five for the first group task

There were 3 students in group five. The total number of messages for the group task one was 16 and the average postings number was 5.3. Most messages (62.5%) were posted by Mr. Yangjinshan. Mr. Luorongda contributed 4 messages (25%) and Miss Vicky posted 2 messages.

The number of messages were posted to the group centre was 14 (87.5%) which means that only 12.5% messages were used for communicating between or among different participants. With respect to group interaction, Mr. Luorongda was the most active student because he communicated with another 2 students. Miss Vicky and Mr. Yangjinshan were the weakest active students because they only interacted with 1 student. Miss Vicky and Mr. Yangjinshan did not communicate each other and it reveals that the interaction was not completely.

The interaction for the group task two within group five is presented in Figure 11.

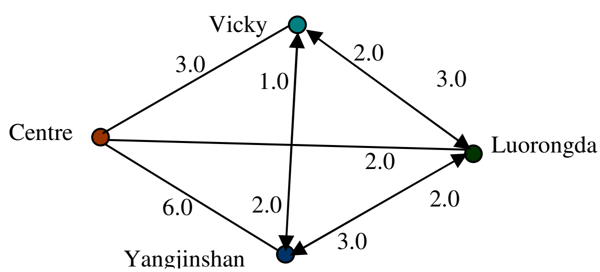

Fig. 11. The interactions within the group five for the second group task

The total number of messages in the group five for the group task two was 24 and the average postings number was 8, which was much bigger than it was in the group task one. Mr. Yangjinshan contributed 11 messages, Mr. Luorongda posted 7 messages, and Miss Vicky posted 6 messages. Mr. Yangjinshan posted near half messages (45.8%), and Mr. Luorongda and Vicky posted 54.2% messages to the group.

The number of messages to the group centre was 11 (45.8%), which demonstrates that more than half messages were applied to interact between or among participants.

Every group members communicated each other in this group which presents an ideal interaction because all the students could engage in the learning activities and contributed to group task collectively.

The number of messages for group task two was increased (16 vs. 24), which means that the interaction was more active. Meanwhile, the number of the messages to group centre was reduced from 87.5% to 45.8%, which reveal that students had more chance to communicate each other. The number of the messages posted by two most active students (Mr. Yangjinshan and Mr. Luorongda) was reduced from 87.5% to 75%, which reveals that the interaction was more average.

4 Discussions

The results of sociogram analysis reveal that students were more active when they were working on the group task two, because their postings to group discussion forum increased, and there was more interaction between or among participants rather than for the group task. In fact, students concentrate to the group task would increase the efficiency of group work. However, it would reduce the effectiveness of group learning if students did not realise the importance of communication with each other. Actually, communication is the important component for forming a social network/community[14][13][15]. How to facilitate students to engage in interaction is a priority mission when a discussion forum is used for learning, especially for Chinese students. From a longitude view of Chinese education, conventional education ideas, such as teacher-centred and duck-feed approach, is still dominated, even Chinese educators have been realising that it has to be transformed[16][17]. Therefore, students in this situation learned how to do according to teachers' requirement and anticipation, rather than from their own needs[18]. If when students do not know how to cooperate and communicate with each other, the efforts of transforming Chinese traditional education approach would not be success.

Findings of the research reveal that group students were less active when they were working for the group task one, but the situation was changed for the group two. Actually, I have conducted an interview for analysing how students made this change[19]. The results demonstrate that students were lack of understanding of group learning. In fact, they have participated in it in other courses. However, most of them did know how to cooperate with others. They still preferred individual learning, even if they engaged in a group. In order to help them involve in group learning more effectively, I introduced what group learning is, how to use it in education, and what kind skills need for it. The results of course evaluation reveal that students' understandings of group learning have much improved eventually. Reflecting on what I did in this study, we cannot assume that students who have already known how to participate in social activities. If we found students cannot work well in a group, the extra support should be offered to them immediately.

Analysing students' postings showed that some students posted most group messages, but others were not. It illustrates that there is most active student in each group and she/he contribute to group work very much. This is good for group learning. However, the active student may dominate group interaction, and then it would damage other students' enthusiasm of participation[19]. Teachers should analyse the reasons why student contribute to the group work much, but others do not. Less active students should be encouraged to participate in their online group discussion.

The sociogram analysis also founded student who did not post any messages, which caused her/him isolated interaction. It is useless for building a learning community if members have no any contribution. If one does not take any action in a group, one would learn nothing. Some strategies could be used for helping nil contribution students engaging in the learning activities, such as writing them email and face-to-face conversion[20][21][22]. When teachers know the reasons behind them, they can facilitate them to be involved in the online communication more frequently. In fact, writing an email to nil or less active students is an effective way to encourage them engaging in the learning activities. Students would feel that she/he has been concerned and could be motivated to participate in group learning. If a face-to-face conversion with student could be arranged for open-discussion her/his absence, teacher would know the reason quickly and offer support to her/him effectively.

With respect to the sociogram analysis itself, it showed the weakness in this study. The diagrammatic expression presents the interactive relationship between or among participants directly. However, it did not explain what kind meaning behind the simple lines. We can see how much times students have communicated with others, but we did not know what kinds things they have talked. Sociogram analysis help us to know how often and how much stronger the interaction is, which offers us a whole picture for describing the community relationship. If we want to know more about the quality and content of the interaction, the further qualitative analysis, such as content analysis, should be used for analysing.

5 Conclusions

A sociogram analysis in this study described how students interacted with others, and how much stronger of their interaction was in WebCL system. Their engagement based on the times of communication with others for the group task two improved comparing with the group task one, which demonstrated that their understanding of group learning helped their participation. The sociogram analysis also demonstrated that students' postings preferred to concentrate to the group task, rather than to other students. However, in an online learning environment, they should be encouraged to engage in social activities, i.e. communicating with others. The results also showed most active and isolated students existed in the social network, which teachers should pay more attention to them.

Acknowledgements

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Another Dimension of Web-Based Learning: Psychological Bestirring

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Abstract. The concepts of *psychological bestirring* and *psychological distance* in web-based learning situation are proposed. Their significance and effects are examined. An online learning performance model is constructed which employs psychological bestirring as a new factor independent of the factor of information stimulation. Logistic equation and curve is suggested as its fundamental mathematic model. The model was then used to explain the restriction of psychological distance on the usually overestimated advantages of distance education, especially the massive scale and the asynchronous learning opportunity. It is also argued for that the web-based learning framework provides the highest potential to enhance psychological bestirring among different forms of non-face-to-face learning, because of its close integration with BBS, chat room, email, instant messaging, blog and other growing internet-based interactions. Some suggestions drawn out of practice are also presented to make better use of psychological bestirring in web-based learning situation.

Keywords: Web-based learning, Psychological Bestirring, Psychological Distance, Logistic Curve.

1 Foreword

Web-Based learning is attracting great attention from academia and society as well as huge allocation from the state and local education authority. More and more courses and other learning materials are been put on the Internet and an effective returning is expected. Most attention and allocation are put into the infrastructure construction, platform developing, online course design and other learning information resources accumulating. But the returning is very far from being expected. When we put our almost infinite enthusiasm on the technology and information resources, have we ignored some other important dimension independent of technology and learning information?

This paper based on the observing and practice of online (distance) learning, proposes and discusses the concept of psychological distance and psychological bestirring in web-based learning situation, as well as their significance, effects and probably applications.

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2 Psychological Distance, Bestirring and Online Learning Performance Model

2.1 Psychological Distance

We here propose a new concept, which is called *psychological distance between learner and instructor or among peer learners*. Correspondently, when we design and value online learning or web courses, we can then take a new dimension into account.

The term "psychological distance" was increasingly used or mentioned in psychology or pedagogy literature recently. Yoav, Nira, and Yaacov used eight experiments based on the Implicit Association Test (IAT; A. G. Greenwald, D. E. McGhee, & J. L. K. Schwartz, 1998) to demonstrate an association between words related to construal level (low vs. high) and words related to four dimensions of distance (proximal vs. distal): temporal distance, spatial distance, social distance, and hypotheticality. They also concluded that all of them are forms of psychological distance [1]. Rodney R. Cocking and K. Ann Renninger put psychological distance as a role in development theory in which "psychological distance is conceptualized as either the distance between what the learner understands and what still has to be understood (intrapsychic), or ways in which others adjust information for the learner in order to be fully comprehended (interpsychic)"[2]. Wheeler and Steve Explored the nature of psychological distance in distance learning and identified some student support issues[3]. TEFL Studies refered psychological distance as "to the learner's overall psychological set with regard to the target language and its community" and "determined by factors such as language shock and motivation"[4].

But here we define psychological distance in web-based learning situation as "a perceivably social space of learner with his or her instructor (e-moderator) and learning peers". Obviously, compare to physical space or distance, this dimension or factor is more subjective or personalized.

In other words, here psychological distance is something like feelings and emotions towards other social partners. Learner perceives himself (or herself) be recognized, regarded by other ones around. He could be acknowledged, admired, encouraged. But He could also feel the peer pressure, competition, doubts, criticism and even contempt. All these feelings contribute to the atmosphere of his learning and take effects on learner himself.

2.2 Psychological Bestirring

Not every psychological effect is positive to learning, but some do play a strong positive role in learning process and promote learning results. We might as well call those making positive effects as psychological bestirring factor. Knowing peers are working hard will help learner to overcome indolence and reject temptation. It should be indicated that some of the effects are very implicit, especially those of between peers. For example, competitive awareness between talent students, which may stimulate them pay more attention and effort on their learning. Generally speaking, the shorter the psychological distance, the stronger the psychological bestirring factor.

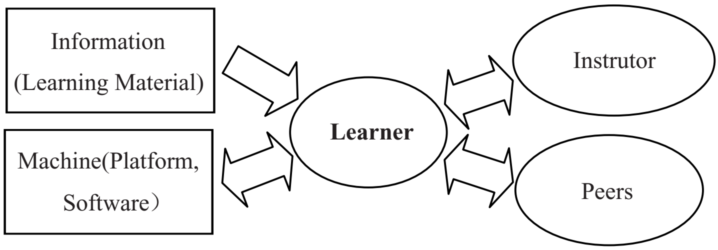

Fig. 1. Learner's environment and Psychological Interaction

2.3 Examining the Learning Environment from the New Dimension

Now let us examine the online-learner's environment (Fig. 1) again. The left parts include devices (hardware), Platform, other software and the information as learning materials, which can perform human-machine interaction with learner. The right parts are instructors (may include managers, e-moderators) and learning peers. They perform physiological interaction with learner, and co-construct learning organization and correspondent learning atmosphere.

We notice that when the synchronal (unison pacing) teaching and learning in traditional classes are strongly criticized, we have probably ignored an important advantage of it. It is that learners are really in a compact learning community. There is always a very short physiological distance. Even though, the diverse of bestirring factor are having strong effects on the learning. Examples include: Some pupils have no interests and poor performance in some subjects simply because they don't like the teacher (They could even admit that the teacher did teach the subject content well), and contrariwise, they feel their teacher doesn't like them too; some pupils specially devote into particular subjects because they perceive themselves cared and highly regarded by the teachers. Most people have the experience that during learning, their performance of a particular subject is self-assessed by comparing with those of their peers rather than by the measurement of their absolute degree of the subject content mastering.

In the online learning situation, we can use the similar viewpoint of the learning environment. The transmission and presentation technology of information did be shortening and even spanning across the physical distance, including geographic and time distance. But it absolutely doesn't mean the physiological distance in the learner's learning process has been stepped across spontaneously. The existence of this physiological distance could become a huge barrier from promoting the result of non-face-to-face learning. While more and more learning materials and web-courses are being put online, include: course pages (html), instruction video with synchrony integrated electronic slides (SMIL Streamed Media), BBS forums, automatic checking tests, and even some good subject-related learning tools (software), we may suppose that everything is ready but waiting learners wherever and whenever to log in and to complete learning self-motivated. But the fact is much far away from our expectation. Most potential learner will never click your web. Some may scan your homepage with minutes and then give up. The hard work preparing the learning material cannot get due returning. There could be different causes to degrade the performance of the online learning. But we believe, in a lot of cases, the lack of psychological interaction or the existence of psychological distance could be a more important reason.

2.4 Online Learning Performance Model

Therefore, we suppose that, for most people, there have been an implicated online learning performance model that employs the learning information stimulation (about subject content) dimension as the unique factor impacts the learning results. Using E to denote the effects (performance) of learning, id (information distance) to denote the information distance or the dimension of the validity of the learning information delivering, the model can be described as in following formula (1):

$$\mathbf{E = f\ (\ id\ )} \tag{1}$$

Now we add psychological distance as the other dimension which independent of id, the improved model should like formula (2):

$$\mathbf{E = f\ (\ id, pd\ )} \tag{2}$$

Here pd denotes the psychological distance between learner and his instructor and learning peers. The improvement of this dimension could include proper organization of learning communities (class, group), and construction of interaction, cooperation, competition, discussion and other learning atmosphere.

In this model, the reduction of both id and pd will bring on the increasing of E. People may prefer an increasing function. So we can introduce *information stimulation* (i) to instead of id, and *psychological bestirring* (p) to instead of pd. Then the formula should transform into formula (3):

$$\mathbf{E = F\ (\ i, p\ )} \tag{3}$$

And formula (3) will be an increasing function. The enhancement of both i and p will bring on increasing of E.

2.5 Borrowing of Logistic Model and Curve

For any particular learning unit (or course) or task, the learning effect (achievement of learning objectives) should have its limitation. Information stimulation should have accumulating effects, and psychological bestirring could promote the learning efficiency. So, here we suggest borrowing the logistic model, formula (4), which is often employed in Item Response Theory [5]:

$$E = \frac{k}{1 + \exp(-p \bullet i)} \tag{4}$$

Where k is a constant denoting maximum E (may be understood as the absolute achievement of learning objectives), and p acts as a parameter. The curve of the function will look like that in Fig. 2.

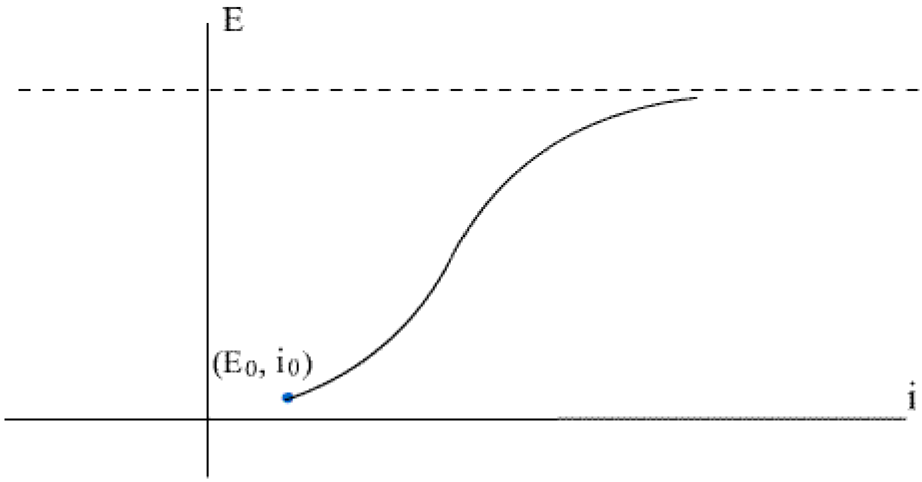

Fig. 2. Logistic Curve of the Learning Performance Model

The increasing of parameter p means the enhancement of psychological bestirring. Fig. 3 shows the curve variation because of different p [6]. The variant i usually means information delivering or stimulating and therefore takes up learning time. (E_0, i_0) means the starting point of the particular learning of a course or a unit. Learner usually has some basic subject information, so starting point could be not zero.

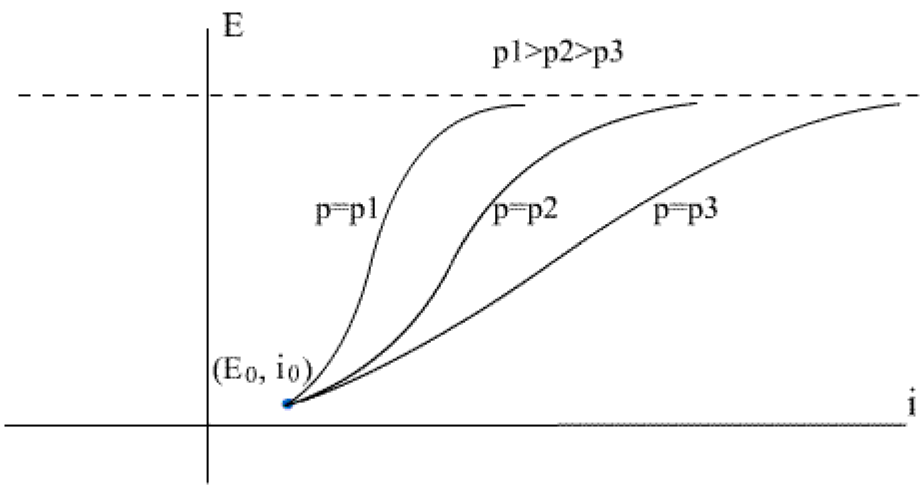

Fig. 3. Logistic Curves with different parameter p

Actually, this model will also adapt to traditional school education, where factor of psychological bestirring has been naturally immersed into conventional class/group organization and instruction model. In the situation of non-face-to-face learning, the positive psychological bestirring makes the p bigger. Learner could make more progress in the same learning process or time. If the p is too small, more learners may lose willpower and effort, probably give up learning. Only the people with very good learning ability or extreme tenacity can insist on to success.

3 The Restriction of Psychological Distance and the Utilization of Psychological Bestirring

3.1 Negative Effects of Psychological Distance on Distance Learning

It is a pity that the existence of psychological distance might be a serious restriction to the potential of distance education including web-based learning.

First, the benefit of massive-scale of distance education, which had been over-estimated before, should not be expected as before. If we only consider the factor id, the success of modern ICT (Information and Communications Technology) did break up the boundary of the course scale, no matter based on whether TV or Network. Once course materials are ready (broadcast or put on the internet), unlimited-number of learners can be allowed to access these materials theoretically. But, if we take the pd into account, the scale of effective learning will surely be limited due to limited scale of effective psychological interaction between learner and his (her) instructor and learning peers.

Second, the benefit of asynchronous learning should also be re-estimated. Web-based courses and VOD do allow learners to access and learn whenever and wherever. Popularity of Email and BBS forum makes fast and low-cost communication possible. But learning without explicit schedule or progress chart could loose learners' tension, and the non-realtime interaction could also weaken instructor's bestirring and the implicit peers' pressure. It does not mean that more pressure and tension are always better for learning. However, for most online subject contents and most non face-to-face learners, necessary tension and pressure are definitely the guarantee of effective learning.

3.2 Potential of Web-Based Learning Framework to Enhance Psychological Bestirring

Then are there any possible means to shorten this psychological distance in non-face-to-face learning situation? Fortunately, it is the web-based learning framework that provides the highest potential among different forms of non-face-to-face learning. Now browser has integrated original static web pages closely with BBS, chat room, email, instant messaging, blog and other growing internet-based applications. Most of these Internet vogues can be actively used to provide interaction between learners and then help shorten the psychological distance. If we consciously and properly make use of them, a very positive psychological bestirring can be achieved to support web-based learning and obviously promote learning performance. However, positive effects will heavily depend on the flexible and state-of-art technical platform developing, compact learning community organization, delicate instructional design including adequate interaction, as well as adept online instructor.

3.3 Suggestions about Utilization of Psychological Bestirring

Here are some suggestions to make better use of psychological bestirring in web-based learning situation. Some of them have already practical evidence based on our experimentation.

We should be aware of taking the advantage of proper learning community. Actually, the history of education can give some hints. Before modern schools and classes, there were education, but only the original education without efficiency. Distance education (non-face-to-face education) without good organizations based on learners and courses would also stay at its original stage. Even the size of the basic unit (class, group) should be smaller than those in traditional schools. From computer-based learning to web-based learning, there is a distinguishability to make sense, which is the main interaction manner. The former absolutely depends on human-machine interaction while the latter shift return to inter-human interaction again. Similar difference even has been observed on the comparison of online game vs. video game.

Non-face-to-face learning depends on communication so deeply that the reliable communication mechanism establishment is at the top of the priority. Beside email address, sometimes the short message function of mobile can be a very suitable complement, because of its popularity, low cost, and the momentariness.

Here we take special attention to psychological rather than subject matter interaction. If possible, we should demand synchronal learning instead of asynchronous ones. Synchronal learning scope can include online reading, BBS discussing, and video or audio broadcasting. As a function of the learning platform, instructor and every logined learner should be able to "see each other" from an attendee list.

For automatic assessment exercises or tests, there could be a top n rank to encourage learners more actively and seriously taking part in. Human-made comments should be timely mixed in somewhere to make the maximum of the effects.

Instructors still should make effort to show their personality attractions as much as possible. There can also be daily life interaction besides the subject matter between learning peers ant let them know each other. Instructors should try to have personal talk to every learner even if only a few minutes, to let his personal concern reach everyone.

Online learning materials of one course needn't be put on the web one time, and then let them stay persistent without updating and even any changing. Progressive presentations sometimes are much better. It also needs support of the course platform function, with which course material could be controlled more easily and flexibly.

Exhibiting learners' progress and works is also an impactful way to enhance learning process in most cases. It's another important superiority of web-based learning among various learning schema including non-face-to-face learning and traditional class-based learning.

Personalized psychological distance couldn't be totally overcome by automatic human-machine interaction, but proper and limited utilization of technology surely has good chance to promote the efficiency of psychological interaction and bestirring.

All the mentioned improvements depend on more conscious and skillful e-learning instructors.

4 Conclusion

Comparing to physical distance or distance of space and time, a concept of psychological distance can be abstracted in the distance (or non-face-to-face) learning domain to independently express the social and spirit communication between learner and his or her instructor and learning peers in the learning process. Introducing this parameter into distance learning performance model can help explain some unexpected but ever-present phenomena in the practice of online learning. Positively shortening of this distance means enhancement of psychological bestirring to learners in the learning process and promotion of learning performance. This new dimension may also provide a new angle of perspective to design of platform, course materials, learning model, as well as management and assessment of distance learning.

In distance learning, proper organization of the learning community to establish closer relationship between learners and instructors or among peer learners, can effectively enhance learning bestirring to learners, construct positive learning atmosphere and therefore promote learning proficiency and success rate. From this perspective, web-based learning framework provide the most potential in the history of distance education.

Effects of psychological bestirring on learners may be very personalized, but further research on some characteristics categorized by age group, sex, profession, educational or cultural background, etc. may currently make more important sense.

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Construct Teacher Community in E-Learning System

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Abstract. At present, most universities had completed the basic facilities and services of Information and Communication Technology (ICT), and installed e-learning system. What should be done to facilitate teachers' transition to employ ICT to their new teaching practices? We believe that virtual communities for Teacher Professional development (TPD) and socialization are supposed to be an excellent solution. We also deem that e-learning system could be a place for TPD as well as assisting teaching. In this paper, we present our past attempts, and the rationale behind the design of the Zjiao.Com virtual community.

Keywords: Information and Communication Technology, Teacher Professional Development, Virtual Community, Open Educational Resources.

1 Introduction

The survey (2004) of computing and information technology in China higher education showed that almost all universities had completed the basic facilities and services of Information and Communication Technology (ICT) for teaching, research and management. Nowadays ICT has gradually become a part of teaching and learning, and has changed the mode of them largely. This is a great challenge for teachers. Teachers have better gain the knowledge of ICT to facilitate their teaching and professional development as well as have to learn the current evolvement of their specialty.

The data (2004) also displayed that 41 percent of the schools had installed e-learning system and 46 percent would do in two or three years. E-learning system is playing the central role on incorporating ICT into teachers' teaching, and more and more teachers would like to use it to improve their teaching. However, there exist many factors that stand in the way of the adoption of e-learning system. For instance, most teachers have little time to develop and test new ideas, create resources that reflect new teaching practices; ICT could bring some negative effects if used irrelevantly. In order to accelerate the step on applying ICT to education, it is very important to pay more attention on teacher professional development (TPD). Traditional ways of TPD, such as seminar or workshop, is expensive and inefficient, and it is difficult to maintain support and encourage sustained discourse among participating teachers, so that teachers have little chance to discuss new ideas, co-construct and publish resources. What should be done?

Some education technology advocates (Guzdial & Weingarten 1996) suggest that virtual communities for TPD and socialization could help teachers learn new skills

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and adopt new approaches that will facilitate their transition to new teaching practices. Recent years, there emerge lots of projects for virtual TPD communities and some of them operate successfully, for example TAPPED IN, Teachers.Net, ILF, K12.Com.Cn, EduOl.Cn, Qiusir.Com etc. With the help of virtual communities, teachers with diverse interests, skills, and backgrounds can meet and learn from one another at any time, be exposed to a variety of education reform concepts and approaches, and find high-quality resources and contribute those that they find useful (Fitzpatrick, Mansfield, & Kaplan, 1996). In fact, many teachers benefit from TPD communities and Teacher Xiaoman is one of them (Junxue Wu, 2006).

Virtual TPD community is supposed to be a first-rank solution for promoting the quantity and quality of utilizing e-learning system in education. How to construct it? We believe that besides a place of assist teachers' teaching, e-leaning system could be a venue for TPD, though each single system is independent from others like an isolated island at the present time. In this paper, we will describe how we are weaving theoretical considerations and practical design constraints to realizing our goal of a self-sustaining online TPD community.

2 Our Practices of Organizing the Teacher Community

We believe that ICT could improve teaching greatly, and therefore worked together to develop an e-learning system that could increase the efficiency of teaching and save on teachers' time, the first version of witch named College Physics Assistant System (CPAS).

2.1 The Purpose of CPAS

CPAS is not a substitute for classroom. Its aim is to track the students learning with the help of network so that the teaching plan can be adjusted to suit teachers' needs. Simultaneously, teachers' working load can be relieved so that they have more time to help students to apply what they have learned in classroom teaching.

2.2 The Result of Putting It into Practice

Making use of CPAS, teachers are able to collect and calculate a lot of data on students' learning. From these data, many problems are identified. For instance, most students have misunderstood a key concept because of the vague illustration in the textbooks. In some cases, the data show that students lack the ability of integrating

Table 1. The mean and Stv.Dev table in the final test of the experimental class and the control class

	The experimental class		The control class	
	1999-2000 Second semester	2000-2001 First semester	1999-2000 Second semester	2000-2001 First semester
The mean	65.6	81.4	77.5	74.3
Stv.Dev	14.58	12.47	12.65	14.28

knowledge. From the comparison of a class in two semesters and two classes in two tests in one semester (see Table 1), it is obvious that the teaching mode with the support of CPAS would get a bright future.

2.3 Share with Other Teachers

At first, there was an only user who is a member of our team. As our experiences began to accumulate, he would like to offer his experiences to other teachers. Many teachers expressed their interest and some copies of CPAS were also provided to them free. A long time passed, but there was no any feedback. It was clear that the attempt of increasing the user group of CPAS had been proved to be a case of failure.

There mainly exist two facts that restrict the development of CPAS. Above all, CPAS is simply designed with Microsoft Access database and ASP technology, so it can support few of teachers working together. As a teacher in another school meant to take part in the user group, he has had to get a copy of CPAS and find a people for maintenance and technique support. It is a hard thing for these college physics teachers so as to result in their quitting. In addition, an assistant role for traditional classroom teaching is the exclusive function of CPAS and the interaction and communication between teachers are not taken into account. As a teaching problem come out because a new user lacks of experiences, experienced teachers could not find it out and give him a hand to solve the problem. The new user has to struggle alone and maybe feels lonely sometimes.

In 2005, the system was redesigned in total and it got a new name—Zjiao.Com. This is a Website that employs the theory of virtual communities, where teachers could share new ideas and resources with each other, even carry out collaborative teaching. Teachers can login this Website through Internet by using its domain address is www.zjiao.com, and there have been about ten teachers who draw on it to realize more referential and effective teaching at present and there will be more on next semester. In theory, the Website could hold any teacher who wants to make a change of his teaching.

3 Designing the Community Environment

Zjiao.Com is a Website that could serve as an assistant tool for traditional classroom teaching and also a platform by which teachers exhibit their efforts, communicate and assist with each other in the process of teaching. Here, the design of framework that realizes the effective interaction between teachers and relevant peoples will be shared.

3.1 Teacher Communities Based on Course or Subject

The word community has lost its meaning accompanying with the prevalence of terms such as “communities of learners,” “discourse communities,” and “school community.” In spite of that, it is helpful to begin by noting that community can be approached as a value. As such it may well be used to bring together a number of elements, for example, solidarity, commitment, mutuality and trust, which could facilitate the process of learning. Because of its advantages, community has become an obligatory appendage to many educational researches.

A community is constituted with a group of peoples; for instance, teacher community is a group of teachers. But a group is not equal to a community. Researchers have yet to formulate criteria that would allow them to distinguish between a community of teachers and a group of teachers sitting in a room for a meeting. In his review, Westheimer (1998) pointed to five common themes in theories of community, which are interdependence, interaction/participation, shared interests, concern for individual and minority views, and meaningful relationships.

Zjiao.Com is a system that could support the teaching of different courses and subjects. In practice, the teachers teaching some course seldom communicate with the teachers teaching another. If the teachers of Zjiao.Com have constituted a large community as a whole, unsorted resources and aimless interaction would undermine teaching and intercourse. Therefore, OTS is separated independently by course or subject, and the teachers teaching identical course have formed a virtual community (see Fig 1) where they could share educational resources and organize teaching activities together through Internet.

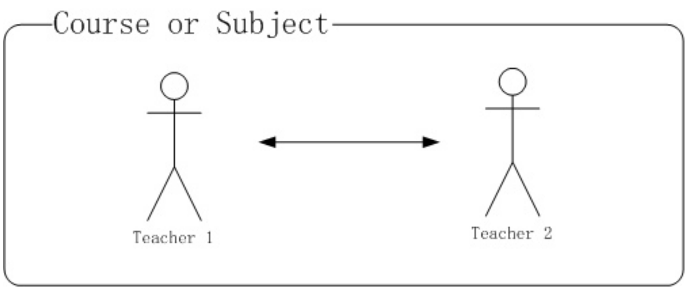

Fig. 1. Teachers' personal teaching and interaction are based on a course or subject

3.2 Personal Space and Common Space

The teachers drawing on the Website to support teaching come from different schools spreading in different districts. They have formed the notion of teaching on their own,

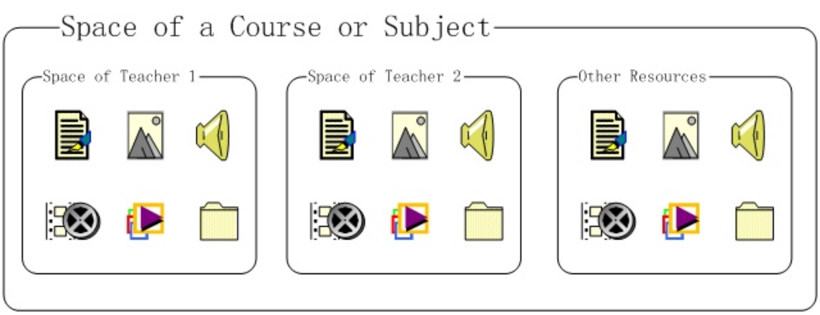

Fig. 2. The common space of a course or subject is made up of the teachers' personal spaces and other correlative resources

and must face the given student population. Just as in clothing, one size does not fit all, and the fact should be taken into account seriously.

In the communities, every teacher as an individual is fully regarded, and owns a personal space where he may edit and upload appropriate materials and organize teaching activities according to their own request. Indeed, the personal space is also a proportion of the common space comparted by a course or subject (see Fig 2). So if a teacher did more personal work, he would do more contribution to the entire communities.

3.3 Picked Resources

Enriching personal space is a kind of spontaneous behavior, and it is beneficial for the construction of the communities. But the effect of personal materials is to some extent subtle, for other teachers could hardly find them when knowing nothing about them. On the other hand, the materials from each of the teachers are often used to solve some small and specific problems, and thus fragmentary. So the experienced and talented teachers should be selected out to pick out and compile the excellent contents from the teachers' personal spaces in the communities and to import advanced educational materials systematically from outside (see Fig 3).

In addition, these experienced teachers not only serve as compiler, but also act as salesman who take responsibility to popularize the new teaching styles, ideas and approaches concerning with the picked resources. In fact, they act as a role of manager. The guide and help of the managers for peripheral participator are helpful for the development of the communities, especially in the process of enlarging the user group. Because the works of the managers are coincident with the tendency of the progress of the communities, therefore enable teachers to work together toward a common goal.

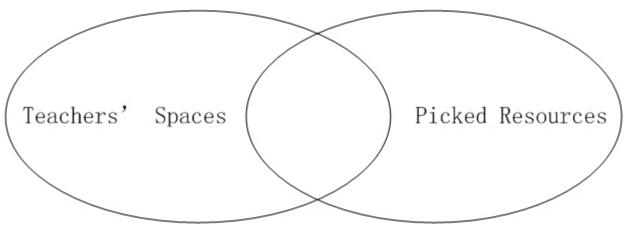

Fig. 3. The experienced and talented teachers choicely take out the excellent materials from the teachers' spaces and outside

3.4 The Mechanism of Intercourse between Teachers

With referring to the design above, the course resources the teachers upload in the communities are entirely accessed to all users, as common spaces are opened. Differing from course resources, teaching process is very difficult to open fully, because the privacies of teachers and students have to be seriously and soberly regarded.

The respect for the privacies of users does not means that teaching process must be close to others, but acknowledges the right that teachers should be master of the data

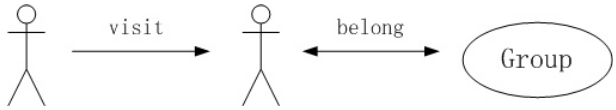

Fig. 4. The teachers in a research group may share their teaching processes with each other, and anyone could be a visitor to view some teacher's teaching process if the teacher grants it

of their teaching processes. Teachers should be able to take control of whether their teaching processes are completely opened or who would be granted access.

On the Website, there are three different ways that teachers choose to exchange teaching experiences with others. First of all, the teachers might open their teaching entirely, but few of the teachers would like to do like this by reason of uncertain harmful effects that possibly happen. Secondly, a research "group" could be created and the activities of its members are transparent for each other. There objectively exist small groups in the communities, members of which have interests and ideas in common and would collaborate with each other. "Group" is the right place where the members of a small group share their experiences and realize collaborative teaching (see Fig 4); for instance, a teacher might solve a problem emerging in another teacher's class. Lastly, any user could be a visitor to trace the teaching process of some teacher if granted by him (see Fig 4). Students' families, education researchers and teachers outside the group are likely to become the visitors. As an example, the statistical data for teaching activities are useful to the work of education researchers, and as visitors, they would be able to access these data. As a whole, the open mode of teaching process is very flexible and controllable.

4 Problems in Use

The Website operates smoothly over two year. Though its development is restricted because of being short of financing and personnel for technique support, many teachers have joined, and more teachers express their support and incline to become a member on appropriate opportunity. In addition, there emerge many problems during the development of the user group.

The most intractable one is that most teachers keep a conservative and sloth attitude towards the acceptance of new ideas and styles of teaching. Some teachers worry about negative effect to students' level of accomplishment, and it maybe happens if they do not deeply understand the teaching process. In addition, teachers have to spend some time on learning how to use and catching on why to use at the beginning. Though the recommendation from one teacher to another might be a good solution, it would be a long term one.

The protection of copyright is another one. Share does not mean free access to resources in any mode. If some one wants to use them for commercial purpose, he must get permission from the copyright holder. In China, consciousness of protecting copyright is reinforcing because of the endeavor of the entire society. It would be believed that more and more teachers would like to share their knowledge with others accompanying with stepped-up consciousness on the protection of copyright.

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The Design and Implement of Knowledge Building Classroom Based on Web2.0*

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Abstract. With the rapid development of the internet, e-Learning is playing an important role to life-long learning. But the phenomenon that e-Learning is lack of Knowledge Building at large has raised the attention of educational circles. This paper presents an idea that Knowledge Building Classroom based on Web2.0 as a solution to e-Learning. Based on this idea, we design and implement the e-Learning which introduces Knowledge Building Community theory and web 2.0 technologies. By the end of this paper, we take "Laboratory Inquiry" as an example to demonstrate the advantages of Knowledge Building Classroom based on Web2.0.

Keywords: e-Learning, Knowledge Building Classroom, Web2.0.

1 Introduction

With the rapid development of information society and wide spread of life-long learning, the needs for knowledge are growing dramatically. With the fast pace of modern life, most people cannot afford to take formal courses in the classroom. Therefore, more and more people turn to distance learning for its flexibility in time and space. Different from face to face learning, both the learners and tutors can resort to information technology to facilitate communication and information transfer. As PCs become popular and the bandwidth increases, e-Learning has gained major popularity among the learners. Consequently, a well-designed and sophisticated online learning environment can stimulate learners to learn, simplify the learning process, facilitate deeper comprehension and increase collaboration, which can contribute not only to the growth of learners' knowledge, but also to the improvement of learning and communication capability.

As a developing country with the largest population in the world, e-Learning is playing an essential role to Chinese lifelong education, as well as the development of China. Although much progresses and even breakthroughs have been achieved in e-Learning, we have also identified some problems.

1. Emphasizing too much emphasis on content presentation and ignoring instructional design. While making great efforts to present the learning contents to learners,

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most e-Learning systems fail to bring in instructional design. Thus the e-learning system can not fit in well the specific features of distance learning. For distant learning, the instructor needs to guide the knowledge building by producing instructional materials, directing team work, interacting with individuals, tutoring practice and giving feedbacks.

2. In current e-Learning environments, learners communicate mainly with BBS and chat rooms, where learners discuss the topics raised. This helps learners to voice their opinions but the teacher can hardly help learners to construct knowledge based on their discussions.

From the discussion above, the main problem is the lack of construction of knowledge in the community. The concept of "Knowledge Building Community [1]" (KBC) has been proposed in the 1990s, which emphasizes that people produce knowledge together by exchanging ideas in easy and flexible ways. This has laid the foundations for the realization of KBC. To implement KBC in online environment is a hot issue in e-Learning research recently.

This paper will present our study of Building Community Knowledge in an e-Learning environment, and illustrate our resolution with the Knowledge Building Classroom, which is a system developed on the concept of KBC theory.

2 Theory of KBC

The theory of KBC emphasizes that students should focus on Knowledge building and that they should participate in the construction of the knowledge of the community, which is the community of learners, other than the entire human race [1]. In the process of building community knowledge, they can develop the knowledge of their own. KBC aims at the instructional mode and idea of knowledge innovation.

3 Implementation of the Knowledge Building Classroom

3.1 The Function of the Knowledge Building Classroom

Implementing the KBC theory in the e-Learning environment, we developed a Knowledge Building Classroom based on KBC theory and Web2.0 technology. The relationship in the system can be list as follows:

- Learners benefit from learning resources with the help of learning tools, gaining knowledge. This process represents that learners acquire and digest knowledge from learning resources. At the same time, as consumers of learning resources, the knowledge they gain becomes their own ability. This is the traditional learning process.
- Learners' Knowledge building is restricted by learning resources. When the learning environment does not satisfy the learners' Knowledge building, the environment restricts the development of knowledge. For example, when learners have no condition to borrow or read books from a digital library, or they do not have any tool to help interact with knowledge, Knowledge building would be low efficiency.

- Learners create new learning resources, making the repository rich and grow. In this process, after acquiring and digesting of resources, learners summarize and generate new knowledge, then they use authoring tool to present this knowledge, making it externalized. Learners would become learning resource producers in this process, and after re-constructing knowledge by many learners, these resources are optimized.

Knowledge Building Classroom can carry a series of learning processes from the stage of understanding problems to the stage of arranging learning. The functions and modules in Knowledge Building Classroom are listed in Table 1.

Table 1. The functions and modules in Knowledge Building Classroom

Functions	Modules	Description	Participators
Learning guidance	Helpful Materials	Materials for helping the use of the system	Individual
	Teacher's Materials	Materials for motivation involving and learning	Individual
	Sharing Materials	Materials which were provided by others	Individual
	Group Materials	Materials of the group	Individual
	Q&A	Questions and answers during the class	Individual
	Real-time alert		Individual
	Preparatory Room	Learner preview the course before the class	Individual
Knowledge Building	Homework		Individual or Group
	Wiki	Learning group to converse about their learning	People in the system
	E_mail	E-mailing among in-learners, out-learners and the teachers	People in the system
	Conversation Room	Learning group to converse about their learning	Group
	Discussion Room	Write learner's opinion on a subject in the from of statement	People in the system
	Electric whiteboard	Learners use the graph or multimedia to communicate	People in the course
	Online Course	Teachers and students interact in real-time class	People in the course
Knowledge Production	Individual Exhibition Room	Individual learning history and production	People in the course
	Group Exhibition Room	Group learning history and production	People in the course
Evaluation	History Evaluation	self-evaluation and inter-evaluation of the learning history	People in the course
	Production Evaluation	self-evaluation and inter-evaluation of the learning production	People in the course
	Production Evaluation	self-evaluation and inter-evaluation of the learning production	People in the course

3.2 Process of Community Knowledge Building in the Knowledge Building Classroom

Figure 1 presents the community's Knowledge building process in Knowledge Building Classroom. At the beginning, members in the community acquire public knowledge;

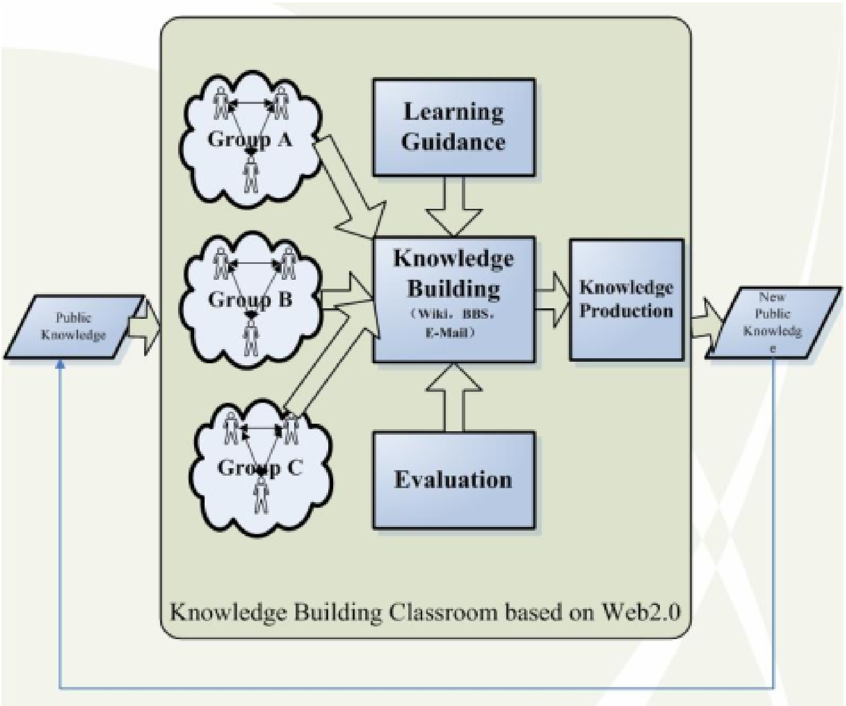

Fig. 1. Process of Community Knowledge Building in the Knowledge Building Classroom

with the instructions of learning guidance, individuals and groups construct interactive activities (wiki, email, BBS, etc.) to add, edit, integrate public knowledge, and finally generate new constructed public knowledge. Learning tools (Individual Exhibition Room and Group Exhibition Room) presents such Knowledge Production; members in Knowledge building Community now come to a new round of Knowledge building. In this construction process, learners are able to positively construct new knowledge, rather than negatively receive in the former time.

3.3 The Support Providing to the Knowledge Building Classroom from Web2.0 Technology

In the process of community knowledge building in the Knowledge Building Classroom, the members of KBC acquire the public knowledge firstly by learning the sharing materials and wiki, and then they re-author the material by adding, editing or integrating through the interactive activities (e.g. theme-based discussion on Wiki) among the individuals, among the groups, and between the individuals inside the group at last contribute the new constructed sharable knowledge, which begins a new cycle of the knowledge building activity. Web2.0 technology successfully realizes the instructional design as a Knowledge Building Classroom.

In studying and promoting web-technology, the phrase Web 2.0 can refer to a trend in web design and development — a perceived second generation of web-based communities and hosted services (such as social-networking sites, wikis, blogs, and folksonomies) which aim to facilitate creativity, collaboration, and sharing between users. It is a knowledge-oriented environment where human interactions generate content that is published, managed and used through network applications in a service-oriented architecture. Web2.0 technology has its innate characteristics for building the web-based interactive learning environment. The main Web2.0 representation approaches of this system are as follows:

1. The system introduces AJAX technology to improve the interactivity between students and interface.

It provides functionality for interactive activities. The learning environment interface should be combined with the correlation theories of aesthetics and educational psychology. For example, the color should complement each other and the alternative response speed should be fast. If it takes a long time to wait for the reaction after clicking the mouse, the students may be tired of learning, which will have a negative impact on learning interest and effect. At the times of Web 1.0, web-based learning environment's development adopted traditional Web development technology, the interaction between the users and the web page demanded the entire page to refresh, even if there is only a small part of the page was changed. Therefore, regular screen blinking and waiting always happened. However, AJAX in Web2.0 technology solves the problem: AJAX technology takes asynchronous date by using XML HttpRequest Object. It is able to retrieve date from the server according to the requirement. When small part of the page needs to be updated, users could just submit that small part to the server instead of the entire page. Therefore, the condition of screen blinking and refreshing does not exist.

2. This system uses Wiki to provide interactional functions among the members of the community.

In the process of web-based learning, the human-computer interaction is of great significance, while the interpersonal interaction is also important. Web-based learning is a learning approach which separates the teachers and the students in time and space. Therefore, the interpersonal interaction which is common in traditional education is hard to realize. Nevertheless, the learners' affective interaction in learning environment has an important role in the learning process. The interpersonal interaction in traditional internet education was principally realized by the use of BBS, E-Mail, Chat Room, etc. In the Web2.0 era, a number of interactive software appears which have three ideal characteristics: humanization, identity and society. Such software provides diversified, humanized and socialized interaction which could be either real-time or non-real-time. It is very powerful to the development of web-based learning. Wiki is a collaborative tool in Web2.0 technology. It provides learners with collaborative learning platform in which learners can both discuss and share their knowledge. This system integrates Wiki inside to be a Knowledge Building Classroom in the e-Learning environment.

4 The Application of the Knowledge Building Classroom

Knowledge Building Classroom has been used by the course named "Laboratory Inquiry" since 2006, in Tsinghua University. This course introduces the experiment environment and scientific projects of laboratories in the university. Its objective is to make orientation for freshmen to get to know experiments and research environment so that students would be clearer about their prospect directions. This is helpful for students to be objective-oriented and construct their own knowledge architectures. This course introduces 72 laboratories from 31 departments, formed by 72 units, among which students could select 8 interested ones. At first, the teacher introduces equipments and approaches for experiments, and the related research projects. The next step of the teacher is to make demonstration, and then provide abundant learning resources in Knowledge Building Classroom, based on which the students could choose their interested units, looking for and reading materials, discussing and inquiring. Students will generate new learning resources and add them into Eco-Classroom so that every member in the community could both create individual knowledge structure and share more knowledge.

In the analysis of application effectiveness, we conduct an extensive questionnaire survey to the students. The questionnaire contains two parts: 1. the design assessment of the interface and the guide of the Eco-Classroom; 2. the assessment of the students' attitudes towards the time, frequency, interaction and course module. The author adopts the organizational survey. He sends the questionnaires of the date of one month before the end of the semester. Among the 200 distributed questionnaires, 182 (88.2%) were returned. 121 male students and 61 female students participate in the survey. 150(56.7%) students have personal computers and 163(63.3%) always surf online.

Table 2. The design assessment of the interface and the guide of the Eco-Classroom

Questions	Strongly agree	Agree	So-So	Disagree	Strongly Disagree
The interface of the system is friendly.	32.04	43.01	14.07	8.6	2.28
The system is easy to operate.	22.05	47.01	15.06	10.2	5.68
The discussion and interaction to use the system is convenient	15.07	40.4	22.3	14.2	8.03
Students like this learning environment.	17.06	39.9	28.45	10.24	4.35
The function of the system is powerful.	29.4	32.7	26.5	9.97	1.43

Interpretation of Results: (32.04%+43.01%) of the students consider that the interface design is intuitive, good-looking and attractive. (8.6%+2.28%) of the students consider that the interface design has excessive colors and seems disorder. From the results of the survey, the design of the e-Learning is successful, since we introduce both domestic and international e-Learning environments, and follow the e-Learning visual designing principles. The fact shows that we should follow the visual designing principles in the e-Learning environmental interface design process below:

1. Give prominence to teaching subject in order that the learners can learn and master the content.
2. Unify the content and form in order that the learners can be easily, quickly and cozily use e-Learning.
3. Combine the unity of whole style with the variable layout in order to add learning sentiment to e-Learning.
4. Adopt new techniques in order to make a vivid virtual environment for the learners.

Table 3. The assessment of the students' attitudes towards the time, frequency, interaction and course module

Questions	Strongly agree	Agree	So-So	Disagree	Strongly Disagree
I learn online more then once a day.	32.04	39.07	21.02	5.03	2.84
The ability to obtain the knowledge using the internet is improved	25.09	32.09	32.01	6.07	4.74
I have made good use of the resources provided by the system	18.09	32.98	35.21	7.8	5.92
I can express my ideas freely	14.02	29.48	33.2	15.03	8.27
I can fully express my ideas.	17.23	32.42	33.05	12.01	5.29
I often communicate my idea with others.	21.32	25.43	29.42	15.9	7.93
I like to consult with others for opinions	20.32	32.05	27.42	14.89	5.32
My ideas are often different with others	8.08	25.4	30.2	27.5	8.82
I often rebut others' opinions.	14.06	24.05	32.9	19.77	9.22
I often review their study method in the study.	19.04	27.04	34.08	12.06	7.78
I think more deeply than before	17.42	32.07	34.05	12.97	3.49

Interpretation of Results: Nearly half of the students(21.32%+25.43%) said that they exchanged their ideas with others more frequently, and more than a half of the students preferred to consult with others for opinions.

From the analysis, we can draw a conclusion that the method of applying the KBC idea into Knowledge Building Classroom helps the learners improve several abilities, as listed below:

1. Improve ability of acquiring and utilizing information;
2. Improve ability of expression and communication;
3. Inspire creativity;
4. Improve ability of meta-cognition and reasoning.

5 Conclusion and Future Work

Lacking support of Knowledge Building in learner community is the disadvantage of many current e-Learning environments. The idea that this paper presents –Knowledge

Building Classroom based on Web2.0 – could specifically solve this problem. According to this idea, we design and implement Knowledge Building Classroom, which has been successfully used in the course "Laboratory Inquiry" in Tsinghua University. The Knowledge Building Classroom based on based on Web2.0 has several promotion effects, such as improving the interpersonal interaction of web-based learning, increasing the teaching design and teaching strategy and optimizing knowledge building. We will develop components for knowledge management and construction modules in Knowledge Building Classroom

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An Online Theme-Based Collaborative Learning System

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Abstract. In this paper, an online theme-based collaborative learning model (OTBCL model) is proposed. Unlike the current approaches, the model takes into account the two aspects in learning: interpersonal socialization and mental internalization, and joins them with learning portfolios in learning activities of themes. Then, the architecture, user interfaces and learning portfolio module of OTBCL system are elaborately presented, some useful principles are summarized which guide the process of developing learning systems. Finally, a case study was introduced, which explains how to intuitively analyze the participation in group lifecycle with statistical diagrams automatically generated by the system.

Keywords: Online learning system, CSCL, Thematic Learning, Participation Assessment.

1 Introduction

Thematic learning is based on the idea that people acquire knowledge best when learning in the context of a coherent "whole" [1]. In this learning paradigm, learning themes becomes the critical thinking binder that helps bring different and seemingly unrelated information together into a unified whole, and students are encouraged to think around a subject and seek relationships between information and facts from various sources inside and outside of the classroom [2]. Therefore, if a curriculum is organized by a number of learning themes, that is, the unit of a curriculum is a theme, not a chapter; students will construct new intensive and practical knowledge.

In addition, learning is also a social cognition process. Researchers report that, regardless of the subject matter, students working in small groups tend to learn more of what is taught and retain it longer than when the same content is presented in other instructional formats [3]. Therefore, over the past decade, many researchers explored the theories on computer supported collaborative learning (CSCL). Tuckmann pointed out that once groups have been formed they often go through five stages as members work towards a common goal. The five stages include forming, storming, norming, performing, and adjourning [4]. In each stage, the participation and interaction of members have particular characteristics in their different learning activities. Gunawardena proposed an interaction analysis model which can evaluate the levels of knowledge construction in the online collaborative learning environment [5].

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In the situations above, we proposed a theme-based online collaborative learning model, which integrated the online thematic and collaborative learning. Then, guided by the model, we developed an online learning system, and performed a case study which can intuitively analyze the varying tendency of the participation in five stages of group lifecycle in some online collaborative learning activities, such as collecting and sharing learning resources, communications in online virtual forums, and so on. Finally, we drew some conclusions and discussed some future works about the system.

2 System Design

2.1 An Online Theme-Based Collaborative Learning Model: OTBCL Model

Based on the definitions and instruction design of online thematic and collaborative learning, we proposed an online thematic collaborative learning model, named OTBCL model acronym of Online Theme-Based Collaborative Learning (Fig. 1). The model is composed of three circles: outside circle, middle circle and inner circle. In the outside circle, there are eight explicit learning activities, which are typical and necessary steps to carry out an online thematic collaborative learning. In the middle circle, it is learning portfolios that serve as tools scaffolding introspection of learners and evaluation of teachers. The learning portfolios are represented by some participatory indicators which are educed by learners' actions tracked and logged in outer circle. Inner circle includes the processes of reasoning and thinking in the mind of learners: plan, action and reflection. In the overview of the model, the learning portfolios in the middle circle, which serve as social media and technology tools, support and facilitate the process between interpersonal socialization in the outer circle and mental internalization in the inner circle.

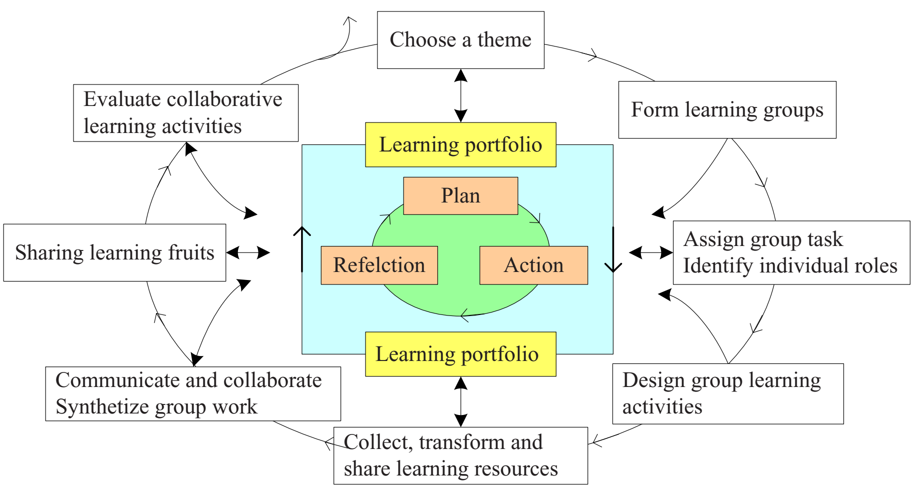

Fig. 1. An online theme-based collaborative learning model (OTBCL model)

The typical steps of online theme-based collaborative learning are explained below:

Choosing a theme. The choice of a theme is central to the ultimate success of the project [1]. In this phase, teachers analyze the goals and contents of a curriculum, and divide the curriculum into several learning themes which have definite goals and specific tasks. There are three principles when choosing a theme: 1) the theme is based to one problem or project; 2) the goals of the theme is attainable and measurable; 2) the tasks of theme are practicable and can be divided into several subtasks.

Forming learning groups. Groups can be formed in many different ways: lecturer assigned groups, students self-select, and random allocation/selection [6]. The size of a group usually is not more than 8 members. Besides, when forming a group, it is necessary to assign a member to be the leader of the group, who manages the learning affairs and coordinates the correlations between members in the group.

Assigning group tasks and identifying individual roles. Based on the goals and tasks of the theme, the members of a group need to further set up its goals and impose its tasks by communicating each other. Then, members divide tasks of the group into several subtasks, and assign a certain role to each member who is charge with one or more subtasks.

Designing group learning activities. Learning activities are the schemes and scaffolds of collaborative learning process. Designing group learning activities means transforming the tasks into a number of learning events which are arranged by a reasonable schedule. Therefore, in this phase, members need give their attention to these aspects: the sequences of learning events, rationality of the timetable, the definite outcomes in each learning event. Besides, the states of learning activities should dynamically show the actual progress of learning event in real time. When a certain learning event is dropped behind the schedule of learning activities, members of the group will be reminded in time.

Collecting, transforming and sharing learning resources. Learning resources provide contents for members of learning groups. At the beginning of this phase, lectures/tutors need provide some learning resources about the theme, which can make students understand the basic knowledge about the theme. Then, members of each group collect their learning resources by web searching engines, such as Google, Yahoo, Msn and so on. Students construct their individual knowledge by assimilating learning resources, and share the learning resource in the group private or class public resource repositories. Finally, members can rate and comment the learning resources shared by their peers.

Communicating, collaborating and synthesizing group work. Interactions and communications rare the most important and fundamental components in online collaborative learning. Forming of individual identity, appearing of shared values and accumulating of learning outcomes are built on them. In addition, by discussing the concepts, doubts and questions in learning themes, members of the group synthesize their individual work into group work collaboratively [7].

Sharing learning fruits among groups. After finishing group's work, members of the group need to share their learning fruits with the other groups in the class. On the other hand, members of other groups can rate and comment the learning fruits of the group. The score of the group work is an index to evaluate task-based performance of the group.

Evaluating collaborative learning activities. There are two kinds of methods to evaluate the task-based collaborative performance, one is teacher evaluation, and the other is peers evaluation. In the moel, we integrated the two kinds of evaluation method. Firstly, members of a group score and remark the other members of the same group. Then the teacher of the class evaluates each member based on the scores and remarks from their peers and indicators in the learning portfolios.

2.2 System Architecture

Guided by the OTBCL model described in above section, we designed the architecture of the system (Fig. 2), which is composed of eight modules: theme basic information module, task assignment module, learning resources module, learning activities module, interaction module, learning fruits module, learning portfolio module and evaluation module. The main modules are described briefly below:

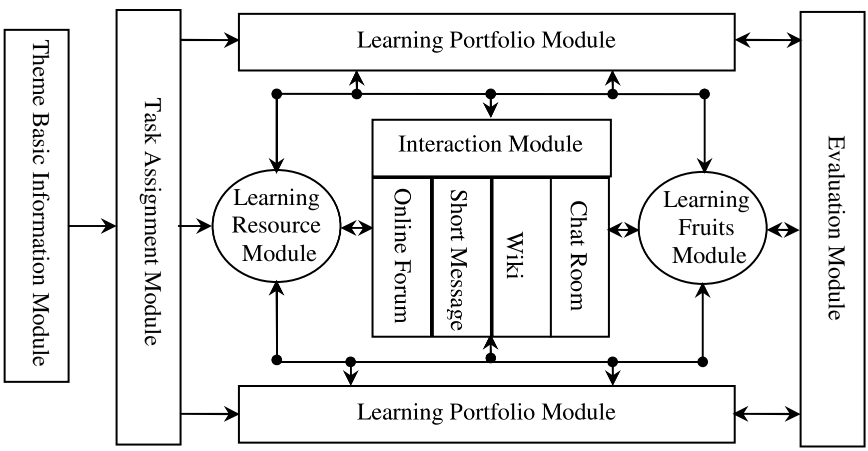

Fig. 2. Architecture of the system

Theme basic information module. Once a teacher chooses a theme, he/she will define the basic information of the theme, such as the title and descriptions, goals and tasks, the starting and ending time, and so on.

Task assignment module. The functions of the module include: forming the groups, assigning group task, identifying the individual roles and responsibilities. The module support three ways of forming a group: lecturer assigned groups, students self-select, and random allocation/selection by system.

Learning resources module. In this module, there are two kinds of learning resource repositories: 1) one is group private where members in the same group share and comment resources; 2) the other is class public where the resources shared by members of a group can be read, downloaded, modified, and commented by the all the students of the class. Besides, the module provides powerful searching functions for the members to search their needed resources.

Learning activities module. The leader of a group can design the learning activities which is composed of a number of learning events. All the learning events are schemed by a timetable. Besides, the sequences, the starting and ending time of learning event of learning activities can be changed by the leader of a group.

Interaction module. There are four kinds of tools supporting the interactions and communications among members of a group. The BBS and Wiki support asynchronous communication, the chat-room supports students' synchronous communication, and the short message tool supports both kinds of communications. All the actions, such as posting, reading, replying, and building on, are tracked and logged into the database of the system. The details about the process will be explained in the next section.

Learning fruits module. Groups can present and share their group learning fruits with other groups of the same class in the class public workspace. On the other hand, members of a group can share their personal learning fruits with their peers in the group private fruits workspace. Moreover, members of groups can rate learning fruits of other groups with five grades: best, better, medium, worse, and worst.

Learning portfolio module. This module consists of two sub learning portfolios, one is group learning portfolio which archives the interacting behaviors and collaborative works of a group, the other is member's individual leaning portfolio which archives those of every member of the group. The specific indicators in learning portfolio will be discussed in the fourth section of this part.

Evaluation module. In this module, we can assess the task-based performance of online collaborative learning. As described in the OTBCL model, the integrated evaluation can conduct peers evaluation and teacher evaluation.

2.3 User Interface Design

The interface of collaborative learning system must meet with four principles: 1) is convenient to operate for users, 2) can easily track and log users' actions, 3) can navigate a user to further take actions, 4) can effectively support and scaffold collaborative learning task. Two examples of interface design are represented below:

In the first example, the notes posted by members in online virtual forums are displayed with a tree structure. The design has many benefits. Firstly, a student, at a glance, will perceive and understand the outline and structure of knowledge represented. Secondly, the system will log the reading action into database when a student clicks the note's hyperlink to read the content of it. Thirdly, the interface display different levels of knowledge with different image icons and colours, which scaffolds the met cognition of students.

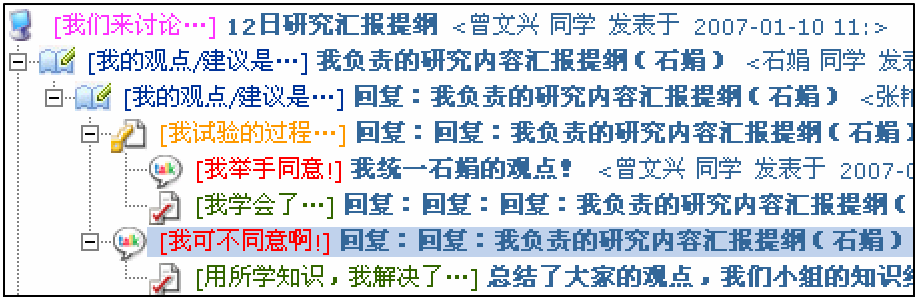

Fig. 3. Tree structure of notes

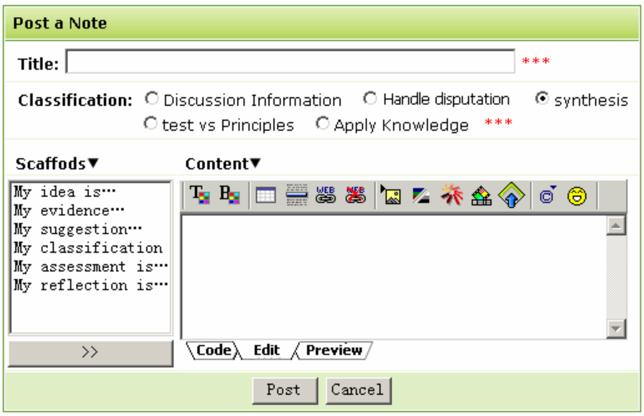

Fig. 4. User interface for posting notes

In the second example, we designed the interface where members post a note in the online virtual forums, as illustrated in figure 4. When a member posts his/her notes, he will classify it one of five knowledge construction levels in the interaction analysis model [6]. And after he selects one level in the classification, the system will automatically generate the corresponding thinking scaffolds. In this study, thinking scaffolds are composed of all kinds of sentence openers representing different implications and situations, which can guild students to construct high level knowledge. In addition, eWebEditor, a kind of multimedia editor based web, is embedded into the interface, so students can publish notes with images, animations, sounds, videos and so on.

2.4 Learning Portfolio Design

Referring to the unified framework of interaction analysis [8], we designed the schemes of learning portfolio formation, as shown in the figure 5. Learning activities influence the choice of indicators used to conduct further analysis. Indicators chosen in learning activities determines the design of system interfaces, which is responsible for generating the raw data used in further analysis steps to compute the chosen indicators. Then the raw data is put into the analysis method and is processed there. After the analysis, the high and low level indicators are produced. In the end, indicators which are represents by a certain tool constitute the learning portfolios. Moreover, for the concrete utilization of the indicator norms can be applied. These norms which define desired values and behaviors are used for meta-cognition or guiding.

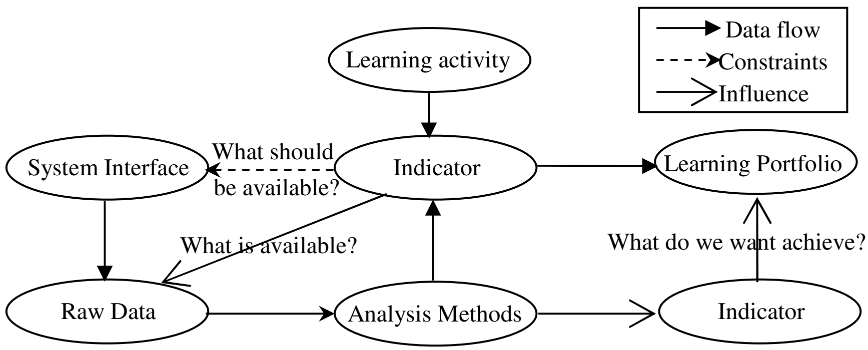

Fig. 5. Schemes of learning portfolios formation

In the system we designed, there are three learning activities which are represented in the learning portfolios: 1) sharing and using learning resources, 2) sharing and using learning fruits, 3) interactions and communications in online virtual forums. The indicators in the three kinds of learning activities are described in the case study section. The system by far mainly uses quantitative statistics method to analyze the raw data, and represents indicators in learning portfolios with participation diagrams.

3 System Implementation

The standard Object-based software engineering methods were adopted to implement the system. The procedures of implementation mainly went thought three phases.

Firstly, PowerDesigner 12, a powerful, visual and easy-to-use enterprise modelling tool, was used to create the requirement model with use case and entity-relation diagrams.

Secondly, PowerDesigner 12 automatically converted the entity-relation model into the class model, and efficiently generated the SQL scripts. As we know, the class model shows more details of the static system structure than the module architecture does, and can be used to generate the code frames which shortens the cycle of development; the SQL scripts can be used further to create the target database in MySQL 5.0 which is an open source relation database management system.

Thirdly, the programs on Web server (Apache 2.0) were coded with PHP which is a webpage script language. For JPGraph is an Object-Based Graph creating library for PHP, We directly take advantage of its functions to create numerous types of statistical graphs in learning portfolios module.

4 Case Study

The participants were 32 graduate students majoring educational technology in the south china normal university, who took the course of research methods of educational technology. The teacher is a famous professor who has studied CSCL for many years, and three doctor candidates took on the research assistant. The learning theme chosen is about .data collection and analysis of qualitative research method. The study was conducted within 5 weeks after the participants were introduced the OTBCL model and functions of the system. The procedures of this study were carried out strictly according to OTBCL model.

The purpose of the case study is to seek the varying rules of participation in group lifecycle. According to the five stages of group lifecycle in collaborative learning proposed by Tuckmann [3], we divide the period of theme learning into five phases, each phase is about one week. In this paper, we explain how to analyze the rules of participation in the two kinds of learning activities: 1) sharing resources, 2) communicating in online virtual forums.

4.1 Analysis of Sharing Resources

The variation of the number of resources shared shows the dynamic process of collaborative learning. In this activity, we proposed the hypothesis that a group does not perform well if its members share resource in the last two stages of the group lifecycle. In this system, the results of resources shared were automatically summarized in tables, as shown in table 1.

Table 1. The results of statistics of sharing resources

	Ⅰ week			Ⅱ week			Ⅲweek			Ⅳweek			Ⅴweek		
	S	Pr	Pu	S	Pr	Pu	S	Pr	Pu	S	Pr	Pu	S	Pr	Pu
Group 1	7	5	2	0	0	0	11	11	0	15	2	13	1	1	0
Group 2	0	0	0	4	3	1	1	1	0	4	4	0	0	0	0
Group 3	1	1	0	2	2	0	4	3	1	3	2	1	0	0	0
Group 4	6	5	1	10	9	1	6	5	1	0	0	0	1	1	0
Group 5	0	0	0	1	0	1	4	4	0	10	9	1	3	3	0
Group 6	0	0	0	10	8	2	1	1	0	19	17	2	2	1	1
Group 7	2	2	0	5	5	0	1	1	0	7	7	0	3	2	1
Group 8	2	2	0	18	12	6	10	4	6	8	8	0	0	0	1

Remark 1. S: sum of resources, Pr: group private resources, Pu: class public resources.

The data in the table1 can not intuitively shows the varying rules and tendency of reading resources in the group lifecycle, so the system generated the line plots. Obviously, Figure 6 clearly shows the variations of participation in sharing resources activity of group 5 and group 8 during group lifecycle.

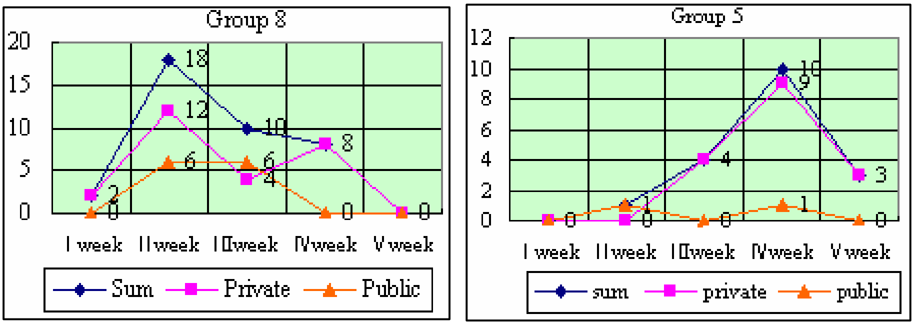

Fig. 6. Variations of participation in reading resources of group 5 and group 8

From the line plots in figure 5, we can easily discover that the peak of sharing resources of group 5 lies in the fourth stages, but that of group 8 lies in the second stages. In the case of group 5, it means that the members of the group did not begin to passively collect and share their resources until the last two stages. But, in the efficiently collaborative learning, the actions of sharing resources are centralized in the first two stages. In addition, the hypothesis is also verified by the task-based performance evaluation: the performance of group 8 is evidently better than that of group 5.

4.2 Analysis of Participation in Online Virtual Forums

As we know, efficient communications in online virtual forums can facilitate the knowledge construction. So learning portfolios should provide indicators which can measure the levels of knowledge building. In this system, content analysis was used to perform the function. In the analysis, each note was classified as belonging to one of five levels of the interaction analysis model [5]. In the case study, because knowledge test and application is not the goals of the leaning theme, the system only outputted the results of analysis of the first three levels. The results are shown in the figure 7.

The variation of number of notes in group lifecycle can explain whether members of a group devote themselves to communicate, and can indicate which stage is

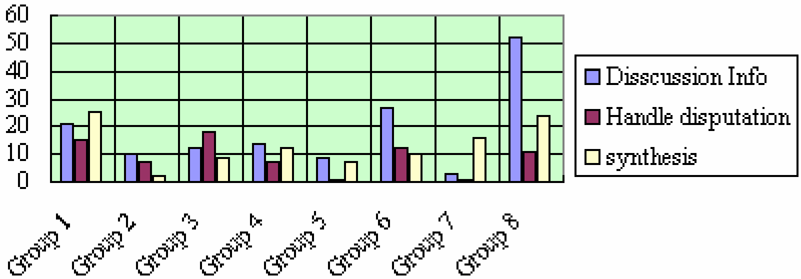

Fig. 7. Content analysis of communications in online virtual forums

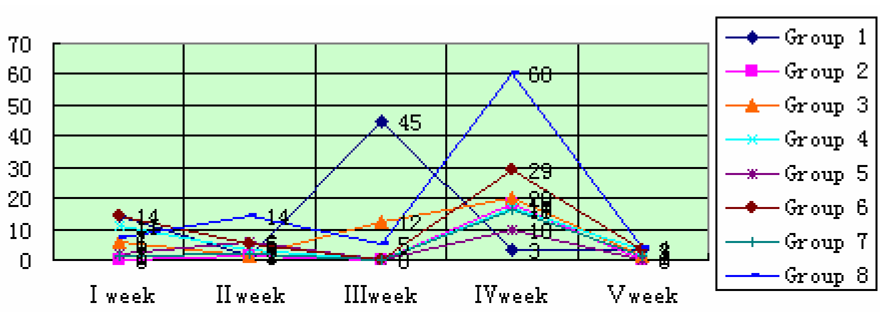

Fig. 8. Variations of communications of forums in group lifecycle

centralized by the efforts of members. From the results depicted in the figure 8, we can inspect two kinds of interesting phenomena: 1) Except that of group 1, the peak of participation emerged in the fourth stages of group lifecycle. It means that it is the assignments that force student to take efforts to communicate each other in the fourth stage. 2) Except in group 1 and group 3, the number of notes posted by members in the third stage is less than in the other stages. It shows that the learning motivation of members diminish from the first stage to the third stage. Therefore, the teacher should take effective measures to change the situation.

5 Conclusions and Future Work

This paper makes several contributions. Firstly, an online theme-based collaborative learning model (OTBCL model) was proposed, which can guild teachers to implement thematic learning or collaborative learning supported by internet. Secondly, the design and implementation of a powerful system based on the OTBCL model were described in detail. Especially, the principles achieved in the design of system architecture, user interface and learning portfolios module are very useful for developing online collaborative learning system. Lastly, a case study was introduced which explains how to intuitively evaluate the varying rules of participation during group lifecycle and the levels of knowledge construction with statistical diagrams.

Researchers in CSCL fields claimed that there are three kinds of collaborative management tools: mirroring tools, monitoring tools and guiding tools [9]. In the system, the selected indicators in the learning portfolios module are belong to the first two kinds, which means teachers would depend on their experiences in CSCL when make decisions in their instruction. Therefore, as for the future of the system, new analysis method need be adopted to analysis the participation and communication of members of a group, such as social network analysis [10], focus group interview and so on. Then, it is necessary to carry out many additional experiments to summarize many causal norms. Supported by the norms, the system can automatically and effectively generate useful guides in formative evaluations, which will reduce the burdens of teacher and provide learning scaffolds for students.

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Design on Collaborative Virtual Learning Community and Learning Process Visualization

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Abstract. Along with the rapid development of network education, virtual learning community emerges its apparent advantages continuously. Collaborative learning has played an important role in educational patterns. Based on the constructivism learning theory, this paper designs a collaborative virtual learning community on the subject of Software Engineering. Moreover, the learner's online action is a force to be reckoned with. In view of collaborative learning processes are very important, the group member's learning characters such as sending or watching the amount of message are extracted to evaluate their usual performances. Then they can be visualized in forms of chart or data report for learners, to the effect that urge learners into adjusting themselves duly.

Keywords: Constructivism, Collaborative, Learning process, Visualization, Performance, Algorithm.

1 Introduction

Learning is perhaps the most indispensable activity in the current society. Owing to the fleetly development of information and communication, E-learning has gradually become one of the main learning styles. And the virtual learning community emerges as the times require. Firstly, virtual learning community originated from BBS, newsgroup and chatting room. Now the virtual learning community suits learners better due to the improvement of technology as well as the full-fledged learning theory like constructivism and collaborative learning. Bill gates said virtual communities' building will be one of the fastest growing areas of network applications in the next few years [1].

Based on the subject of Software Engineering, the paper designs collaborative virtual learning community which includes the theory of constructivism and collaborative learning. Meanwhile, usual performance should be sampled in the learning process. Not only the summative evaluation but also the formative evaluation is an important fact of measuring learning. So the visualization of learning process is introduced to present the collaborative learning.

2 Background

China has already done much works in the field of virtual learning community. An example is the learning community of Capital Normal University（http://www.etkeylab.

F. Li et al. (Eds.): ICWL 2008, LNCS 5145, pp. 424 – 433, 2008.

com:8081/）. The function of this community is composed of three parts: course development, course support and teaching management, respectively. This platform also involves the intellectualized decision-making support tool, reconsideration tool and many kinds of teaching evaluation tools, and so on. Other platform like VClass teaching platform contains homework gathering module, test information gathering module and answering module. But both these platforms have similar limitation, for example, the behavior in the learner's learning process is still studied superficially. Nowadays, virtual learning community is no longer a static support program. People focus on what kind of intelligence and how does it come true [2], as well as on evaluating and adjusting each behavior through the learning behavioral analysis. Shengquan Yu [3] proposed that the way of evaluating network learning includes formative evaluation and summative evaluation. And formative evaluation should be paid more attention than before.

There are also a lot of virtual learning communities around the world, example as the "Creation Of Study Environment" in Staffordshire university in British, which provides a great deal of resource. Meanwhile, some researchers interest in teaching effect evaluation. Virtual-U teaching platform presents comprehensiveness in this aspect. But in the learner's online behavior analysis, it is also lacked or insufficient. Stufflebeam, an educational evaluation authority, said the intention of evaluation is improving rather than proving.

In conclusion, now the construction of virtual learning community leans to learners' summative evaluation. In this case, the paper combines formative evaluation when describing the construction of virtual learning community. In other word, Using student's participation degree, online learning situation and progress test as the measure basis, the paper analyzes the collaborative performance and designs the visualization algorithm.

3 Rationale

3.1 The Learning Theory of Constructivism

As is known, integrating computer technology with advanced learning theory is the key of designing E-learning [4]. Blindly producing the non-field related network tool will not exist for long. Constructivism considered: as the understanding of the impersonal world is decided by human himself, learning is the process of learner's actively constructing his inner psychological attribute. Constructivism emphasizes learner's learning. At the same time, it doesn't neglect the instruction of teacher. Situation, Cooperation, conversation and meaning construction make up of the four essential factors of learning [5]. Among those, collaborative learning is an important component of constructivism. In order to reach the common learning goal, learners cooperate with each other in groups, which could maximize individual and other's learning harvest in certain mechanism of inspiration. This is so-called collaborative learning. Collaborative learning will bring about better relationship, learning performance and quality. Furthermore, collaborative learning takes into effort in the aspect of psychological healthy, social accountability and the establishment of self-respect [6]. Therefore, collaborative learning is preferable theory in constructing the virtual learning community.

3.2 Theory of Learning Process

As a result of widespread in behaviorism theory, learner's learning style is typically a passive form in China. Teachers impart the same knowledge and content to individuality, which leads that students are weak in innovation consciousness and autonomous learning ability. Facing the knowledge's quickly change, lifelong learning is a tendency sooner or later. Nevertheless, students lack in autonomy, independence and self-control ability. Under this transition stage, the supervision of learning process appears more significance. Owing that people may understand graph or chart more directly and vividly, the paper considers visualizing the learning process through filtering data in the log and progress test, in order to make learners and teachers observe them learning situation better. It uses the concept of psychology such as motivation and feedback to make the learner learning better.

3.3 Subject Characteristic

Software Engineering is a subject of computer science. Its research area is widespread, which mainly contains theory, technology, method, tool, standard, and development environment. Software Engineering is a comprehensive subject, who consists of Computer Engineering, Management Engineering ,and System Engineering. In other words, it requires richness and various resources, which proves the reason for E-learning. The subject shows high practicality. Students majoring in Computer Engineering must acquire the ability to solve the same kind of problems that they will encounter once they graduate [7]. Thus, simulating real world to grasp the problem solving or project developing gets important.

4 The Architecture of Collaborative Learning Community

4.1 Community Architecture

As is known, designing a project should follow certain standard. At the beginning of the 21st century, Chinese E-learning Technology Standardization Committee (CELTS) proposed a full-pledge standard architecture of China network education technology [8], which suits for a great deal of fields such as education, learning and training. We design the virtual collaborative learning community of Software Engineering according to the standard structure diagram as figure 1 shows.

Through the structure diagram, combining the rationale of constructivism, learning process and subject characteristics, collaborative virtual learning community is composed of learning resource system, learning process system, management system and research system. Figure 2 gives the thumbnail of its architecture.

Learning resource system is simply introduced in this part. It contains course reader, online course, dictionary, and resource link. Course reader displays the subject's content, which includes brief introduction of the course, teaching syllabus, test syllabus and learning guidance. Online course provides network courseware, which has been developed by the author before. Some content can also be uploaded in online

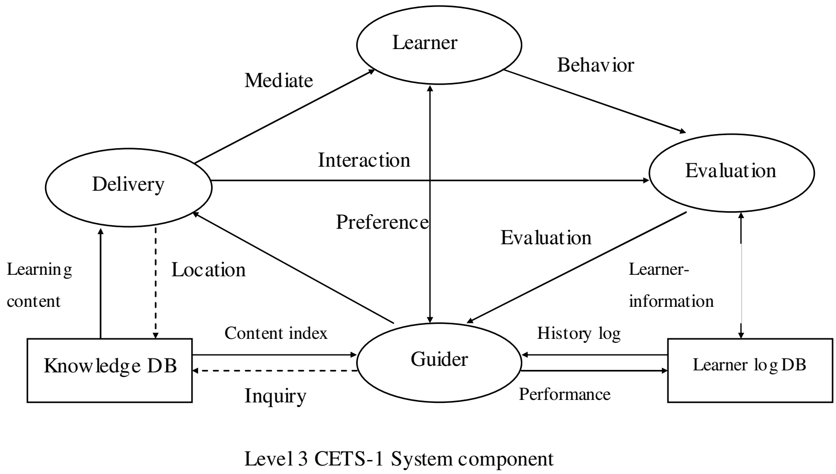

Fig. 1. CELTS System Component

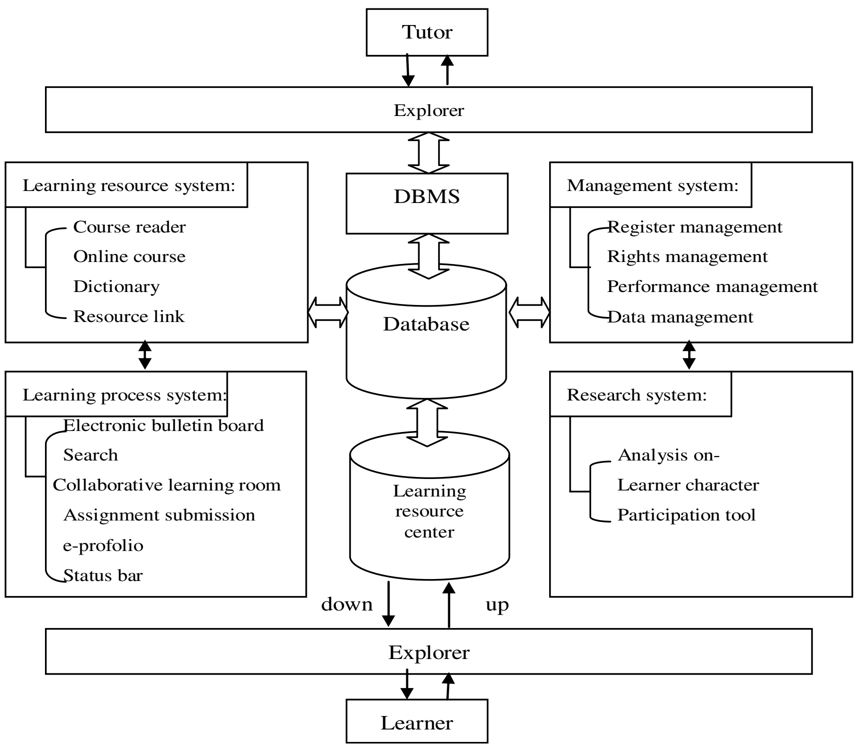

Fig. 2. The Architecture of Virtual Learning Community

course in forms of word and PPT. Meta-knowledge is explained in the dictionary, example as the concept of software Engineering. Resource linkage links a lot of other addresses to develop learner's thought. Then, the paper mainly discusses collaborative learning in the learning process system.

4.2 Collaborative Learning Room

Collaborative or group learning evolved from the work of psychologists such as Johnson and Johnson (1975) and Slavin (1987) [9]. It involves interpersonal processes by which a small group of students work together cooperatively as a team to complete a problem-solving task designed to promote learning (Alavi, et al., 1995) [9]. Thus, the collaborative learning community is composed of chatting tool, source, co-editor, BBS. Figure 3 shows a screenshot of group members discussing. Chatting tool is used for synchronous communication between group members. Chatting history is stored automatically and can be re-read at any time. Students can read the description of the group task and search for relevant historical information using the Sources tool. The Co-Editor is a shared word-processor, which can be used to write a group text. Using the Co-Editor, students can work simultaneously on different parts of their texts. If students catch on some knowledge in difficulty, BBS provides the platform with

Fig. 3. Screenshot of discussing

asynchronous communication. Besides, virtual learning community refers to the concept of visual process chart (VPC), so that it can visualize the learning process.

4.3 Visual Process Chart (VPC)

VPC as a chart tool can display the learning process of group member or between the group members. According to the collaborative learning, factors of affecting learner's learning involve group's division, participation of group members, task distribution and teachers' help in time, progress test and so on. The paper illustrates one of the factors named the participation of group members to design VPC. The measure of learning participation contains learner's sending message, replying message, looking message, neglecting other factors. Each group members contribute to their group's online communication in certain message. In VPC, red circle presents group member while grey circle presents a group [10]. The same group agglomerates together with dashed Circle. As shows in figure 4, it is assigned into 3 groups in a class.

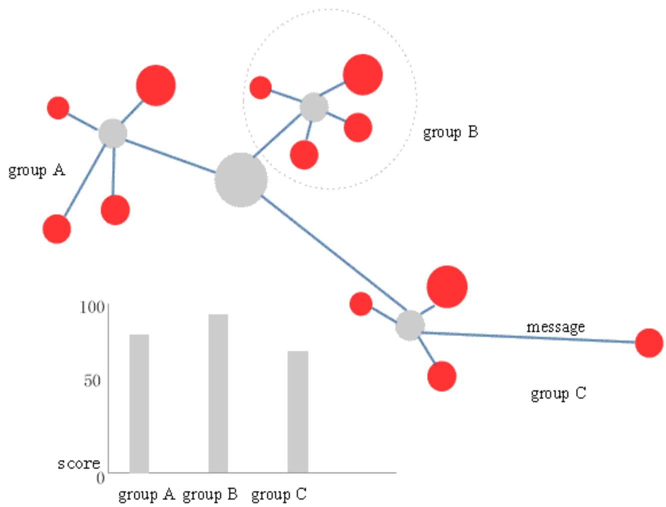

Fig. 4. Screenshot of the VPC

For example, observing the encircled part we can see there are four red circles which stand for group members and one grey circle which presents a group. They are around the group tightly. In VPC, the distance between circle and group circle, named line segment (LS), points out the length of sending message. We called information content (IC) for short. If a circle is near the group, then its IC is more, compared to far away. Circle's diameter implies the quantity of a learner's average message, we called it information degree (ID) for short. If a circle is smaller, it means the message quantity is less, compared to those bigger ones. According to this, we can know the group circle in the same way. If the grey circle is bigger, in other word, the diameter of which is longer, the ID is bigger, compared to the smaller one. If LS between group and class is longer, the information content is less. Therefore, students can recognize themselves clearly through VPC. The total information equals to the sum of IC and ID. Finally, the class circle could be drawn. Following is the algorithm of VPC.

We use the kind of C pseudo code and Natural Language to describe the algorithm of VPC chart as follows:

```
int totalMessage;  // total information degree
int totalInformation; // total information content
int group_Count;  // the amount of groups
int stu_info;  //student information content
int stu_in;    // student information in-degree
int stu_out;  // student information out-degree
int group_info; // group information content
int group_in;  // group information in-degree
Int group_out;  // group information out-degree
define p; // parameters
if totalMessge>0
{
 if totalInformation>0
     Class_R= (totalMessage+totalInformation)*p;
     Class_X=0;
     Class_Y=0;
     Take (Class_x, Class_Y) as circle center, Class R
       as radius to draw the class circle;
  if group_Count>0// Here starts to process the group
   { i=0;
     while i<group_Count  {
      group_l=(group_info)*p;
       Confirm the length of line segment according to
          group IC;
      group_r=(group_in+group+out)*p;
       Comfirm the circle center based on the group ID;
       Take group_r as radius to draw circle;
    Link the group circle center and class circle cen-
ter;
     j=0;
     while j<stu_count  {
      stu_l=(stu_info)*p;
      Confirm the length of line segment according to
        learner's IC;
      stu_r=(stu_in+stu_out)*p;
     Comfirm the circle center based on the learner's
ID;
      Take stu_r as radius to draw circle;
       Link the student circle center and group circle
       center;
            j++;
     }
     i++;
   }
}
```

Fig. 5. Pseudo code of VPC chart algorithm

As figure 3 shows, there is a coordinate graph in down left position. It demonstrates the performance of group's collaborative status when a task is finished, named collaborative performance. The result of collaborative performance is measured by some factors of each group member, like the total information quantity, learner's online time and progress test. Fuzzy comprehensive evaluation is involved to calculate each group member's dynamic performance. The brief step is as follows [11]: evaluation purpose and evaluation index should be determined firstly. Analyzing the group member real- time learning process, the purpose is to attain feedback in time and reach better learning way. Total information quantity, learner's online time and progress test are chosen as evaluation index. Then, evaluation index weight and comment rate are confirmed to establish fuzzy relation matrix. After choosing fuzzy operator, we use mathematical model of fuzzy comprehensive evaluation to gain the evaluation result. Then, the result is utilized to measure the collaborative performance, the concrete method refers to the book of "The Theories and Methods of Computer-Supported Cooperative Learning" [6].

(a). Evaluation of concentration magnitude.

Arithmetic average, a method of evaluating concentration magnitude, is involved in the paper. Suppose the group scale is n, the group member's score is respectively x1, x2,…, xn., $\bar{x}$ is the average score of group members(**1**).

$$\bar{x}=\frac{1}{n}(x_1+x_2+\cdots+x_n)\ ,\quad \bar{x}=\frac{1}{n}\sum_{i=1}^{n}x_i \tag{1}$$

(b).Evaluation of difference magnitude.
Standard deviation is calculated: (**2**)

$$s=\sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2} \tag{2}$$

(c). Evaluation of the collaborative performance based on the collaborative performance formula (**3**).

$$C=\frac{\bar{x}-s}{\bar{x}+s}\ ,\quad E=(\bar{x},c)\ ,\ \mathrm{C}<1 \tag{3}$$

Where C presents collaboration degree, as well as E presents collaborative performance.

The higher the collaboration degree is evaluated, the better the collaborative performance is proved. Thus it illuminates high cohesion. For example, look at Fig. 6.

$$s=\sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2}\approx 3.6056\ ,\quad C=\frac{\bar{x}-s}{\bar{x}+s}\approx\frac{81.3944}{88.6056}\approx 0.9186\ ,\quad E=(\bar{x},c)=(85,0.9186) \tag{4}$$

The member of group B:	①	②	③	④	ave
score	90	86	84	80	
$x_i - \bar{x}$	5	1	-1	-5	85
$(x_i - \bar{x})^2$	25	1	1	-25	

Fig. 6. Score of group B

By calculating (**4**), group B is proved better in collaborative performance. That is to say, the group members cooperate and communicate with each other well and achieve the task perfectly.

Following is the algorithm of the histogram in VPC to present the collaborative performance shown in Fig. 4, using the kind of C pseudo code and Natural Language.

```
drawing(x,y); // draw the Coordinate Graphs.
Int i=1;
Int S; // Group performance
Int p,q; //parameters
While(i<=group_count)
{
  S= (group IC)*P+(group ID)*q;
     Draw columnar section in the interval of
     (x>5*I, x<5*(i+1), y>0, y<s);
}
```

Fig. 7. Pseudo code for implementing the collaborative performance histogram in VPC

4.4 Realization of Virtual Learning Community

The development of virtual learning community involves many tools. Firework is used to design the foreground graphic interface. Dreamweaver and visual studio 2005 is combined to edit webpage and develop programs. C# is a programming language developing by Microsoft to fit .net. Modules designed with C# may easily transform to web service, may arbitrary transfer in random language and operating system. So the system uses C# to instantiate algorithms. Background database uses SQL server2000, while server adopts the production of IIS 6.0.

5 Conclusions and Perspectives

Collaborative virtual learning community is a tendency of the future development. Constructing effective and suitable virtual learning community must integrate certain theory. Under the collaborative learning theory of constructivism and the standard architecture proposed by Chinese E-learning Technology Standardization Committee, this paper designs a “software engineering” collaborative virtual learning community to maximize each learner’s learning performance. Moreover, it is feasible to introduce a concept of learning process visualization in collaborative learning because of China’s traditional learning pattern. Information content and information degree is distilled as learner’s characteristics to design the visualization of learning process, which provides nicer feedback information. Nevertheless, we must emphasize that not only constructing learning environment is complex and comprehensive, but also visualizing learning process needs to be paid more attention. Some factors can affect the learning effect, such as learning style, group member’s organization, the quality of information communication and so on, which is not contained in the paper. This part needs to be studied farther in the coming future, and collaborative virtual learning community also will be improved.

Acknowledgment

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The Design of Web-Based Personal Collaborative Learning System (WBPCLS) for Computer Science Courses

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Abstract. The Web-based collaborative learning system (WBCLS), which is considered a highly effective teaching method by most theory researchers, could not achieve the goals that can be obtained by traditional in-class teaching method in the teaching practice. Therefore, some problems that are harbored in the operational process of the current popular WBCLS were pointed out. In order to overcome problems mentioned above, a new framework for Computer Science Courses, which support the personal learning, was proposed and the algorithms about the intelligent course recommendation, optimal group formation, and the optimal collaborative partner discovery are discussed in this paper.

Keywords: Web-based Collaborative Learning, Personal Learning, Optimal group formation, Optimal Collaborative partner discovery.

1 Introduction

Currently, Web-based learning systems are one of the most interesting topics in the area of the application of computers to education. Using computer technology, especially distributed computing technology, teaching resources share has become reality. Web-based collaborative learning system (WBCLS) , which is considered a highly effective teaching method by most of theory researchers[1, 3], could not achieve the goals which can be obtained by traditional in-class instruction in the teaching practice[2]. The operational process for the WBCLS can be shown in the *Fig. 1*.

According to the operational process mentioned above, we analyzed its reasons for its lower effectiveness than the traditional teaching mode. The reasons are as follow:

The first problem for the WBCLS is that improvement of hardware environment has been heavily emphasized, whereas the improvement of learning organization has been heavily ignored in the course of WCBS design. The grouping is one key step of the WBCLS, and is often randomly done without considering the characteristics of individual learners. Therefore, the quality of learning in the collaborative platform is not well achieved as desired.

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The second problem is to emphasize excessively the collaborative learning, but ignore the personal learning process. The effectiveness of collaborative learning is different according to the different studying tasks. The effectiveness for some tasks that cannot be partitioned depends on the personal learning process (such as understanding). Under this situation, it is important to provide appropriate studying resources and learning methods for different learners.

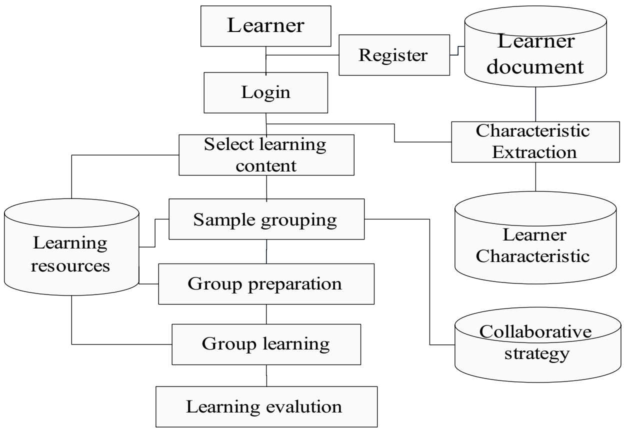

Fig. 1. The common operational process for WBCLS

The third, the present WBCLS could not intelligently manage the studying record or satisfy learners enough. Because the different courses need different intelligent strategies, the expectation that takes a WBCLS as a common learning environment for all courses is unrealistic.

In this paper, the design of the WBPCLS for computer science course will be presented and discussed. The WBPCLS target is to support intelligent grouping and personal learning.

2 The System Design

In order to improve the effectiveness of the web-based teaching and overcome the problems in the WBCLS, the operational process of WBPCLS has been designed *(Fig. 2)* by referencing to the relevant literatures [4-6].

The operational process was summarized in:

1) To login or register: Once a student's identity is verified by comparison with the corresponding ID in the WBPCLS, the student can enter the WBPCLS environment. The student, who first uses the WBPCLS, needs to fill in some tables for login. The system extracts the student characteristic from the login information; and then builds the personal model database of the student. In the end it adds special measurement mechanisms for measuring the student's characteristic.

2) To select learning content: After the student enters the environment, the system gives student a catalogue of learning content extracted from the studying resource warehouse. Then the student selects one's learning content.

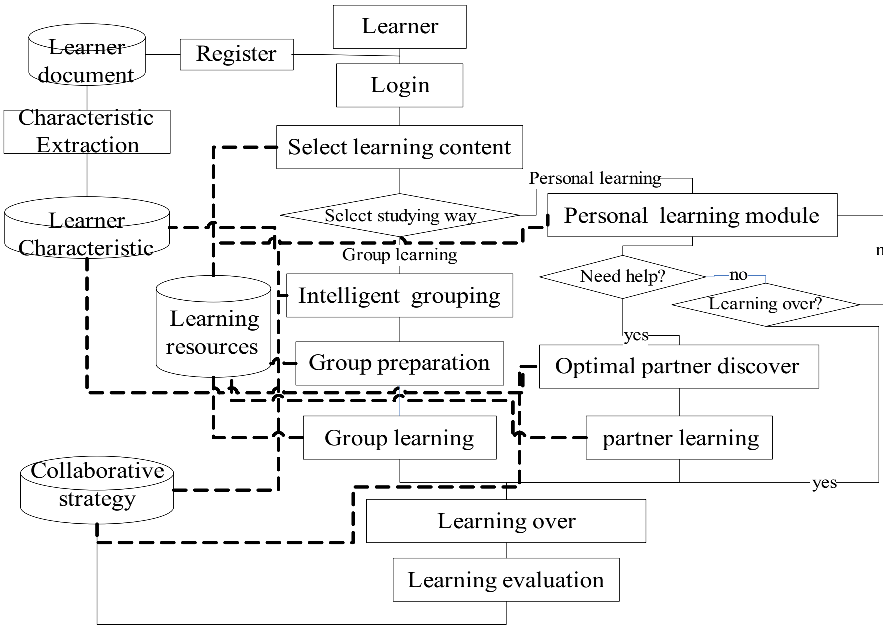

Fig. 2. The process flowchart for our system

3) To select the learning way: System provides two kinds of learning ways, e.g. the group learning and personal learning.

If the student selects the group learning way, steps which students should follow are:

(ⅰ) Intelligent group formation. System divides the members into groups and assigns learning tasks to them based on the studying target, the learner characteristic, and the learning strategy.

(ⅱ) The group learning preparation. The learner not only gets acquaintance with other members, environment, and overall target, but also with the roles that the member plays and the collaborative rules. At the same time, the learner extracts the learning target (group and the member target) information from the resource warehouse.

(ⅲ) The group learning. The learner studying appointed content, accomplishing the appointed role tasks. The learning resource warehouse provides fundamental material, implements and corresponding function software so that the learning tasks can be completed. System will record interactive behavior in group learning process, stores the information to the corresponding documents, which can be used for the evaluation about member's learning.

If learner chooses personal learning way , the steps which learners should follow are :

(i) Begin to personal study;

(ii) In the learning process, learner, if needs help, can start Optimal Collaborative partner discovery mechanism, which will find out the optimal collaborative partner for current help-seeker;

(iii) The collaborative learning with partner.

4)Learning over;

5)Learning evaluation. The WBPCLS modify the corresponding database according to evaluation result of learner's behavior in entire learning process, for instance, the learner feature model, the collaborative document.

3 The Learner Feature Selection

The learner feature model is the important database, on the basis of which the system is able to provide personal learning and help, realize collaborative learning tasks, and find out the optimal collaborative partner.

Learner feature can be acquired by register and characteristic measurement. The register generates the learner's fundamental information, whereas the characteristic measurement generates the learner's characteristic warehouse. Both of them constitute the learner feature model.

For learner's fundamental information, except ID (system assigned), sex, and age, we pay more attention to student's course selecting situation. The system records the courses which the learner has studied, at the same time records student's score if learner has participated in examination.

When learner first enter the collaborative learning system (login), the system records the learner's selected course that includes course name and course conception. first, Then it measures the learner's characteristics (Table 1) automatically, and store the result to the corresponding learner's feature model. The data can be corrected continually according to the learner's learning situation.

Table 1. Learner personal characteristic

value / meaning / characteristic	0~2	2~4	4~6	6~8	8~10
Character	not be very much	not Be	both will do	be	*Be very much*
knowledge grade	very low	low	medium	high	*very high*
collaborative ability	very low	low	medium	high	*very high*
studying style	*field dependent*		*medium*	*field independent*	

We have chosen four characteristics which include the character, the knowledge grade, collaborative ability and studying style to build a learner feature model. The values belong to the range (0~10).

System divides "character" into 5 grades: Be ready to help others very much , be ready to help others , both will do not being ready to help others, not being ready to help others very much. The knowledge grade and collaborative ability are also divided into 5 grades: high, very high, medium, low, very low. The studying style is divided into field independent tendency or field dependent tendencies. If the value of studying style is in range (4~6), the learner has not obvious field independent and dependent tendency, thus is called "medium ".

The knowledge grade was acquired by measuring some knowledge points with grade label, whereas others were measured using the test scale that is composed of an example and 30 tests problem.

4 The Intelligent Course Recommendation

In our system, when the learner searches for a course, the system not only can get the relevant information from local resource warehouse or internet, but can also recommend the courses according to the learner's selected courses records. Exampling student A, we introduce the realization of course recommendation.

1. Course classification

In order to reduce course matrix size, we classify the computer science courses using the method of conception extraction. The classification result of all computer science courses and their corresponding conceptions are shown in the *Table 2*.

Table 2. Classification of computer science courses

Course name	Course conception
Network Programming	{network,software,method}
Network Management& Security	{network,hardware,management }
Distributing System	{network,system,management}
Software Engineering	{software,method,management}
Systems Analysis & Design	{software,database,method,system}
Multimedia System Design	{software,system}
Database Management	{network,database,management}
E-Commerce	{software,database,method,system,management}
Programming	{ software,system}
Management Information System	{ software,database,method,system,management}
Computer Architecture	{hardware,method }
Multimedia Introduction	{software,system }
Data Structure	{software,system}
Database Management System Introduction	{ Network, hardware, software, database,method,system,management }
Artificial Intelligence	{ software,method }

2. The course conception favor mining

Once student's records of selected courses were taken out from the learning database, the course conception favor can be found by using the Apriori algorithm. For example,

Table 3. Student A selected courses

Course name	***Course conception***	items
Network programming	{ network,software,method }	{ACE}
Network management & security	{ network,hardware,management }	{ABG}
Distributing System	{ network,system,management }	{AFG}
Software Engineering	{ software,method,management }	{CEG}
Systems Analysis & Design	{ software,database,method,system }	{CDEF}
Multimedia System Design	{ software,system }	{CF}
Database Management	{ network,database,management }	{ADG}
E-Commerce	{software,database,method,system, management}	{CDEFG}
Programming	{ software,system }	{CF}

Table 4. Student A course conception favor vector

favor vector	reliability
A->G	0.833333333
C->E	0.75
C->F	0.833333333

the student A's records shown in the *Table 3*, in which the item A , B , C , D , E , F , G represent 'Network', 'hardware', 'software', 'database' , 'method' , 'system' and 'management', respectively. The finally course conception favor vector is formed *(Table 4).*

3. To comparison and recommendation

When the student wants to search for the course that belongs to someone course conception, we first turn the course conception favor vector into favor rule vector, then compare it with the course vector *(Table 5)*, calculate comparison value *v* using contrast formula*(**1**)*, and finally recommend courses according to the descending order of v value. For example, when student A wants to search for the course with course concept *C (software)*: according to *C-> E , C-> F* which come from student A course conception favor vector, we may deduce out that student *A* possibly likes the course with the course conception including *'software', 'method' , 'system' (C , E , F).*The course conception favor vector is turned into favor rule vector *[0010110]* (possibility favor course's vector value sets 1 , the others sets 0), and then the favor rule vector is compared with the course vector by using characteristic contrast formula, the results were shown in *table 5.*

$$v = \frac{1}{n}\sum_{i=1}^{n}(1-|x_i - y_i|) \tag{1}$$

The bigger the *v* value is, the better the corresponding course is *(Table 5)*, based on which if student A wants to search for the course with the course conception *'software'*, the system will recommend three courses, e.g. *'multimedia introduction'*, *'programming'* and *'data structure'*.

Table 5. Student *A* comparison favor rule vector with course vector

Course name	Course conception	Items	Course vector	V-value
Management Information System	{software,database,method, system,management }	{CDEFG}	[0011111]	V=4/7 =0.57
Computer Architecture	{hardware,method }	{BE}	[0100100]	V=4/7 =0.57
Multimedia Introduction	{ software,system }	{CF}	[0010010]	V=6/7 =0.85
Programming	{ software,system }	{CF}	[0010010]	V=6/7 =0.85
Database Management System Introduction	{Network, hardware, software, database, method , system, management}	{ABCDEFG}	[1111111]	V=3/7 =0.43
Data structure	{software,system}	{CF}	[0010010]	V=6/7 =0.85

5 The Optimal Collaborative Partner Discovery

"The optimal collaborative partner discovery" means that when the learner who is learning in the personal way encounters the difficulty, an optimal learning partner, who can help him solve the problem, may be found out from all online learners currently.

Once the learner has logged in, the system is able to get his personal characteristics from the learner model according to his ID, the personal characteristics of all current online learners have buildup a fuzzy matrix. The algorithm of "the optimal collaborative partner discovery" will run around this matrix mainly.

Besides, for Seeking of the optimal collaborative partner, the system or the teacher need to define the standard of "the optimal collaborative partner", and the weights of characteristics which were included in standard beforehand.

For example, the standard can be defined by expression forms (the knowledge grade similar/the studying style complementary = 0.6/0.4). It means that the learner should seek the person whose knowledge grade is similar and studying style is complementary with him, and "the knowledge grade similar" is more important than "the studying style complementary".

The main idea of "the optimal learning partner discovery" algorithm is: by analyzing the feature model of help-seeker, the algorithm produces a "visual learner ",puts this "visual learner" in current online learners and then mines out the class whose members are similar with the "visual learner" using clustering method. Finally, according to the weights in standard, it figures out matching values for each member who will be compared with the "visual learner" and recommends the optimal partner according to the descending order of matching value.

The steps are:

1. a "visual learner" is created, then a new characteristics matrix $U= (u_{ij})$ is generated by putting it's characteristics into the matrix that is composed of present online learner's characteristics.

Creating "visual learner" includes three aspects:

(1) the character characteristic value of "visual learner" was set as "be ready to help others very much" or "be ready to help others".

(2) the value of characteristic that demands to be similar in the standard of "the optimal collaborative partner" is equal to the corresponding characteristic value of help-seeker.

(3) the value of characteristic that demands to be complementary in the standard of "the optimal collaborative partner" was set to the result of full mark minus characteristic value of help-seeker.

2. standardization

If needed, the original data can be standardized using formula *(2), (3), (4), (5)*. After above translation, for each variable, the average is 0, the standard deviation is 1, and the value range belong to 0~1.

$$\overline{u_k} = \frac{1}{n}\sum_{i=1}^{n} u_{ik} \quad (k=1,\ 2,\ 3,\cdots,\ m) \tag{2}$$

$$s_k = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(u_{ik} - \overline{u}_k)^2} \quad (k=1,\ 2, 3,\cdots, m) \tag{3}$$

$$u'_{ik} = \frac{u_{ik} - \overline{u}_k}{s_k} \quad (i=1, 2, 3,\cdots, n;\ k=1, 2, 3,\cdots, m) \tag{4}$$

$$u''_{ik} = \frac{u'_{ik} - \min\limits_{1\le i\le n}\{u'_{ik}\}}{\max\limits_{1\le i\le n}\{u'_{ik}\} - \min\limits_{1\le i\le n}\{u'_{ik}\}} \quad (i=1, 2, 3,\cdots, n;\ k=1, 2, 3\cdots, m) \tag{5}$$

3. the fuzzy similarity matrix calculation

For the matrix above-mentioned $X = \{ X_1 ,X_2, \ldots,X_n \}$, $X_i =(x_{i1} , x_{i2},\ldots, x_{in})$, calculate the fuzzy similarity matrix $R = (r_{ij})$, $r_{ij} =\mu (X_i , X_j)$.*The* r_{ij} is called similarity coefficient. In our system , the formula (6) be used for r_{ij} calculation.

$$r_{ij} = \begin{cases} 1, i=j \\ \frac{1}{M}\sum_{k=1}^{m} x_{ik}\, y_{jk}, i \neq j \end{cases} \quad (i=1,2,3,\cdots,n;\ k=1,2,3\cdots,m) \tag{6}$$

For example, 10 online learners x_1 , x_2 , x_3 , x_4 , x_5 , x_6 , x_7 , x_8 , x_9 , x_{10}. Their characteristics are described in the *Table 6*. Assuming that the learner that currently need helps is x_{10} , need to seek a "the optimal collaborative partner " in current online learners. Here, the standard defined By : the studying style is complementary, but other characteristics are similar, and each characteristic weight in standard is 0.3, 0.1 , 0.4 , 0.2, respectively.

Table 6. Learner's characteristic

characteristic \ value \ ID	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
Character	6	8	5	5	6	6	8	8	9	3
knowledge grade	5	8	5	7	6	8	6	3	1	*6*
studying style	3	3	3	2	6	7	2	5	3	*7*
collaborative ability	*8*	*2*	*7*	*8*	*2*	*8*	*9*	*6*	*5*	*8*

Referring to the *Table 6*, we can generate the matrix *U* ∶ as shown in expression(**7**).

$$U = \begin{pmatrix} 6 & 8 & 5 & 5 & 6 & 6 & 8 & 8 & 9 & 3 \\ 5 & 8 & 5 & 7 & 6 & 8 & 6 & 3 & 1 & 6 \\ 3 & 3 & 3 & 2 & 6 & 7 & 2 & 5 & 3 & 7 \\ 8 & 2 & 7 & 8 & 2 & 8 & 9 & 6 & 5 & 8 \end{pmatrix} \tag{7}$$

For *U*, its fuzzy similarity matrix *R* is as shown in *(8)*.

4. clustering

For the matrix *R*, choose the threshold for the similarity coefficient λ. then the class A, to which the help-seeker belongs, can be attained. In our system, for the choosing of λ-*value* , we test the clustering results while assigned the different value to λ which can be also given by the expert who is experienced in professional area.

When λ=0.88 be selected, the class A=(x_1, x_3, x_4, x_7, x_{10}).

5. comparison and recommendation

For class A, the algorithm calculates the inner products M using weight vector in the standard and characteristic vector of the members in the class A except for help-seeker. The system recommends the “the optimal collaborative partner”, according to the descending order of inner product.

$$R = \begin{pmatrix} 1.00 & 0.82 & 0.90 & 0.88 & 0.82 & 0.86 & 0.88 & 0.85 & 0.85 & 0.91 \\ 0.82 & 1.00 & 0.82 & 0.82 & 0.83 & 0.82 & 0.82 & 0.82 & 0.82 & 0.82 \\ 0.90 & 0.82 & 1.00 & 0.88 & 0.82 & 0.86 & 0.88 & 0.85 & 0.85 & 0.90 \\ 0.88 & 0.82 & 0.88 & 1.00 & 0.82 & 0.86 & 0.89 & 0.85 & 0.85 & 0.88 \\ 0.82 & 0.83 & 0.82 & 0.82 & 1.00 & 0.82 & 0.82 & 0.82 & 0.82 & 0.82 \\ 0.86 & 0.82 & 0.86 & 0.82 & 0.82 & 1.00 & 0.86 & 0.85 & 0.85 & 0.86 \\ 0.88 & 0.82 & 0.88 & 0.89 & 0.82 & 0.86 & 1.00 & 0.85 & 0.85 & 0.88 \\ 0.85 & 0.82 & 0.85 & 0.85 & 0.82 & 0.85 & 0.85 & 1.00 & 0.85 & 0.85 \\ 0.85 & 0.82 & 0.85 & 0.85 & 0.82 & 0.85 & 0.85 & 0.85 & 1.00 & 0.85 \\ 0.91 & 0.82 & 0.90 & 0.88 & 0.82 & 0.86 & 0.88 & 0.85 & 0.85 & 1.00 \end{pmatrix} \quad (8)$$

For A=(x_1, x_3, x_4, x_7, x_{10}),and standard weight vector (0.3, 0.1 , 0.4 , 0.2) ,the M value can be decided, which is as shown in***(9)***.

$$M = \begin{pmatrix} 6 & 5 & 3 & 8 \\ 4 & 5 & 3 & 7 \\ 5 & 7 & 2 & 8 \\ 8 & 6 & 2 & 9 \end{pmatrix} \bullet \begin{pmatrix} 0.3 \\ 0.1 \\ 0.4 \\ 0.2 \end{pmatrix} = \begin{pmatrix} 5.1 \\ 4.2 \\ 4.6 \\ 5.6 \end{pmatrix} \quad (9)$$

According to the results calculated above, the recommendation order (“x_7, x_1,x_4, x_3”) can be estimated.

6 The Optimal Group Formation

The collaborative learning mode is adopted usually when all learners are confronted with a definite and identical studying task. But in almost all current online learning systems, the learner is randomly grouped. In order to improve the learning effectiveness, the grouping method based on the learner’s characteristics was adopted in our system.

The main idea is: according to grouping standard, “the optimal group formation” first generates a matrix that consists of the characteristics that need to be similar among the members in same group from the earner's characteristics model, then attain requested *K* groups using clustering method depend on the similar characteristics. And then pick out a learner from each group as representative and assigned the other learners one by one to the existing group according to the grouping standard of some characteristics similar and some complementary.

In our system, we calculate the group average distance d based on these similar characteristics, and calculate the group average variance σ based on these complementary characteristics. It’s obvious that the group more matches the grouping standard, if the *d* value is smaller and theσvalue is bigger. Therefore, we take the result of *d* minus $\sigma(d\text{-}\sigma)$ as grouping estimation value. The group whose $d\text{-}\sigma$ is the smallest is our desired one.

The founding process of the optimal group includes the following key steps:

1. According to grouping standard , the algorithm generates a matrix that consists of the characteristics that need to be similar in the grouping standards and are from the learner's characteristic model. The system assigns all learners into the request *K* group using Fuzzy *C* Mean *(FCM)* clustering algorithm;

2. Pick out a learner from each group as representative who should be kept in the group and others should be deleted from group. In our system, the representative may be the arbitrary member in the group.

3. Pick out a learner from learners who have not been assigned into any group, then find the group that the selected learner should be assigned to, using the data calculation and comparison. Finally assign the learner to the group that has been found.

Data calculation includes:

1) We calculate the group average distance *d* base on these characteristics which needs to be similar.

2) We calculate the group average varianceσbase on these characteristics that need to be complementary.

3) For each group, calculate *d-σ* value.

4) Finds out the group whose *d-σ* value is smallest among existing groups. It is the group that the learner should be assigned to.

4. If all learners have been assigned in a special group, then grouping is over, else return to 2.

In our system, we have adopted the *ISODATA* （iterative self-organization data analysis techniques algorithm）clustering algorithm. Its advantage is that the algorithm is clear and definite, clustering effectiveness is pretty well. However, because each iteration needs to calculate the clustering centre again, the amount of calculations is tremendous.

7 Conclusion

The WBPCLS, into which “the intelligence course recommendation”, “the optimal group formation” and “the optimal collaborative partner discovery” have been imported, support not only collaborative learning, but also personal learning. It is able to change learner's passive collaborative style into active one. It will overcome the deficiency and shortcoming of current learning systems in the organization environment and will attract more learner's participation and improve the learning effectiveness and efficiency.

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An E-Learning System Engineering Ontology Model on the Semantic Web for Integration and Communication

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Abstract. This paper investigates ontology-based approaches for representing information semantics and in E-learning system. A general E-learning system engineering (ESE) knowledge representation scheme, called an ESE ontology model, to facilitate communication and information exchange in heterogeneous E-learning systems. The proposed approach focuses on how to support the integration of heterogeneous E-learning systems, and how to complete information autonomy allowing the individual learners to keep their own information models rather than requiring them all to adopt standardized terminology. Meanwhile, a communication model Based on SOAP and ontology, is designed for heterogeneous information systems interoperable communications. A prototype interface has been developed to validate the communication model.

Keywords: Ontology, E-learning system integration, Information island, System Communication.

1 Introduction

Since the world has entered the information era, the E-learning system integration has been the hot spots in education technology research, computer science and education, e-education technology, and other cross-cutting research field. The flexible integration of the E-learning system is a new research point on the education technology file, which should improve the sharing of learning resource.

During the process of the development of learning informationization, there are many application systems that have been developed by many education sectors. Many of those systems are based on the development of functional modules, but also based on the model of development organizations. With the changing needs of learning and the continuous expansion of functions, those application systems can not effectively quick adjustments for the change. Meanwhile, the differences of the system architectures and the system resources semantic description of E-learning systems are difficult to achieve the sharing resources and systems integration. The different information systems can be integrated by E-learning Application Integration (EAI). Initially, education sectors focused their concern on the connection of the internal systems of the application, and the integration of their own subsystems. But now, more of the agencies would like to achieve the integration of Learner to

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Teacher to connect learning processes. Of course, the realization of the latter is very difficult and complicated. The core problem is difficult to achieve the communication mechanism particularly between heterogeneous systems.

Department of education issued the standards of E-learning management information [1] is to address the problem developed, and its essence is to classify the information of China's E-learning into various types, and establish an information model by the approach data dictionary, in order to achieve the certainty and consistency of the semantic of the exchanged information. Compared with this, a number of specific technical solutions are proposed by some foreign agencies in the same case for the interoperability issues of E-learning information systems, such as the E-learning wide interoperability framework (EIF, E-learning Interoperability Framework) implemented by the United States software and information industry associations in North America [2]. For addressing the issues the ISO launched ISOTC184 as the international standard of industrial automation systems and integration areas. Meanwhile, many technology vendors (such as Ariba, I2, Microsoft), some Technology Associations (such as UDDI, QAGI), and several individual industries (such as RosettaNet from the electronical industry, BoleroNet from the financial services industry, and WISe of the insurance industry) have implemented various (not compatible) standards. To sum up, the existing solutions have mainly the following two aspect deficiencies: Existing interoperability frameworks depend on special systems too much to suit heterogeneous and complex systems. Traditional methodology need to compile code for each application to achieve interoperability, based on their databases. The methodology settles existing E-learning MIS system interoperability issues, which may be an effective solution. However, development of the E-learning management information system needs realize an independent solution model to drive the communication of the complex systems. Because of the tightly required by coupling semantic of information and communication data, so traditional communication models will not accommodate the changing of a information which should directly rise a large-scale modification of the communication model.

In such circumstances, we established a heterogeneous information systems interoperable communications model following the model of the E-learning information management standards.[1] The model was implemented based on Web services technology to achieve the seamless exchange of information among autonomous management information system, E-learning management information resources databases, various units, and departments.

The rest of this paper is organized as follows. Section 2 designs the Analysis of the E-learning Integrated System; Section 3 discusses the relation of Ontology and E-learning system; Section 4, we provide the communications model of the system; Section 5 describes the methodology of data exchange; Section 5 presents a case study; Section 6 concludes the paper with perspectives.

2 Integrated E-Learning System Analysis

E-learning system architecture is shown in Figure 1. The Web layer of the E-learning platform provides a Web interface and a range of services for users. The E-learning platform is the application service layer of the topology which includes the integration of supply chain services of agent system-level unified data format and security authentication. Agent layer is composed of the different companies which are scattered in the supply chain, which have different advantaged education. After the integrating and reengineering E-learning portfolio, these originally loose heterogeneous E-learning systems show integrity to learner. Meanwhile, the integrated process is transparent to the user.

2.1 Web Layer

Web layer is composed of the Web servers distributed around and browsers of the terminal-users. The layer is the interface between the system and terminal-users. The requests of the terminal-users are sent to the browsers of Web server in the form of RDF files to the information database of logistics. The users receive inquiries in RDF file form from the Web server by RDF Parser. Those RDF files are parsed with referring to RDF Schema that is used to define parsers, and shown on the Internet.

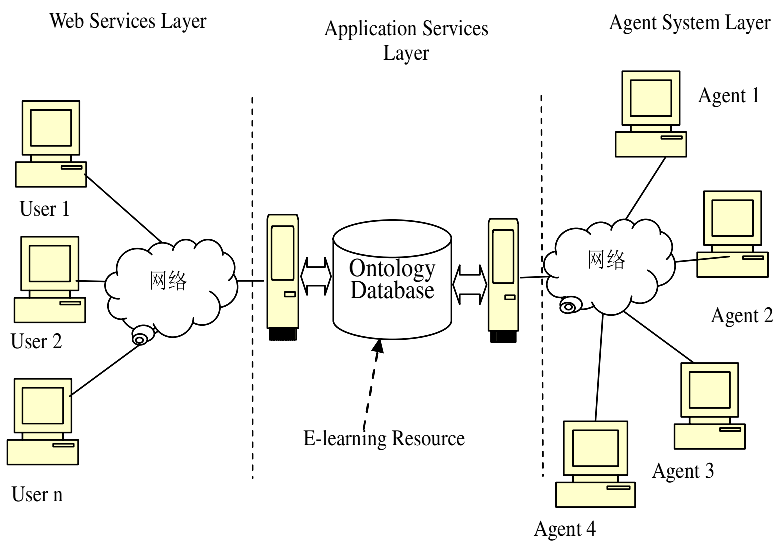

Fig. 1. Network topology for E-learning system

2.2 Application Services Layer

Application services layer receives Web service requests from Web services layer, and transmits services to the Agent system layer. Application services layer is composed of the following three parts:

1) Analysis Module: The module is responsible to receive service requests from the Web services, and searches the service Registration Information database to find the agent system which provides the service. Then the module transmits the service requests to the database server.

2) Services registration Module: The module stores the information of the specific services agent systems including their credit evaluation records. When the system adds some new services, the information of those services should be published to the registration information database through credit evaluation / service module.

3) Order Module: The module addresses the implementation of orders and transmits the results to the heterogeneous systems in a unified RDF form to the Web servers.

2.3 Agent System Layer

Agent systems layer provides a variety of logistics services. There are a lot of differences in the data forms due to the difference of the size and type of the E-learning system, collection and requirements of data. These data has still significant difference whether in the description or in storage, therefore, information center and converter should be constructed for various services agency. E-learning system converter can convert the services submitted by the services parser into a variety of operations for different services, and hand them for the order actuator to implement their services by accessing the data dictionary in the information center. Similarly, when a new agency joins the E-learning system, its service information should be transformed and stored in the information center. At the same time, its integrity and the basic conditions will be stored in the registration information database to be accessed by users online.

3 Ontology and E-Learning System

3.1 Ontology

Ontology is the study of existence of all kinds of entities (abstract and concrete) that make up the world. Ontology defines the kinds of things that exist in the application domain. Without ontology, the terms and symbols of a domain will be ill-defined and confusing [10], [11]. Ontology, therefore, is a content theory about the sorts of objects, properties of objects, and relations between objects in a specified domain [12]. It is a representation vocabulary specializing in a domain and includes terms that capture the conceptualizations of the domain elements. A conceptualization is an abstract, simplified view of the world that we wish to represent for some purpose [13]. The subject of ontology is the study of the categories of things that exist or may exist in some domain.

On the Web, the use of Ontology needs the support of language Web in order to promote interoperability and make full use of existing tools. In order to enable Web Ontology data can be widely understood and accepted, a clear set of terms must be defined on the Web in the name space so as to provided consistent understanding of the semantics for the data described by the ontology.

Ontology describes resources, but also describes services [13]. For example, Web services based on OWL ontology can be used to support Web services, through sign language to provide a core constructed set to describe the functions and attributes of Web services in a computer understandable form. OWL-S's goal is to promote the automation of Web services, including automated Web services such as synthesis and interoperability.

3.2 Semantic Ontology Mapping Model

Semantic Ontology mapping is used to describe the semantic relationships between the concepts. The semantic exchange and reservations of information between the two E-learning applications need to build a logic mapping mechanism for the similar concept in each application [14]. Therefore, semantic integration is equivalent to building a correct mapping relationship between the two E-learning systems, which provide a means of communication in the mapping implementation. Semantic Mapping is a very effective visualization technology in the E-learning process description [15]. In the paper, we designed a semantic mapping model based on goals, task, and property to describe the mapping of process and organization, the process model and the coordination, and the learning activities and related resources. The education service model is mapped to the application system model based on the concept of peer-related, partial-overall, and includes-ownership shown in Figure 2.

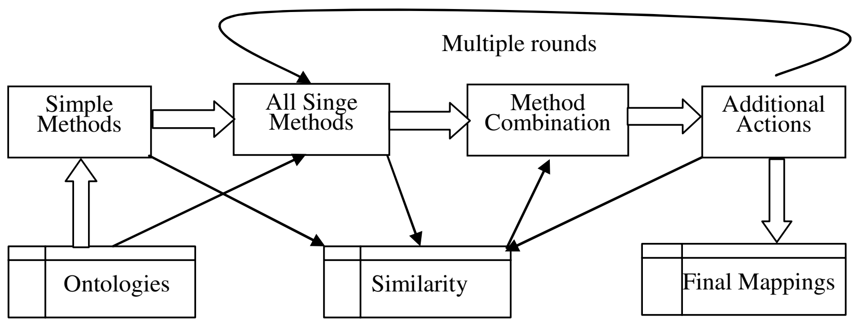

Fig. 2. Ontology mapping model

This process deals with the mapping of different data descriptions in the warehouse. For example, data source formats are usually mapped to the attributes of the staging tables.

4 Communication Module Based on SOAP and ONTOLOGY

In this module, we design a common client terminal, which can automatically generate one or more the corresponding client agent objects to access the services in the server through the URL of the ontology documents inputted by user (obtained through the above modules), or the address of the local disk location, or analytical ontology text of the ontology string directly inputted by user. The function of the module is that whatever services is provide by the server, as long as service user give out ontology documents, the model should be able to automatically generate the corresponding request to access the different services that provided by different subsystems crossed the heterogeneous systems. Meanwhile, we had done an expansion that an encryption and decryption model is embedded for the information of the server and client communication in the application layer of the model, in order

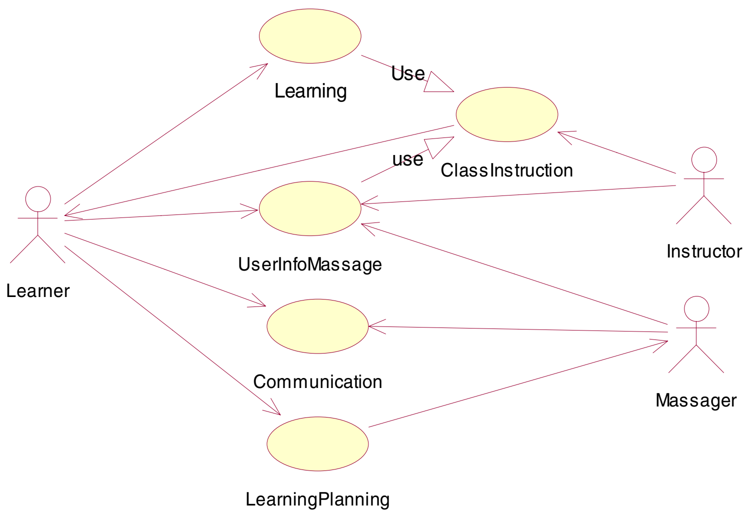

Fig. 3. A segment of use case

to ensure information security. The learners of the system own mainly operations that are learning, user information management, communication with each other and learning planning. The use case figure is shown in Fig. 3.

Meanwhile, the instructors of every course take charge of the consultations of the learners, and answer their question online. The consultations have got together to the

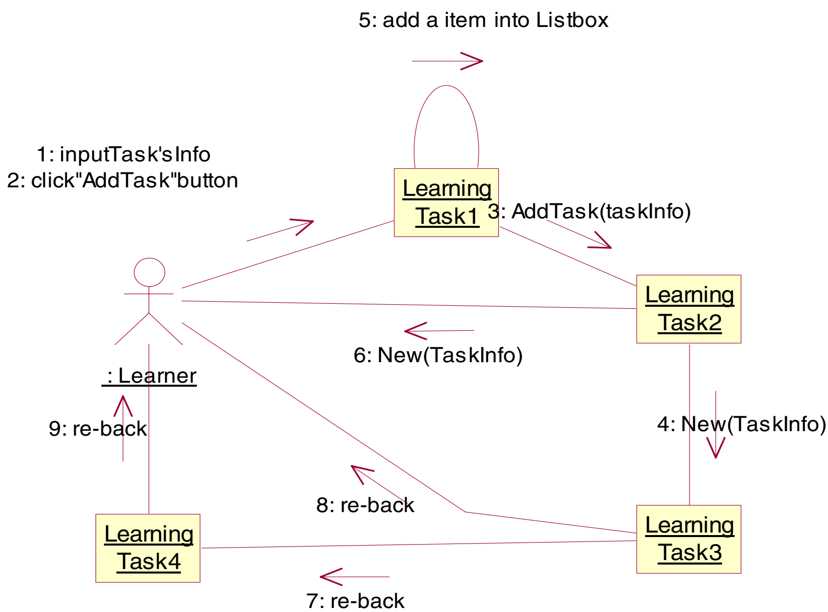

Fig. 4. Sequence diagram of learning activation

class instruction model to the course instructor. The duty of the manager is update the learning source, manage the communication personal information of learners.

In the Fig. 3, the work flow model is showed of the learning activation. After the login, the learner inputs the information of the learning task to do the first learning task, then, clicks the Add Task button to start the second learning task. If the second task is unready, the work flow re-backs to the first task.

The module is designed to dynamically generate client agents to communicate with the corresponding services in the server based on analytic ontology documents, which is the key idea of the module [16, 17]. Meanwhile, there is another one that an encryption and decryption expansion model is implemented by SOAP in application layer. Namely, sensitive information Packaged in the SOAP body is achieved encryption through the SOAP extension technology. The encrypted information is transmitted in the network. And then the decryption or other treatments are implemented respectively in the client terminal and server. The general process of the communication in the client and server is as follows.

5 A Case Study

Based on the communication model designed in above paragraphs, we implemented a program of the core issues, which includes a services discovery module, a registration module, and a communication module based on SOAP and ontology. Meanwhile, the three modules were tested and evaluated in our laboratory. The implementation of the communication model is achieved on the .NET development platform and in the C# language both provided by Microsoft. Following the design of the section 4, the paper gives out the timing plan diagram that is shown in Fig. 5.

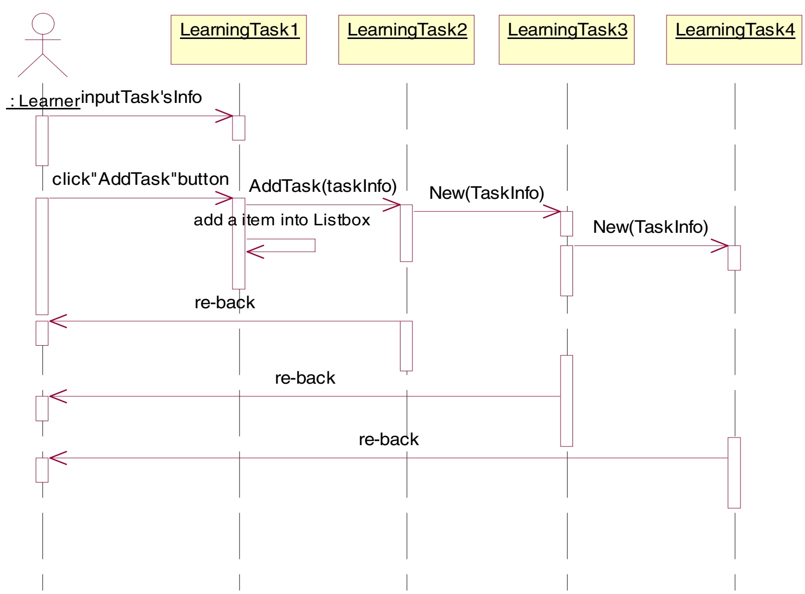

Fig. 5. Timing plan diagram of learning activation

5.1 UDDI-Based Service Discovery Module

As a complete communications model, first of all, needs for the existing Web service discovery and positioning[17], finds the corresponding ontology files, thus further analyses ontology documents, to the structure corresponding SOAP message to achieve communications. Therefore, we firstly designed the discovery service model.

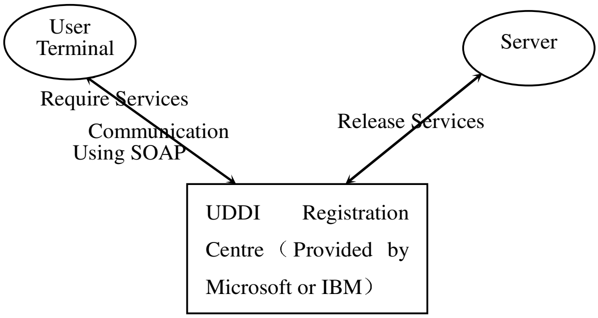

Fig. 6. Principle of service discovery model

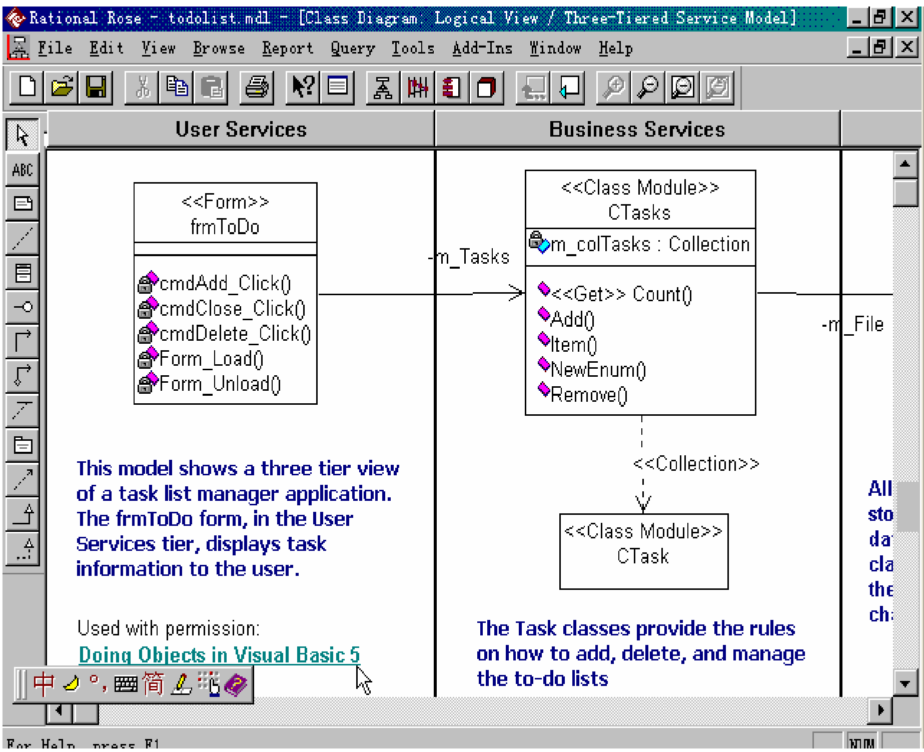

Fig. 7. Class relation of learning activation

The emphasis of the module implementation is the UDDI Specification [18]. The service discovery module queries the UDDI access points (also called UDDI SRC, provided by such as Microsoft, IBM, etc.) to get the documents based on ontology, through which DEA requests the relevant services. The module enquiries the UDDI SRC through the communication by SOAP, and receives also the SOAP message XML-Based. The principle of UDDI is shown in Fig. 6.

Fig. 7 shows the effective classes of the Learning Activation by Rational Rose from the design of timing plan diagram. Meanwhile the relationship of those classes is shown clearly in the figure. The EISP will access this Web service ontology document by the analysis of the URL, and then sent a require message based on the SOAP format to the server to get the resource.

5.2 Communications Module Based on SOAP and ONTOLOGY

This module automatically analyses the ontology document that comes from the service discovery module, gets the service provider information, and then automatically generates client agent. Users communicate with the service provider using the client agent. The advantages of the model are: expansibility and flexibility [18, 19]. Those various services located in different servers can be integrated in a unified client agent. Especially, for those which need to use several different systems in the services work together to complete the task, the module can be very conformable to resolve the problem. Meanwhile, an information encryption and decryption module is embedded into the communications module to enhance communications security.

In the Fig. 8, the server initiates the encryption expansion to encrypt the SOAP message sent by. And the circumstances of activating client decryption expansion, SOAP messages received are effective.

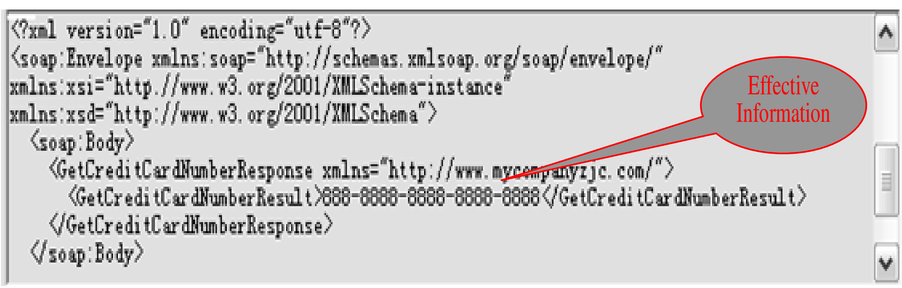

Fig. 8. Client receiving SOAP response message

6 Conclusions and Ongoing Work

The paper based on E-learning information technology standards as a solution to the interoperability information model, built an interactive communications architecture for the sharing of enterprises data resources, and designed the data interactive mechanism of the communications model. The model adopts a flexible approach to better meet the requirements of the loosely coupling between information model and the communications model. Based on UDDI, ontology, and SOAP protocols, we design and achieve the modules, and built an interoperable communication model mainstay of the heterogeneous information systems. According to the communication model design, the method effectively addresses the interoperability issues among heterogeneous information systems. Meanwhile, the core part of the model was applied into a system to test, and got satisfied results.

However, in complex systems integration applications, the capacity and speed of the model remain not to be done further study. We intend to develop new and more complex case studies in order to better evaluate the usability and usefulness of our communications model.

Acknowledgment

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A Semantic Grid Application for E-Learning Data Sharing

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Abstract. In an E-learning scenario, educational resources, such as course documents, videos, test-bases, courseware, and teacher information etc., are needed to be shared across different schools. DartGrid is a semantic grid toolkit for data integration using technologies from Semantic Web and Grid. In this paper, a Semantic Grid for E-leaning based on DartGrid is introduced, and it provides a Semantic-based distributed infrastructure for E-learning data resource sharing. We explore the essential and fundamental roles played by RDF semantics for E-learning. We also introduce a set of semantically enabled tools and grid services for E-learning such as semantic browser, ontology service, semantic query service, and semantic registration service.

1 Introduction

The Semantic Web [3] is an effort to improve the current Web by making Web resources machine-understandable by enriching current Web resources with machine-understandable semantics [5,6]. It provides a common framework that allows data to be shared and reused across applications, enterprises, and community boundaries. It is based on the Resource Description Framework (RDF), which integrates a variety of applications using XML as syntax and URIs for naming.

The Grid [1] tries to connect a wide variety of geographically distributed resources such as Personal Computers, workstations and clusters, storage systems, data sources, databases and special purpose scientific instruments and presents them as an integrated resource, and it is a technology that makes it possible for distributed computing resources to be shared, managed, coordinated, and controlled.

The Semantic Grid [4] is an Internet-centered interconnection environment that can effectively organize, share, cluster, fuse, and manage globally distributed versatile resources based on the interconnection semantics. In short, the Semantic Grid [7] vision is to achieve a high degree of easy-to-use and seamless automation in an effort to facilitate flexible collaborations and computations on a global scale. It takes advantage of machine-understandable knowledge on the Grid.

Nowadays, in an E-learning scenario, educational resources, such as course documents, videos, test-bases, courseware, and teacher information etc, are needed to be

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shared across different colleges and schools. Typically, teachers from different colleges in different districts work together for teaching. As a result of the development of modern information technology, E-learning is the primary method of building life long people education system in this knowledge economy age. E-learning gives students the freedom to study anywhere at anytime and is widely developed and deployed in our country recently. To build an E-learning environment, we often need to integrate E-learning services across distributed, heterogeneous, dynamic "virtual organizations" formed by disparate education resources within a single enterprise and/or external sharing education resource via service provider relationships. This integration can be technically challenging because it requires achieving various qualities of E-learning service while dealing with different scholastic platforms

DartGrid[1] is a data integration toolkit using technologies from semantic web and grid, and it offers a generic semantic infrastructure for building database grid applications. Roughly speaking, DartGrid is a set of semantically enabled tools and grid services such as semantic browser, semantic mapping tools, ontology service, semantic query service, semantic registration service. All that support the development of database grid applications.

In this paper, a Semantic Grid for E-leaning based on DartGrid is introduced, and it provides a semantically distributed infrastructure for E-learning scenarios as we mentioned before. We explore the essential and fundamental roles played by RDF semantics for E-learning grids, and implement a set of semantically enabled tools and grid services for E-learning resource sharing such as semantic browser, ontology service, semantic query service, and semantic registration service.

This paper is outlined as following: Section 2 introduces the architecture and the core components of a Semantic Grid for E-leaning from a technical perspective. Section 3 introduces a working scenario for the E-learning grid application. Section 4 mentions some related works. Section 5 gives the summary.

2 Technical Approach and System Architecture

2.1 Technical Approach

The system is built upon two basic technologies. Firstly, RDF is employed to define the E-Learning ontology in order to integrate heterogeneous databases. Secondly, the system takes the service-oriented architecture and uses Globus toolkit to develop the core E-learning grid services.

2.1.1 RDF

At the present, the most popular languages for data semantics are RDF framework and OWL language. OWL language is proposed in Semantic Web research area and standardize-ed by W3C organization. The Resource Description Framework (RDF) is a language for representing web information in a minimally constraining, extensible, but meaningful way.

[1] DartGrid Official Website: http://ccnt.zju.edu.cn/projects/dartgrid

The RDF structure is generic in the sense that it is based on the Directed Acyclic Graph (DAG) model. RDF is based on the idea of identifying things using Web identifiers (called Uniform Resource Identifiers, or URIs), and describing resources in terms of simple statements about the properties of resources. Each statement is a triplet consisting of a subject, a property and a property value (or object). For example, the triple ("http://example.org", ex:createdBy, "Wenya") has the meaning of "http://www.example has a creator and its value is Wenya".

RDF also provides a way to define classes of resources and properties. These classes are used to build statements that assert facts about resources. While the grammar for XML documents is defined by DTD or XSchema, RDF uses its own syntax (RDF Schema or RDFS) of writing a schema for resources. RDFS is expressive and it includes sub-class/super-class relationships as well as constraints on the statements. The generic structure of RDF makes it easier for data interoperability and evolution because different types of data can be represented using the common graph model, and it also offers greater value for data integration over disparate web sources of information. OWL is an extension of RDF/RDFS and supports more sophisticated knowledge representation and inference.

In our work, RDF is used to describe E-learning data semantics and define the E-learning ontology in order to mediate heterogeneous databases.

2.1.2 OGSA/WSRF and the Globus Toolkit

OGSA/Web Service Resource Framework focuses on service-oriented architecture for grid application. In a grid, computational resources, storage resources, networks, programs, databases, and the like are all represented as services. A service-oriented view allows us to address the need for a standard interface definition mechanism, local/remote transparency, adaptation to local OS services, and uniform service semantics.

The open source Globus Toolkit [20] is a fundamental technology for the "Grid". It enables people to share computing power, databases, and other tools securely online across corporate, institutional, and geographic boundaries without losing local autonomy. The toolkit includes software services and libraries for resource monitoring, discovery, management, security and file management.

In our work, the E-learning services conform to the OGSA/WSRF specification, and are implemented on top of Globus 4 toolkit. Globus 4 is also used as the service container for the E-learning grid application.

2.2 Layered Architecture

Fig.1. illustrates the layered architecture of E-learning Semantic Grid.

At the basic service layer, three services are implemented.

1. E-learning Database Access Service. It supports the typical remote operations on educational resource contents, such as course documents, videos, test-bases, courseware, and teacher information etc. It also includes querying an education resources, insertion an education resources, deletion an education resources, and modification an education resources.

2. E-learning Database Information Service. It supports inquiring about meta information of the educational data resources such as DBMS descriptions, privilege information, statistics information that includes CPU utilization, available storage space, active session number etc..
3. E-learning Access Control Service. This service is developed for access control in E-learning Semantic Grid. For example, it provides the service of authorizing or authenticating students to access courseware resource.

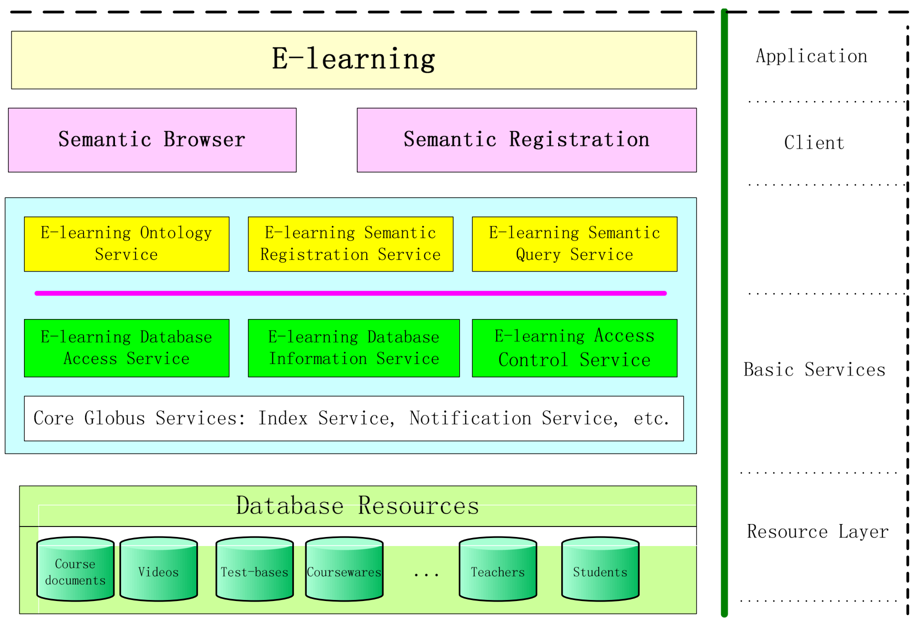

Fig. 1. Layered Architecture of E-learning Semantic Grid

The services at the semantic level are mainly designed for RDF-based relational schema mediation and semantic query processing.

1. E-learning Ontology Service. This service is used to expose the E-learning ontology which is defined by RDF/OWL language. The ontology is used to mediate heterogeneous relational databases.
2. E-learning Semantic Registration Service. It establishes the mappings from source relational schema to sharing RDF ontology. Semantic Registration Service maintains the mapping information and provides the service of registering and inquiring about this information. For example, it provides the service that enables teacher registering courseware and student inquiring about registration information of courseware.
3. E-learning Semantic Query Service. This service accepts RDF semantic queries, uses Semantic Registration Service to determine which databases are capable of providing the answer, then rewrites the RDF queries according to relational schema. Namely, the RDF queries will be ultimately converted into a set of SQL queries. The results of SQL queries will be wrapped by RDF/OWL semantics and returned as RDF triples.

3 The E-Learning Ontology

The E-Learning ontology is used not only to standardize the E-learning vocabularies, but also as a shared model to mediate heterogeneous databases. The ontology is developed by using the Protégé ontology building toolkit. As Fig 2 displays, there are two parts in the courseware ontology. One part is defined based on CELTS [18] or IMS. The other part is defined as an extended set. The core set of CELTS has 11 elements as follows: Title, Subject, Keywords, Description, Identifier, Format, Date, Language, Type, Creator and Audience. The definition and determinant of these elements see also CELTS40. The extended set involves general architecture information class (FRAME) and page information class (PAGECONTENT).

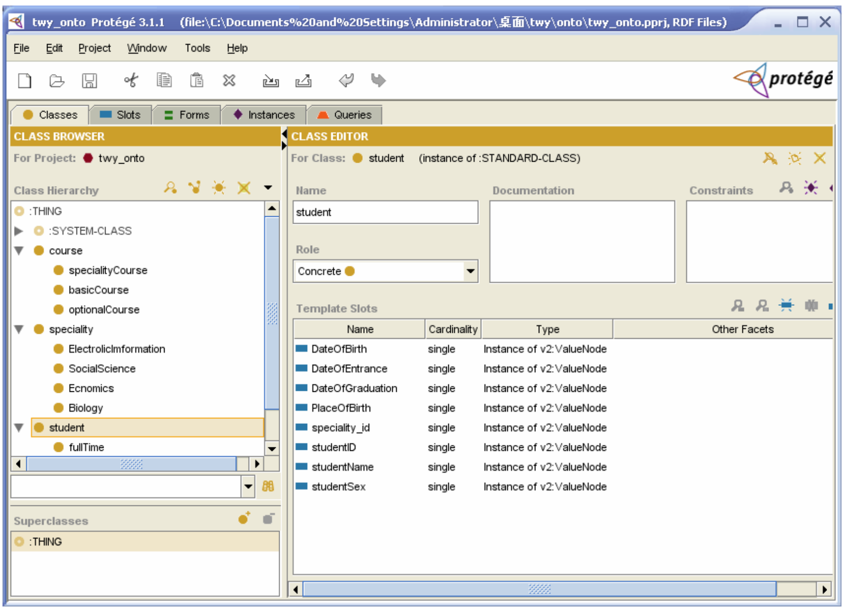

Fig. 2. E-Learning Ontology

4 Working Scenarios and Semantic Tools

4.1 Typical Use Cases of E-Learning Semantic Grid

Generally, there are two kinds of user roles in E-learning Semantic Grid, they are: Local Database Administrator (such as teachers), and Normal User (such as students). Fig.3. illustrates the relationship between these user roles and the core components of E-learning Semantic Grid.

Local Database Administrator (such as teachers). Education resources can be dynamically added into the sharing cycle of an e-learning semantic grid. E-learning Semantic Grid provides the education resource provider (such as a teacher) with a

Semantic Mapping Tool. After a database grid service is up, the teacher can use semantic mapping tool to register his database to the semantic grid. Typically, the mapping tool retrieves the E-learning ontology from ontology service, and gets the relational schema from database grid service. Then the DBA can visually map the relational schema to E-learning ontology. The following are the steps a teacher would follow in order to register a courseware to the Semantic Registration Service:

1. Obtain the local database resource schema;
2. Obtain the domain ontology on the ontology service;
3. Establish the semantic relational mapping between the local database resource schema and the sharing ontology;
4. Submit the registering information to the semantic registration service.

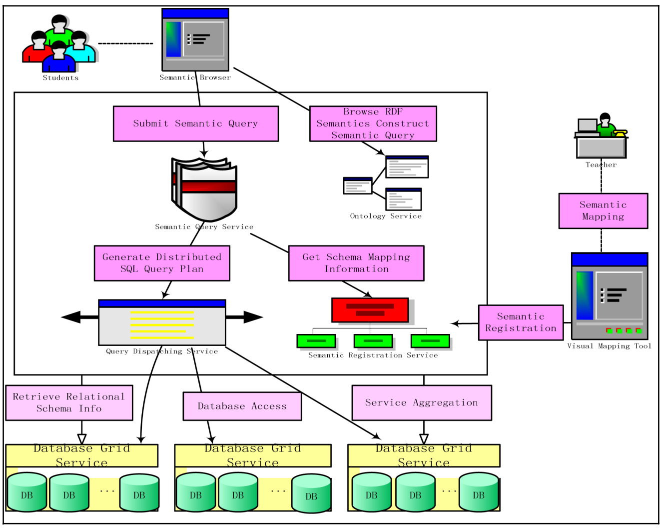

Fig. 3. Working Process of the E-learning Semantic Grid

Normal User (such as a student) for normal users, E-learning Semantic Grid offers an intelligent user interface called Semantic Browser [8]. It is a visual interface that enables the user to graphically browse the RDF/OWL semantics and visually construct a RDF semantic query. The following is the process that a student inquires about a courseware:

1. User browse the E-learning ontology by using the semantic browser;
2. User visually construct a semantic query;
3. User submit the query to a semantic query service;
4. The semantic query service accesses the Semantic Registration Service to query the workable database resource and gets the schema mapping information;
5. The semantic query service generates the distributed SQL Query plan;
6. The semantic query service gets the data information from the idiographic database;
7. Return the result to the student.

4.2 Semantic Tools for E-Learning Semantic Grid

4.2.1 Semantic Browser

E-learning Semantic Grid offers a semantic browser [8] which enables users to interactively specify a semantic query. Users can search education information in an E-learning semantic grid. Although the information comes from all nodes, it is done transparently to users. Users feel as if they are operating on the same database of the same computer. This form-like query interface is intended to facilitate users in constructing semantic queries. The query form is automatically generated according to class definitions. For example, a user wants to search courseware with subject as "Java" from E-learning Semantic Grid. Fig.4 showcases how users can step-by-step specify a semantic query to find out those needed courseware. In the first step (the left part of the Fig.4.), the user selects the *course* class, and the query form for *course* class will be generated automatically according to the property definitions of the class. In the second step, the user inputs a constraint which specifies that the name of the subject as "Java". The Semantic Browser automatically constructs the semantic query in SPARQL query language, the standard semantic query language proposed by W3C. The semantic query will be submitted to the semantic query service, and translated into a set of SQL queries to retrieve data from disparate data sources. The query result will be automatically transformed back to the RDF format.

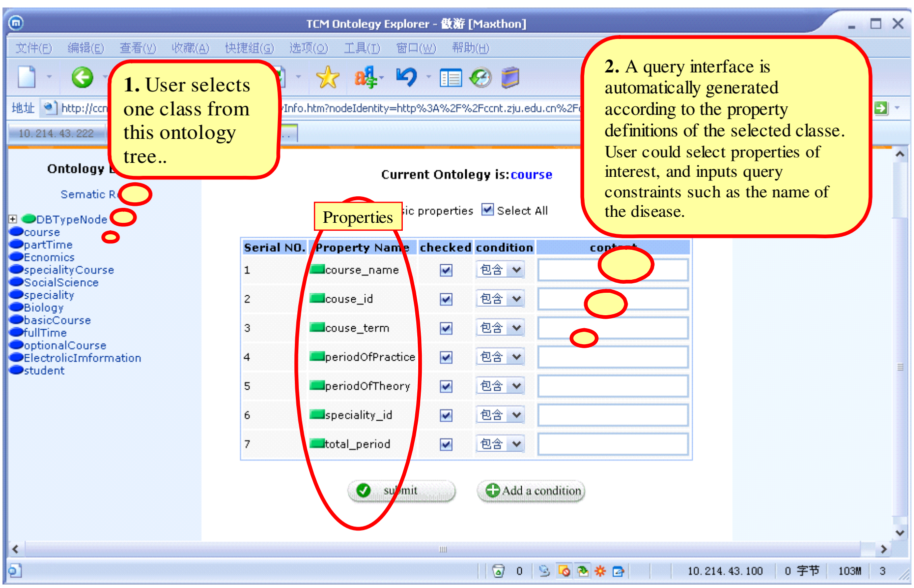

Fig. 4. E-Learning Semantic Browser

4.2.2 Semantic Registration

The task of defining semantic mapping from local relational schema to RDF ontology is burdensome and erroneous. E-learning Semantic Grid offers a visual tool to facilitate the task of defining semantic mappings. As Fig.5 displays, the user can use the database resource panel (the upper-left part of Fig.5) to view the table and column definition of the relational database, and use the ontology browsing panel (the low-left part of Fig.5) to browse the RDF ontology graphically. The user can then specify which RDF class and which RDF property one table column should be mapped onto. After finishing the mapping, the tool automatically generates a registration entry in RDF/XML format, and submits it to the semantic registration service.

For example, a teacher wants to register courseware recourses. The Semantic Registration tool directly registers courseware resources to the Semantic Registration Center. It is a semantic mapping from the local courseware resources to the sharing semantic ontology.

During the registration, mapping information is written into a semantic registry. The courseware resource content itself is not uploaded to the registration center or any other centralized node. When the user searches resources, the Semantic Registration Center will look up the result from the resource registration table. User will download and browse the corresponding resources from the data node by linking it directly. The way it works is very similar to other P2P mode.

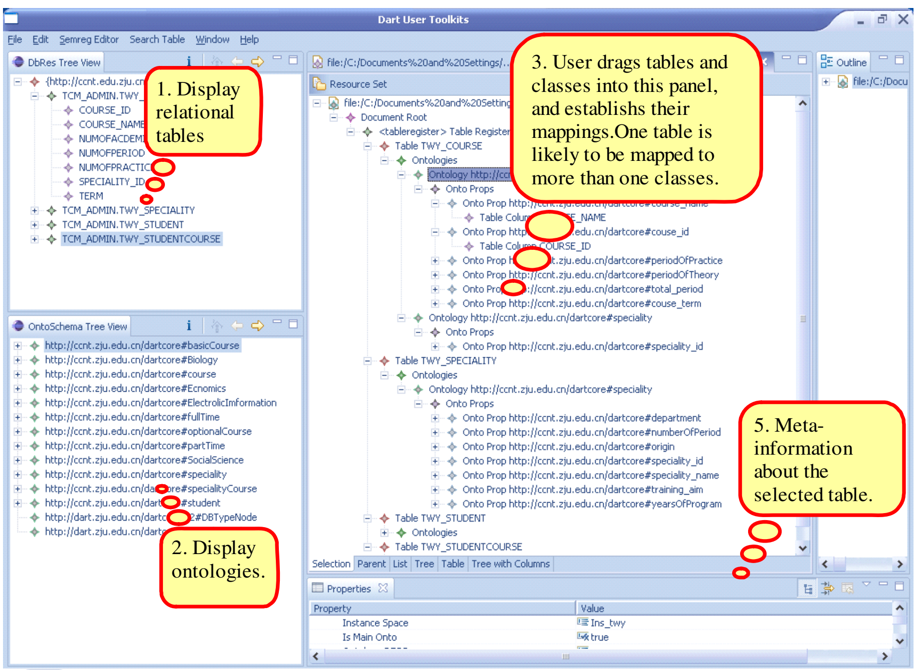

Fig. 5. Semantic Registration Tool For E-learning Semantic Grid

5 Related Work

There are a lot of relevant works. Within the domain of Grid research, there are many efforts about accessing and integrating e-learning database under the grid framework.

Typical example is Realcourse [2]. Realcourse is a successful application of distributed computing [13] technology in a geographically wide area. Different from some traditional distributed fault-tolerant services like ISIS [14], Realcourse emphasizes giving clients' access to the service with reasonable response time. For most cases, it means as much of the time as possible.

In [12], it is clear that standards like LOM, or Dublin Core are gaining importance. They provide more information on the learning material that is to be found on the web. However, their simple structure prevent them being used for modeling more complex knowledge. [10] Explains how Semantic Web technologies based on ontology can improve different aspects of the management of E-learning resources. Indeed, ontology is a way of specifying the concepts and their relationships in a particular domain of interest. Web Ontology languages, like OWL, are specially designed to facilitate the sharing of knowledge between actors [17] in a distributed environment. We wish to emphasize here that Web Ontology languages have various advantages.

The significant difference, compared with others, is the RDF-based and semantic-web-oriented approach adopted in the Semantic Grid for E-learning. The Semantic Grid for E-learning complements those efforts with a semantic infrastructure for building database grid application. And this infrastructure can provide information and knowledge services as other conventional portals. In addition, the use of multiple servers can semantically assist users in formulating their problem description, searching possible solutions on the Grid.

6 Summary and Future Work

The Semantic Grid will play a very important role for the wide acceptance of the Grid [9]. It will provide enhanced support for end users to access heterogeneous Grid services and resources by understanding their domain problems and providing solutions. We present a Semantic Grid for E-leaning based on DartGrid, and also put forward a dynamic, extensible Semantic-based distributed infrastructure for E-learning scenarios. We explore the essential and fundamental roles played by RDF semantics for E-learning resource sharing, and implement a set of semantically enabled tools and grid services for E-learning such as semantic browser, ontology service, semantic query service, and semantic registration service.

There are more works need to be done in this area. Semantic Grid for E-leaning, a DartGrid application, has many obvious attributes as a good test bed. As a typical DartGrid application by its nature, it stores various data classes that can be collected easily. Plus, the test result can be verified easily. The system needs to be further tested with more data classes and more grid nodes. More features are needed for the education resource management. In the meantime, DartGrid itself also needs to be continuously improved for perfection. Now we have a working prototype of an open education resource management system. The next step is to make it more powerful by fine-tuning its operability. As far as education is concerned, it is important to manage all education resources via the semantic grid for E-learning.

Acknowledgements

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Ontology-Based Description of Learning Object

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Abstract. With the development of information technologies many researchers and instructors are interested in the educational resources on the Web. All the resources are described as Learning Object which focuses on reusability and automation. Learning Object is a central notion of the majority of current researches to Web-based education, and many institutions devote themselves to research the standardization of learning object. After analyzing Learning Object's definition and metadata the authors emphasize that the metadata alone is not enough because it is lack of semantic and reasoning capability. Semantic Web is put forward to solve the semantic problems in current Web. Ontology is the core concept and technology in this framework. In order to reuse and share learning object better, the ontology-based description of learning object is expatiated, meanwhile this paper provides a learning object ontology with the development tool Protégé. At last a shareable model in Semantic Web is mentioned.

Keywords: Semantic Web, Ontology, Learning Object, share.

1 Introduction

It is exciting to describe and research a new technology, like the Semantic Web. It is one of the hottest research and development topics resent years. Semantic Web aims at transforming the Web we use today into a new one, which is more intelligent and more suitable for machine processing. People are hoping that the Web can understand what their real needs are. The faster, more accurate and sharable are needed. The evolvement of XML, RDF, OWL metadata and ontology is improving the World Wide Web. Ontology is considered as the key concept in the development of the Semantic Web, and it represents domain and content theories in machine-understandable form and enables Web-based knowledge processing, sharing, and reusing between applications[1].

While the Semantic Web is mentioned, AI or computer science would be involved, but are there any connections between Semantic Web and education? Of course yes! The Web-based Education (WBE) is not a fresh word at all. With the development of computer science and technology Web-based Education has been paid more attention by both instructors and IT workers. As we know, WBE has become a very important branch of educational technology. In WBE the learning content is available online, therefore organization of and access to the learning content are important issues. The learning content we mentioned above is all the materials we can get from the internet, which is Learning Object (LO) terminologically. The LO is very hot in WBE and

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many researchers focus on the description about LO. There are also many standards about learning object metadata; however, the metadata is not enough in fact. The metadata just provides some descriptions of LO's properties, it is lack of reasoning capability and reusing capability, we will discuss in detail in Part 3. In this paper, the authors pay more attention to the ontology driven description of LO. At last this paper presents the approach to build learning object ontology. The benefits of such approach are increasing the share and reuse abilities of Learning Object.

2 Learning Object

Educational content on the Web is often called Learning Object terminological today. Although the Learning Object is accepted widely, the discussion about its definition still remains. So far there isn't a generally accepted definition within the learning object community.

2.1 Definitions and Characters of Learning Object

What are learning objects? There are three prominent characterizations[2]:
"Modular digital resources, uniquely identified and meta-tagged, that can be used to support learning" (National Learning Infrastructure Initiative);
"Any digital resource that can be reused to support learning"(David A. Wiley);
"Any entity, digital or non-digital, that may be used for learning, education or training"(LTSC, IEEE Learning Technology Standards Committee).

All these definitions seem to be different formally but they describe the inherent characters of learning object.

2.1.1 Share and Reuse

All of the researches regard reusability as the core of learning object. Other characters are set to serve reusability. From the standpoint of learning object reusability, it would be advantageous for learning object to have many different uses, so that expensive multimedia content elements could be reused in as many different learning objects as possible[3].

Learning object can't be reused widely unless it can be shared. "Share" is a key-word and a core problem when we use the digital resources today. Share enables people to use the same resource at different time, in different places and for different goals.

2.1.2 Digital

The digital processing is inundante in information time. "Digital" separates the learning object from the traditional education resources. LTSC defined learning object is "digital or non-digital" entity. The point is all the resources can be managed digital.

2.1.3 Metadata-Tagged

Each learning object contents a series of description information that is metadata (like title, author, version, format, content description and instructional function). The metadata is indispensable that ensures learning object can be retrieval easily and effectively; and ensures to transport and exchange learning object between different applications.

2.1.4 Instructional and Target-Oriented

Learning object has a clear target. It generated for instruction and existed for instructional design. Each learning object should have a definite target. The target is for learners in different level to know, master and apply some learning content. After using this learning object the learner should achieve the relevant instructional target.

2.2 Learning Object Metadata

In order to describe, organize, access and reuse learning object efficiently, a lot of researchers and instructors devoted themselves to the development of learning object metadata.

Why the metadata is needed? The Learning Object is lack of integrality without metadata. Metadata provides better representation and understanding of learning content, and enables people to transform, share and reuse learning content. Learning object metadata fulfill many roles. One of them is the role of an indexing system that allows instructors and authors to find educational content easily that matches their instructional needs. A high-level structure of learning object should contain both its content and metadata.

So far several metadata standards and specifies have been developed aiming at improving the reusability. For example, IEEE Learning Object Metadata (IEEE LOM, 2002) and Dublin Core are two important standards abroad which specify a standardized set of metadata that facilitates retrieval of Web-based resources.

2.2.1 LOM

The typical metadata standard for learning object is the Learning Object Metadata (LOM) standard, defined by the IEEE Learning Technology Standards Committee. It defines fields for describing learning object in terms of their general properties (such as title, size, language and author), technical requirements (like type, format and duration), pedagogical characteristics (like context difficulty, interactivity type, etc), and so forth. LOM defines basic schema that is a hierarchy of data elements for learning objects metadata. There are nine categories *(General, Lifecycle, Meta-metadata, Technical, Educational, Rights, Relation, Annotation and Classification)* at the top level of the hierarchy in LOM[4]. For each data element, LOM specifies a name, explanation, size, example value, data type, and other key details.

2.2.2 CELTS

The CELTS[5] is a series of standards and specifications established by China E-Learning Technology Standardization Committee. They references many famous standards like IEEE LOM, DCMES, the taxonomy from GEM and EdNA, and some standards or drafts based on the education status quo in China. CELTS-42 Metadata Application Specification of Basic Education Resource. It is the main reference for our processing.

2.3 The Metadata Is Not Enough

Although the definition of learning object seems clear and the metadata is mostly specified but the metadata is not enough. The metadata just lists some of the properties about LO, thus, many questions still to be answered, such as: from the standpoint of learning object reuse, it is content reuse, how can we describe the content of LO formally? Can LO has stronger reasoning ability? How can we reuse LO in different learning context? To address these questions, we introduce an ontological methodology to describe learning object.

3 Ontology

Ontology is the core of Semantic Web technology, and in recent years the development of ontology has been moved to the desktops of domain experts. Ontology has become common on the World Wide Web, and now let's start from what ontology is.

3.1 Definitions

"Ontology" has a long history in philosophy which means the subject of existence. But this term we use here refers to "explicit formal specifications of the terms in the domain and relations among them" (Tom Gruber, 1993). Thus ontology is an explicit formal specification of the terms in the domain and relations among them [6]. Ontology defines a common vocabulary for researchers who need to share information in the domain. It includes machine-interpretable definitions of basic concepts in the domain and relations among these concepts.

In this research we use Gruber's definition and in which specification means a formal and explicit representation. In a good structural ontology all the concepts are described by formal language and this formal representation makes the ontology machine-readable. The concepts, classes and relations between them are well defined in ontology. The relations among different concepts are specifies which enable different programs to use the same knowledge.

Conceptualization is another character of ontology which refers to the abstract and simplified view of the world [1]. The "world" can be some substances or some phenomenon. In ontology's world everything is represented by abstract concept, i.e. any formally ontology is based on a certain conceptualization. Every conceptualization is based on the concepts, objects, and other entities that are assumed to exist in some area of interest and the relationships that hold among them.

Why would someone want to develop ontology? To answer this question let's list the advantages of Ontology. Ontology enables people or software to share common understanding of the information structure; enables people to reuse domain knowledge and to make domain assumptions explicit; helps people to analyze domain knowledge and separate domain knowledge from the operational knowledge [6]. It is clear that ontology is about domain knowledge and the core of ontology is sharing and reusing.

3.2 Ontology and Education

Applying ontology to education is a new research field, and researchers have developed some educational Ontologies abroad (such as OntoEdu). In the beginning of WBE people worried about that the resources are not enough so lots of digital resources are uploaded to the Internet and plenty of repositories emerge endlessly. It's not exaggerative to say that nowadays resources are abundant or inundante and any resources can be digital nearly, meanwhile the quantity is not a problem at all. But new challenges appear with the increase of resources: How to store and organize resources efficiently and how to enhance the capability of sharing and reusing? How can learners search and retrieval the resources they need as quickly and accurately as possible? How to ensure the learners can achieve the learning goal with the help of this resource?

The development of Semantic Web and Ontology brings fresh air to WBE. Ontology represents domain knowledge by defining terminology, concepts, relations, and hierarchies. They enable different education applications to share and reuse the same educational content. Furthermore, Ontology is machine-readable and it can provide semantic foundation to achieve sharing overall. It will be faster and more convenient to query and retrieval educational material with the Semantic Web services.

4 Ontology-Based Description of Learning Object

4.1 Ontology Is Necessary

The learning object metadata is specified, but it is lack of reasoning ability and the machine processing ability if using metadata only. Note that ontology is good at reasoning and machine-readable as expatiate in Part 3. The benefits of ontological representation of domain knowledge lie in its capabilities of explicitly defining concepts and their attributes and relationships. Coupled with new information technologies, such representation can be encoded in ways that allow for direct conversion into implementation models. Ontological modeling for learning objects may be divided into three broad areas: content, presentation, and application [7].

As a conceptual model, Ontology can express the basic knowledge system of a domain. Basic on the research of the necessity and feasibility to a apply ontology to Web resources, we proposed to depict the learning object semantics by ontology and implemented in the Semantic Web framework, thereby improving the learning object sharing through semantic interoperability.

4.2 Learning Object Ontology (OntoLo)

A Learning Object Ontology for basic education was created here. An effective tool is necessary to develop ontology. We investigate a variety of ontology developing tools (OilEd, OntoEdit, WebOnto, OntoSaurus and Ontolingua) and select Protégé (http://protege.stanford.edu) to establish this ontology. Then we present some formal descriptions of this ontology here.

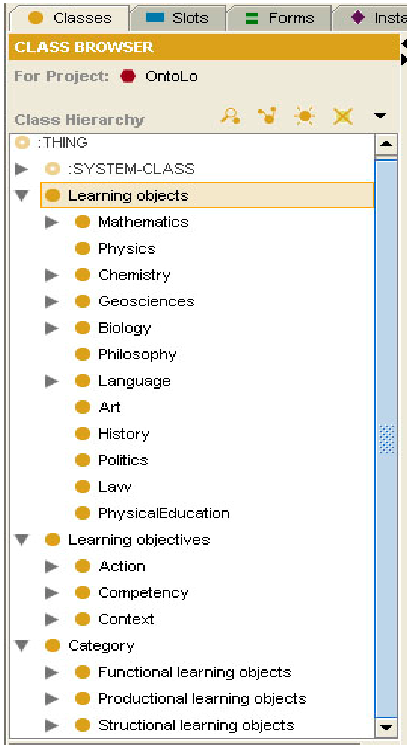

Fig. 1. A Protégé screenshot representing the class hierarchy of OntoLo

4.2.1 Classes

There are several possible approaches in developing a class hierarchy, like top-down, bottom-up and combination development processes. In this study the top-down development process is much more suitable. But the problem is the taxonomy of learning object is not uniform. David Wiley said "All learning objects have certain qualities. It is the difference in the degree to which they exhibit these qualities that makes one type of learning object different from another"[7].According to the situation of the primary education in China mainland we created three basic classed here: Class: Learning Objects, Class: Learning Objectives and Class: Categories. A Protégé screenshot represents the classes hierarchy of OntoLo show in Fig.1.

4.2.1.1 Class: Learning Objects. Learning Object is used to describe the subjects in primary education domain. Considering the expansibility all of the subclasses are defined based on the Subject Classification And Code from Ministry of Education.

4.2.1.2 Class: Learning Objectives. This class describes the different target levels of learning. Learning objectives are composed of Action, Competency and Context[7]. There are 23 sub-classes of this class in total, and we can update these objectives when needed.

*4.2.1.3 Class: Category.*The Category covers many resource types depends on the structure, application, format etc. This class is defined carefully and amply. In Category we reference the learning object hierarchy made by David Wiley and this kind of taxonomy is based on the structural qualities of learning object, show in Table 1. We also list the resource format as many as we can.

Table 1. Learning object hierarchy

Taxonomy	Explanation	Example
Fundamental	Single digital resources	a JPEG picture
Combined-closed	Combination of fundamental elements which can't be restituted	a video
Combined-open	Combination of abundant digital resources which can be acquired and restituted directly	a web
Generative-presentation	Low-level logical reasoning and structure of learning objects	a JAVA applet
Generative-instructional	Interactive logical reasoning and structure of different learning objects	an EXECUTE instructional transaction shell

4.2.2 Relationships

There are two kinds of basic relationships: As an ontology, OntoLo has all of the inherent relationships, such as Is-a, Kind-of, Instance-of etc. As an education ontology(Domain Ontology), there are some special relations as well, such as Composed-of, Target-of etc.

4.2.3 Properties

After all the classes are created we should define the properties(slots in Protégé) of classes. We set the properties by referencing the CELTS-42(Metadata Application

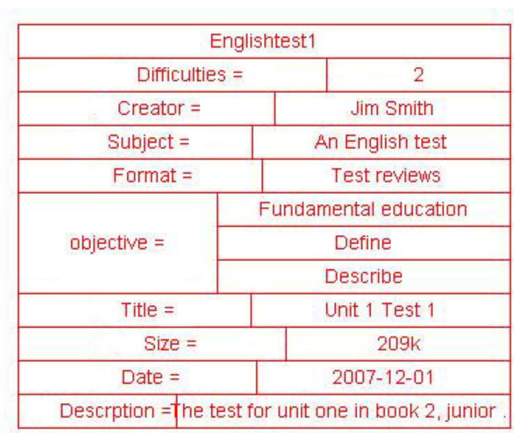

Fig. 2. An instance and part of its properties

Specification of Basic Education Resource) which is based on CELTS-3(Learning Object Metadata)and faces to the basic education in China.

One thing should be noticed is that all subclasses of a class inherit the slots of their super-class. Subclass can have properties themselves. Slots can have different facets describing the value type, allowed values, the number of the values (cardinality), and other features of the values the slot can take. For example, the value of a title slot is a string. That is, name is a slot with value type String. Part of the slots are showed in Fig.2.

4.2.4 Instances

Creating individual instances of classes in the hierarchy is the last step. For example, we create an individual instance Englishtest1 to represent a specific type of *English* (subclass of Language which is subclass of Learning Object) and fulfill the slot value and then this instance has the following slot values defined in Fig.2.

4.3 Learning Object Ontology Sharable Model

In the domain people who have different backgrounds and perspectives needed a consistent framework or specific model to organize the relative knowledge, which enable the understanding and communication between people, keep the semantic consistency and share the common understanding of the domain knowledge. Ontology provides the consistent framework and specific model rightly. The ontology-based description of learning object can support to share and reuse the resources online strongly.

The three-layer sharing model of Learning Object Ontology is proposed here by some concepts from linguistics. This sharing model can implement in Semantic Web framework. In the first-layer, languages base on XML syntax can transform from each other. In the Semantic layer, metadata and ontology provide sufficient descriptions of resources, and metadata interoperability and ontology mapping are supporting. At last the "share" will be meaningless without educational context. The Web-based education environment and Semantic Web supported are the context layer of this sharable model.

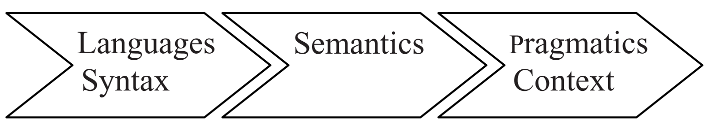

Fig. 3. Learning Object Ontology Sharable Model

5 Conclusion and Further Research

The central idea of learning object is not its form, but it is share and reuse. Learning object enables and facilitates reuse of educational content online. It can be combined with other learning objects for different learning purposes. Ontology-based description of learning object can strengthen the reusability. During this research we are also interested in the learning context and instructional design theory. The reusability of learning objects and their ultimate efficacy is linked to the issue of contextualization [8]. All above is just a rough depiction, too many works had to do and this learning object ontology is under improving. Based this learning object ontology we can enjoy many benefits: the sharing common understanding of the information structure in domain; enabling reuse of domain knowledge and making explicit domain assumptions. Thus in further research we are going to research Ontology-based relationship between learning object and learning design.

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Studies on Human Computer Interface Design of Chinese Mobile Phone Users

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Abstract. In present paper, we briefly presented a series researches from our lab which investigated font size, different pairings of font and background color on Chinese users' ability to effectively read messages and navigate a Chinese mobile phone interface. The findings of the studies from our lab may generalize from mobile phone message reading and menu operation to other circumstances where there is a small screen interface, such as mobile web interfaces, palmtop computers, and electronic dictionaries and other mobile e-learning devices. The results had significant implications on interface design of mobile small screen devices and mobile e-learning devices.

Keywords: Chinese Mobile Phone Interface, Mobile Small Screen Device, Mobile E-Learning Device.

1 Introduction

Rapid growth in computer and communication technology has prompted the development of human-computer interfaces and communication equipment for diverse mediums ranging from desktop computers to mobile communication tools. In China, mobile communication tools, such as cell phones, are widely used. For example, China had 140 million cell-phone users in 2001 (McMillan, 2001)[1], over 300 million in 2004 (Dan, 2004)[2]. According to recent reports internally (Ministry of Information Industry of the People's Republic of China for 2006)[3] and externally (Ministry of Foreign Affairs of Denmark, 2007)[4], China ranks first in mobile phone ownership. This ranking takes into account over 460 million users and the number is expected to increase to 520 million by the end of 2007, and China remains the current largest cell-phone market in the world. The research studies reported here concern features of the cell phone interface that have implications for effective navigation among Chinese users. This work is necessitated as available research on mobile

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communication tool interfaces to examine how to best present Chinese content on a small screen.

The design of efficient screen presentation is an interesting challenge. Generally, the size of the cell phone screen is 3 cm x 3 cm, which is much smaller than that of a computer screen. Just from the angle of information presentation, the small screen results in small output graphs, fonts, and few words, that may impair the coherence and comprehension of the message and impose cognitive load on the user (Brewster & Murray, 2000)[5]. Cell phones, moreover, do not allow for whole page or whole line scrolling as allowed in larger screen devices.

Kim and Albers (2003)[6] investigated factors influencing the reading efficiency of a table displayed on a small screen and found that too many words in one line impaired users' ability to search for information. Findings by Sandfeld and Jensen's (2005)[7] indicated that decreasing letter and target size impaired task performance; that is, participants did worse with small targets than they did with large ones in the same task. However, research by Chen and Chien (2005)[8] indicated that font and font size had no effect on reading efficiency. They found that how the information was displayed and the speed in which it was displayed affected comprehension of a given message.

However, not all researches indicated that presentation on small screens impaired reading efficiency. For example, Dillon, Richardson, and McKnight (1990) [9]found that although fewer lines of words could be displayed on a small screen as opposed to a larger one, no significant differences in reading and understanding effects of information were found. Laarni (2002)[10] contrasted three kinds of small screen palmtop mobile devices, PDA, email devices and mobile phones, and found that on a 3 cm × 3 cm size screen, reading efficiency was not impaired when 15 letters were displayed on one line, and that the efficiency was improved when the information was scrolled gradually as compared to when a whole page was scrolled at once. Melchior (2001)[11] showed that use of a *wiping* design (wiping alludes to the action of a windscreen wiper), whereby content to be scrolled off a screen was dimmed, helped users maintain the context of content presented on a small screen. Shieh, Hsu, and Liu (2005) [12] also found that a pre-guiding presentation style combined with space between words helped promoting reading efficiency and speed of content on a small screen.

Another factor linked to the ease of reading text on a small screen is the color of the font and the background (Wang, Chen, & Chen, 2002)[13]. Research in our lab (Zhang et al., 2004)[14] found that comparable small font size on text and icons and green fonts presented on bright blue background enhanced efficiency in reading among Chinese users.

Clearly, the design of a cell phone's interface must allow for multi-tasking and easy operation (Dong, Wang, & Dai, 1999; Duchamp, 1991)[15]. This issue looms larger as the functions of cell phones have expanded to include surfing the internet and sending and receiving emails. Thus, interfaces should be designed to maximize the users' ability to control it, to minimize the user's cognitive load, and to maintain the consistency of the interface (Chen, 2001)[16]. Three interface design types also need to be considered: framework, interaction, and visual elements which, as relevant to the research reported below, include color, font, and page format.

We briefly present below researches from our lab investigating font size and different pairings of font and background color on Chinese users' ability to effectively read messages and navigate a cell phone interface. The studies presented here were based on mobile phones with Chinese interface, and these studies were more relevant with the mobile phone communication and other functions as message sending, web exploring and learning functions. However, these studies also had significant implications on the other mobile devices designing, and the mobile e-learning devices such the Pocket or Palm PC, e-dictionary and the other learning device designed for the primary and middle school students. We do hope these researches could lead further studies in the mobile interface and help the mobile e-learning device designing, so make the e-learning interface to be operated more efficient and freely.

2 The Effects of Background and Font Color on Chinese Text Presentation

This present study was intended to research color matching of font and background, which was more important for the cognitive science researchers interested in HCI and the media interface designers, as high efficient font and background color matching can improve user operating efficiency, and reduce optical fatigue (Fang, 1998; Fang, Wu, & Ma, 1998)[17,18].

When designing visual computer interfaces, most designers select their matching colors according to their subjective sense or experience, without specific theoretical or experimental and practical support. The theory of optics can provide some theoretical support for color matching of the interface. The interface designers can work on the principle of maximizing the difference in brightness between the background color and two or more dominant fonts (Zheng, 2000)[19]. Some other study (Xu et al., 1997a,1997b)[20,21] also did the further experiment by the subjective colors rating in the user interfaces, and the studies by Hua, Gong, & Zhao (2001)[22] showed that color matching for cathode ray tube (CRT) displayer could be generalized to liquid crystal displayer (LCD). In order to design an efficient interface using high efficient color matching, the researchers should do some further studies on human color vision and personal preferences to support the user interface design. The following was our study on font and background color matching. In this study, the RGB color function, its color parameters of background and font color matching were shown in Table.1.

In this study, computer was used extensively for reading text, and high efficient color matching might be expected to enhance reading comprehension speed. Rapid serial vision presentation (RSVP) was used in the study, which was a method of displaying letters, words or pictures one after another in a specific visual field. Xu and Zhu (1997a; 1997b)[20,21] used this method with a fixed-rate moving windows to study the key factors which influenced Chinese text reading comprehension. Shen, Chen, and Tao (2001)[23] studied the effects of scrolling, leading (in which the text scrolls from right to left on a single line) and RSVP on reading comprehension. These studies were, more concerned with the issues of presenting Chinese text, however, they did little studies on font and background color matching, which the present study have done and reported.

Table 1. The background and font color matching and its RGB parameters

Background color	Font color				
Black	White	Red	Gray	Deep green	Purple
0, 0, 0	255, 255, 255	255, 0, 0	128, 128, 128	0, 128, 0	128, 0, 255
White	Black	Red	Gray	Deep green	Deep blue
255, 255, 255	0, 0, 0	255, 0, 0	128, 128, 128	0, 128, 0	0, 0, 255
Blue	White	Red	Yellow	Deep green	purple
0, 0, 66	255, 255, 255	255, 0, 0	255, 255, 0	0, 128, 0	128, 0, 255

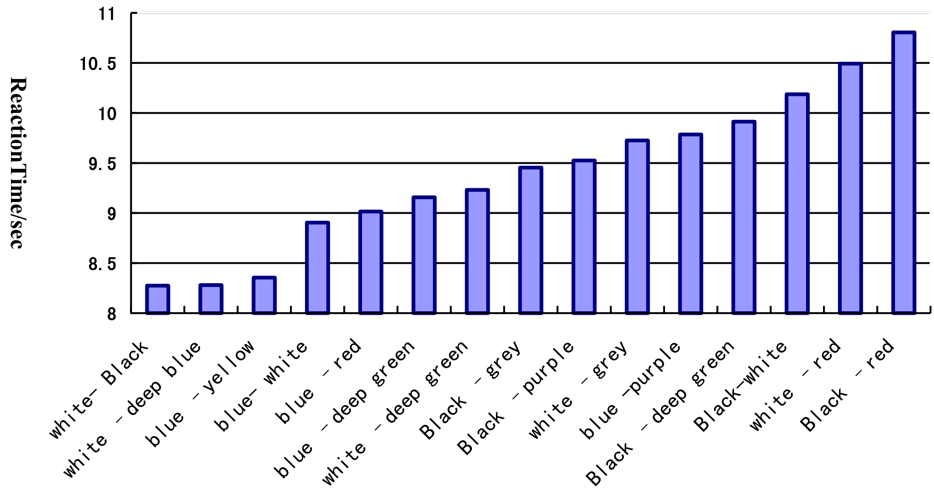

Fig. 1. Average reading time (sec, second) for different color matching pairs

This study was designed to measure the effect of font and background color matching on the participants' reading efficiency (the indictor was reading reaction time), subjective sense of fatigue, and their personal preference for color matching. A moving window paradigm was used. Participants were required to send short messages. The reading time for the fifteen font and background color matching was shown in Fig.1.

According to the results, reading time was shortest with a black font on a white background, and longest with a red font on a black background. The background-font color pairings white-black, white-deep blue, blue-yellow, blue-white and white-deep green had shorter reading reaction time than black-white, white-red, black-deep green and black-purple. Based on these findings and participants' reports of optical fatigue, we can use the result of fig.2. to design the user interface, which the best choice of font and background were white-black, white-deep blue, blue yellow and blue white, avoiding to use black-deep green, black-white, white-red and black-red.

3 Message Reading Efficiency on Color Screen Mobile Phones

As LCD technology has developed, color screen mobile phones are increasingly preferred by users, and are gradually replacing black-and-white mobile phones. Like their black-and-white counterparts, color screen phones use whole-page or whole-line scrolling. One question concerns whether the scrolling style (whole-page, scrolling by line, or scrolling up and down) and screen background (whether there was a background picture) affects reading speed and comprehension.

For this study, we used a software Nokia mobile phone simulator with fixed brightness and contrast ration, and a standard mobile phone keyboard, display and operating system. The simulator's display was 100 pixels wide and 90 pixels high, the illumination level was 130 lux, and there was 30-50 cm between the participants and the display.

Participants were required to read 48 messages of different themes, and then answer 3 multiple choice questions, each with 3 possible answers. Each message was about 50 Chinese characters long. There were 3 reading styles (one-page-at-a-time, one-line-at-a-time, and constant scrolling) and 2 background styles (background with or without picture). Accuracy was measured by the number of correct responses to questions. For the sample presented, the mean accuracy was 89%, and each message was read in less than 60 seconds. The variable of interest was the reading time.

Across background conditions (picture or no picture), there was a significant effect of reading style as the one-page-at-a-time style resulted in significant reduction in reading time than one-line-at-a-time or constant scrolling, in accordance with Laarni's conclusions (2002,2004)[10,24].

Across reading styles, there was a significant difference between the picture and non-picture background conditions. The presence of the picture reduced reading time in the one-line-at-a-time reading style, and increased it in the one-page-at-a-time style. No significant differences were found involving the constant scrolling style.

It was clear that in the one-line-at-a-time reading style, reading speed is enhanced by the presentation of a background picture. The main reason for this finding is likely that the picture supplies background and spatial cues, making it easier for users to focus their attention on reading the messages, particularly when the content of those messages are presented one-line-at-a-time. In the constant scrolling reading style, there was no significant difference between picture and no picture background. In this reading style, the user has to control the movement of the message by repeatedly pressing a key, and users may get lost, resulting in decreased reading efficiency.

In the one-page-at-a-time reading style, reading efficiency was better when there was no background picture. In this style, the users scroll fewer pages and switch lines less frequently, and therefore was not probable to get lost where they were reading. Since there was no message movement, the background picture might interfere with the way the message was perceived. Although the picture was the same, participants might have treated it as a new stimulus, taxing their working memory and thereby demonstrated weaker reading efficiency.

In situations when there was no background picture, there was no significant difference between the reading speed in the one-line-at-a-time and constant scrolling reading styles; however, message reading in the two styles were both significantly less efficient than that in the one-page-at-a-time reading style. The main reason for the similarity of the first two styles is the similar operation, frequent line breaks, and lack of spatial cues, with constant refocusing of attention on the relevant part of the message (Melchior, 2001). In fact, some correlative work on eye movement (Piolat, 1997; Baccino & Pynte, 1994)[25,26] has shown that spatial cues do in fact, contribute to better reading efficiency. However, because participants were unable to forecast successive parts of the message in both reading styles, and may have got lost (Melchior, 2001)[11], a reduction in reading efficiency was found as compared to the reading style of one-page-at-a-time. When there was a background, the one-line-at-a-time and constant scrolling styles yielded significantly better reading efficiency than the one-page-at-a-time reading style.

4 Menu Style of the Mobile Phone Interface on Operation Efficiency

In a well-designed menu pattern, the process of operation should be identical to that of human cognition so as to make the information exchange fluently (Lee, Whalen, McEwen & La-tremouille,1984)[27]. In the perspective of psychology, excellent user interface (UI) should follow the principle that "the operation should be identical to human behavior habits and cognition" (Liu & Shen,2000; Melchior, 2001) [28]. For instance, the process of visual search is an important part of menu selection, which includes two possibilities: parallel or serial selection.

The present study considered three most common UI design patters (matrix pattern, tree pattern and page-to-page pattern). It was commonly considered that matrix pattern was the most convenient design because it contains two dimensions whereas the other two patterns contain only one. However, two-dimensioned menu will take more space of the display, especially when the options are of big number. Some researchers (Hopkins et al.) suggested categorizing the menu options against the logic, but their suggestion had not been justified (Shieh, Hsu, & Liu, 2005; Zhang, et al.; 2004; Zhang, et al., 2006)[12,14,29]. The present study was not only a complement to the Hopkins' theory, but also an experimental study to give support to his theory. Moreover, research by Zhang et al. (2004) on the ergonomics of the menu-display effects of the mobile UI suggested that there was no significant difference between the users' responses to the size of the icons and the size of the characters in all levels. Based on related researches (Laarni, 2002; Melchior, 2001; Shieh, Hsu, & Liu, 2005; Laarni, Simola, Kojo, & Risto, 2004; Zhang, et al., 2006)[10,11,24,29] and some other studies[20,31,32], the present study on the UI operation tended to investigate the following questions: (1) the effect of the menu-display patterns on the efficiency of the operation; (2) the effect of the logical categorization of function options on the efficiency of the operation (totally logical categorization and non- totally logical categorization); (3) user's preference to the menu designing patterns.

The result of the operating efficiency between different patterns was significant: the matrix pattern condition yielded the best efficiency, then the tree pattern, and the page-to-page pattern yielded the worst, which was in the accordance to the hypothesis. The reason why the matrix pattern yielded the best efficiency was that the distance between options was shorter than that of linear menu, and the users could switch from one option to another more easily. Furthermore, the operation of matrix pattern depended on navigation by cognition not by memory and therefore the users would not get lost. The reversibility in operation was one of the reasons, too. Besides, the matrix pattern had a larger capacity for information so that the users could get more information without scrolling pages.

The results showed that the operating efficiency was better in totally logical categorization. The reason was probably that the totally logical categorization could save the users cognitive load in their operation process than non- totally logical categorization. Moreover, the operating efficiency of deeper and narrower menus was better than that of shallower and broader ones. Therefore, the designers should pay more attention on the depth and breadth when designing mobile phone menus.

Generally, users preferred menu patterns in which the RT was shorter to those in which the RT was longer, and it was the case for the logical categorization. The results gave further evidence that the matrix pattern and totally logical categorization could help users to operate the phones more effectively, which provided suggestions to designers on how to design small interfaces with efficiency, individualization and powerful functions.

5 Conclusion

Collectively, the series studies reported in present paper were generally based on the mobile phone interface, and the main questions we concerned were the operating efficiency of the simulated mobile phone and the efficiency of message reading in different font and background based on the computer interface. These studies have important implications on interface design of the mobile e-learning devices, the findings of the studies from our lab may generalize from mobile phone message reading to other circumstances where there is a small screen interface, such as mobile web interfaces, the PAD mobile phone, pocket or palm PC, GPS device, electronic dictionaries and other mobile e-learning devices designed for the primary and middle school students.

With the advent of increasing forms of technology incorporating small screen interfaces both in China and other countries of the world, consideration of how best to design these interfaces will remain an issue. We will do some further studies on this topic, collect more data to support the mobile e-learning devices interface design and help the designer produce more efficient operating interface for the more and more e-based learners.

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A Flow-Oriented Visual Language for Learning Designs

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Abstract. Educational Modeling Languages (EMLs) are notations that allow instructors to describe teaching and learning interactions and activities in a formal way. This description of a specific teaching process is called a Unit of Learning (UoL). The main advantage of UoLs described using EMLs is that they can be automatically orchestrated using an interpreter that coordinates all the activities defined in the UoL. The advantages of this approach in terms of scalability and interoperability are great but, in practice, its application is being hindered by different problems such as the technical skills required to use these languages and the difficulty of understanding preexisting UoLs. In order to allow the widespread adoption of EMLs, it is necessary to reduce steep learning curves that prevent instructors from using them. In this work we present the graphical notation used in the e-LD approach, a methodology which promotes the adoption of EMLs simplifying the authoring process of new and preexisting UoLs.

Keywords: Educational Modeling Languages, Learning Design, Graphical authoring.

1 Introduction

For the last few years, e-learning has been a very active research field with real application in industry and educational institutions. Even though e-learning has been successful in many cases, a number of limitations have been identified and have attracted criticism. One of the key issues identified is that e-learning environments are too focused on learning content to be consumed by the learners. However, an effective learning process requires more than simply being exposed to content. It should also include other activities such as completing exercises, preparing essays, discussing topics, assessing progress, etc. These activities reinforce the knowledge contained in the content. Usually, when teachers or domain experts design a course, they decide which content should be included, which activities should be performed and in which order these activities should happen to achieve effective learning. In other words, teachers must design a teaching method.

The definitions of these teaching methods, referred to hereafter as *learning designs*, include the goals and scope of the course, methods for evaluation, and different course modules (e.g. contents). An explicitly written learning design can be used for different purposes. For example it may be validated by a quality department before

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the course is deployed, or it may be reviewed by students before enrollment. Traditionally, this documentation task is performed by creating descriptive documents using natural language. Nevertheless, learning designs can be formally described using suitable Educational Modeling Languages (EMLs). Currently the most widely-extended formal EML is IMS Learning Design (IMS LD) [5,6].

From a pedagogical perspective, an EML is a notation that teachers or instructors can use to formalize the learning designs that they have in mind. The formal approach, as opposed to using natural language, allows the automatic processing of these designs by a computer system. From a technical perspective, the EML can also be seen as a scripting language for Learning Management Systems (LMSs) that allows the configuration of the learning experiences on these systems. But contrary to traditional programming languages created for technical staff, the intended target audience of EMLs are teachers and instructors.

However, the application of EMLs is not devoid of problems. A formal EML should be carefully designed in order to provide a balance between the expressivity features related to its machine processing capabilities and the high level abstraction to simplify its application by humans. IMS LD, for example, is a powerful EML but its use in practice is being hindered by different problems such as its large expressiveness and the technical skills needed for its application, which are far beyond the reach of most real users without mature user-friendly supporting tools.

To address this complexity-expressiveness balance, our approach is to make a conceptual distinction between two kinds of EMLs: *exchange EMLs* and *authoring EMLs*. Exchange EMLs have a large expressiveness and include low level characteristics that are not very relevant for the instructor. They are closer to the machine level, effectively becoming a low-level abstraction tool for e-learning applications, allowing the customization of any compliant e-learning platform to suit specific needs. In this sense, IMS LD should be classified as an exchange EML. On the other hand, authoring EMLs have a more restricted expressiveness but are closer to instructors' needs and ways of thinking. Because authoring EMLs are specifically adapted to instructors' expertise, authoring and repurposing tasks are far more affordable for non-technical instructors.

Our approach, called e-LD, proposes a collaborative process model for the domain-specific EML authoring design. This process involves not only instructors but experts in computer science who provide support to instructors during the authoring process as well.

In our opinion, in order to facilitate the use of EMLs by teachers and instructors, it is necessary to provide graphical abstractions, which are more user-friendly than the terse XML syntax usually provided in EML specifications. These abstractions are closer to the needs of the user, and then can be translated to the more machine-friendly notations of exchange EMLs via importation/exportation processes. In this paper we describe the visual language used in our e-LD approach. The notation includes concepts closely related to IMS LD, which is our target exchange EML. However, it is simple-enough to be useful for instructors, allowing them to produce and maintain their learning designs.

The rest of this paper is organized as follows. Section 2 introduces the graphical notations used in the diagrams created during the authoring process. Section 3 describes a use case of the e-LD approach and particularly of the visual notation. Finally, we provide some conclusions and outline some lines of future work.

2 Graphical Notations for UoL Authoring

The use of graphical notations to provide a visual syntax for modeling languages has been tested and put into practice in many different domains. Some examples include databases with Entity-Relationship models for defining database schemas [13], software engineering with Unified Modeling Language (UML) for describing software systems [3], and business application with Business Process Management Notation (BPMN) for describing business processes [1].

These graphical notations have been developed to simplify the cognitive load when working with complex semantic models. They provide a simpler notation that can be more clearly understood by a wide range of users, from technical to non-technical staff. Following this trend, we propose the use of graphical notations for the design of UoLs [8]. These notations include:

- A notation for *Learning objectives*. This notation allows an instructor to define which goals (learning objectives) will be covered in the UoL. For this purpose the instructor can define a high level goal that will be the overall objective and later on refine this objective into sub-objectives that will be achieved in the different parts of the UoL. Also, with this type of notation, it is possible to define the actors involved in reaching these goals (e.g. student, teacher).
- A notation for *defining activities*. This notation contemplates the definition of the different activities to be performed during the execution of the UoL. Using this notation, instructors analyze which activities are needed to reach the learning objectives. Then they design activities describing what is to be done and which tools (chat, dossier, laboratory tool, etc.) should be used. These activities will also include the instructions and the resources (learning contents and tools) needed to perform them. Activities can be classified into simple and structured ones. Simple activities are typically performed by students with or without the help of an instructor. Structured activities aggregate simple activities adding an implicit runtime behavior. As structured activities can be very large and complex the notation introduces hierarchical abstraction facilities.
- A notation for *sequencing activities*. By using this notation, instructors make explicit the learning flow through the different activities that comprises the UoL. In addition, the notation allows the roles to be involved in the activities to be defined. Sequencing definitions can be a simple ordering of activities applied to all participants, or can be a personalized definition of the learning flow based on the performance of a particular participant during the execution of the UoL. The definition itself can be verbose. Therefore, the notation also introduces hierarchical decomposition mechanisms. This decomposition involves at least two levels: the first one defines the overall structure (course modules) and the second provides a precise definition of the sequencing of these different parts.

All these notations coexist in a unified, flow-oriented, view of the learning design, which integrates all the aspects of this design. This single unified view avoids unnecessary cross-references between information elements which are usually used only in one place. This feature, together with a carefully designed visual aspect, should increase the usability of the notations with respect to more exchange-oriented ones (such as IMS LD). The following subsections go inside the different notations which constitute the unified flow-oriented view.

2.1 Notation for Describing Learning Objectives

The notation for describing Learning Objectives is a diagram that allows the definition of the learning objectives to be covered in the UoL. In addition, this notation can include the definition of which role will be involved during the achievement of the learning objectives. Each learning objective definition includes a verbose textual description which can be attached to the graphical representation.

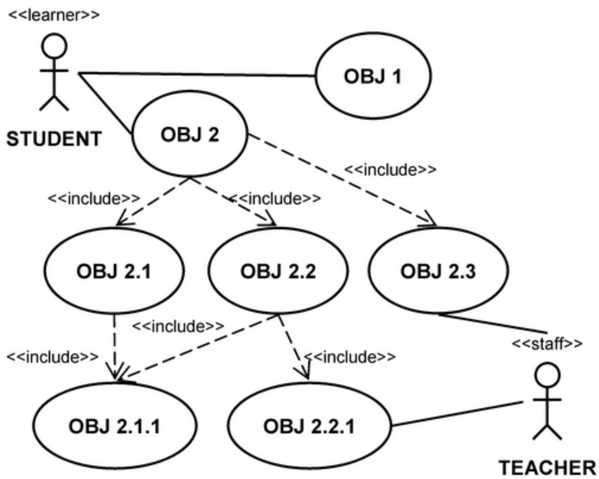


Fig. 1. Example of a learning objectives definition with role association

Fig. 1 shows an example of this notation. This example contains two objectives *OBJ 1* and *OBJ2* represented with ellipses. In addition, *OBJ 2* is subdivided into a graph of sub-objectives using a dashed arrow. In the figure two roles have been defined: *STUDENT* (a learner role) and *TEACHER* (a staff role) represented as stickmen. These roles are associated to learning objectives using lines between the stickman and the objective. It should be pointed out that the association between actors and objectives is inherited by sub-objectives, which means that the role associated to the main objective also participates in the achievement of the sub-objectives. In our example, the *TEACHER* role is only involved in the achievement of *OBJ 2.3* and *OBJ 2.2.1* learning objectives, while the *STUDENT* role is involved in *OBJ 1*, *OBJ 2* and in all the sub-objectives of *OBJ 2* (i.e. *OBJ 2.1*, *OBJ 2.2*, *OBJ 2.1.1* and *OBJ 2.2.1*). Note that it is also possible to design learning objectives for different learner roles because the notation for learning objectives is not restricted to only one learner role per diagram.

2.2 Notation for Defining Activities

Fig. 2 depicts the graphical notation used in defining activities. Using a terminology borrowed from IMS LD, the notation introduces two kinds of activities: simple and structured:

- Simple activities include *learning activities* (Fig. 2a) which are typically performed by students and *support activities* (Fig. 2b) which are performed by students too, but with the help of a supporting role, usually an instructor.
- Structured activities allow instructors to aggregate simple activities adding an implicit runtime behavior. With these activities there are two possibilities: performance in sequence or allowing the actor to choose the order of performance. According to these possibilities, there are two different graphical notations for activity structures: Fig. 2 (c) shows the appearance of a structured activity with a *sequencing* runtime behavior and Fig. 2 (d) shows the appearance of a structured activity with a *random selection* behavior.

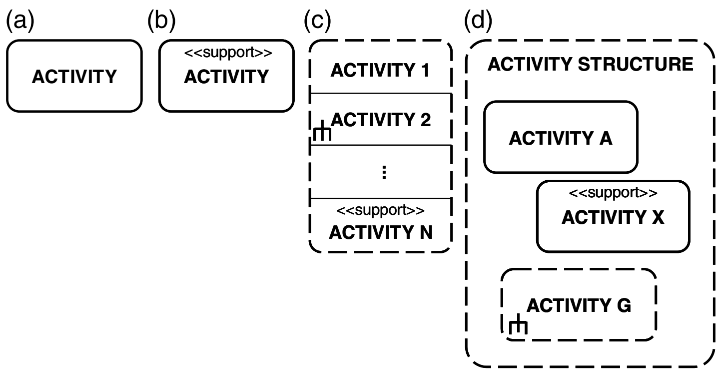


Fig. 2. Notation for simple activities and structured activities

Due to the hierarchical nature of activity structures the proposed graphical notation also allows for the definition of activity structures in separate diagrams. *ACTIVITY 2* in Fig. 2 (c) and *ACTIVITY G* in Fig. 2 (d) show a pitchfork symbol as an annotation of this behavior. However, it is also possible to define a whole complex structured activity in the same diagram.

All activities, whether simple or structured have a set of non-visual properties allowing the complete definition of the activity. For example this definition includes the linking of the activity with the resources that will be available during its performance or the description of the learning objectives that will be achieved after the performance of the activity.

2.3 Sequencing Notation

Sequencing diagrams have similarities with UML Activity diagrams [3]. However, in contrast with works like [7], we are not attempting to use UML as a learning design notation, but simply use activity diagrams as a natural choice in a flow-oriented modeling domain. Our notation also includes many other elements and concepts which have nothing to do with standard UML. Fig. 3 depicts a repertory of symbols used in the e-LD sequencing diagrams. Hence there is a notation for indicating:

– The starting (Fig. 3a) and ending (Fig. 3b) points of the diagram.
– The different learning flows represented by arrows (Fig. 3c).
– Parallel execution of elements (Split element in Fig. 3d). Using this notation, a single learning flow can be divided into different parallel learning flows.
– Synchronization of several threads of execution (Join element in Fig. 3e). Whenever the learning flow is divided, synchronization of the learning flows is needed to reunify the learning flow as well.
– Assignment of participant roles to activities (Fig. 3f-g). Activity sequencing diagrams can be partitioned to specify which roles will be involved in the performance of the activities.

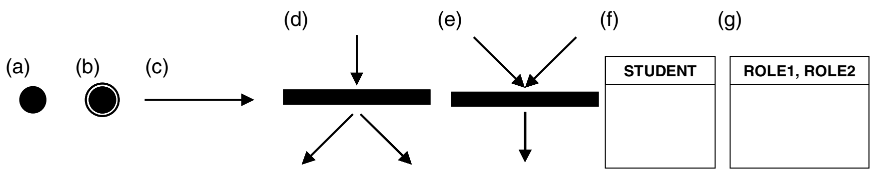


Fig. 3. Symbols used in sequencing diagrams

Activities, whether simple or structured, will appear in activities sequencing diagrams using the same notation as described in section 2.2. In addition the concept of *module* is introduced in activity sequencing diagrams to ease the authoring of complex sequencing learning flows. Fig. 4a represents a module, whereas Fig. 4b represents quite a common structure used during sequencing where Fig. 4c is its compact representation.

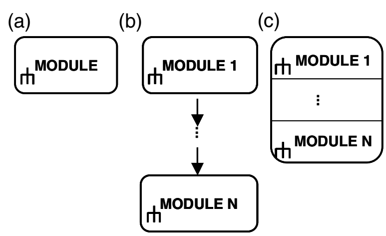


Fig. 4. Notation for play IMS LD concept

The graphical shape for modules is quite similar to the simple activities shape. Note that, just like structured activities, the pitchfork symbol can appear in the module graphical notation indicating that a detailed description is represented in a separate diagram.

2.3.1 Advanced Sequencing: Personalization of the Learning Flow

To facilitate the personalization of the learning flow based on the evolution of the learner during the performance of the UoL, e-LD's sequencing notation incorporates *conditions*. Conditions are also present in mainstream exchange languages, such as IMS LD. However, the way of incorporating conditions in e-LD is radically different from IMS LD. In IMS LD, conditions are not directly linked to the learning flow, but appear as a separate set of reactive rules, which are also available for all the activities. This feature makes the IMS LD level B very difficult to use and maintain. Even computer science experts without an advanced knowledge in rule-based computation systems (a computation model often used in contexts such as artificial intelligence programming [4]) have difficulties using it, let alone an average instructor. By contrast, in e-LD, conditions are integrated into the learning flow, and they are restricted to their occurrence in the diagram. This integration increases the usability of the notation, since now instructors are not required to think about a disaggregated set of rules defined in another portion of the design. They only need to reason out each relevant point in the natural evolution of a learning flow, which is a far lower cognitive load.

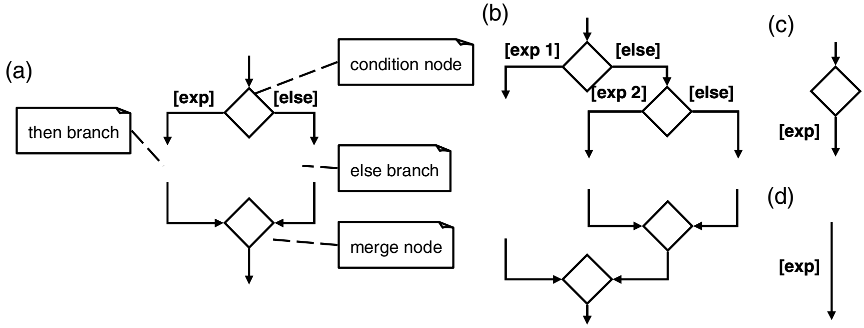


Fig. 5. Notation for conditional sequencing

Fig. 5 depicts the graphical notation for conditions:

- Fig. 5 (a) shows an example of an if-then-else condition rule definition. The flow between activities is guarded by expressions like [exp]. That is, the activity that has a guarded incoming arrow will not be performed if the guard expression becomes false. There is a special guard condition [else] that can be used to mark that this flow will be followed if the guarding expression becomes false).
- Fig. 5 (b) shows an example of a condition definition where if-then-else rules are nested supporting a detailed learning flow definition.
- Fig. 5 (c) shows an example of a condition which only contains the then part. If it is only one branch Fig. 5 (d) notation can be used instead.

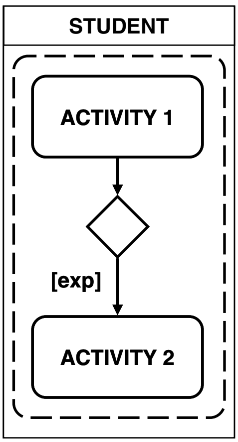
In turn, Fig. 6(a) depicts an example of the graphical notation for conditions. The example scenario involves two activities *ACTIVITY 1* and *ACTIVITY 2* where these two activities will be performed by a student. However *ACTIVITY 2* starts when the expression becomes true. Fig. 6(b) provides an excerpt of the IMS LD XML equivalent to support the graphical notation depicted in Fig. 6(a), which is illustrative of the economy of the graphical notation depicted.

3 Use Case Scenarios

The graphical notation included in e-LD and described above has been successfully tested in two different scenarios: with advanced users (the development team from the e-LD platform) and with PhD students from an e-learning course offered at the Complutense University To test and improve the notation the development team used a pool of well-known UoLs already created including:

– All the examples provided in the best practices document of the IMS LD specification.
– Some popular examples developed by the Open University of the Netherlands available in dspace.learningnetworks.org, such as *Candidas II*, *Geoquiz 3*, *Learning to listen to Jazz* and *QuoBuilder 2*.

(a)



(b)

```
<imsld:components>
 <imsld:activities>
  <imsld:learning-activity
         identifier="A1">
   <imsld:title>ACTIVITY 1</imsld:title>
  </imsld:learning-activity>
  <imsld:learning-activity
         identifier="AN">
   <imsld:title>ACTIVITY 2</imsld:title>
  </imsld:learning-activity>
  <imsld:activity-structure
         identifier="AS1"
         structure-type="sequence"
         number-to-select="2">
   <imsld:learning-activitty-ref ref="A1"/>
   <imsld:learning-activitty-ref ref="A2"/>
  </imsld:activity-structure>
  <-- ... -->
 </imsld:activities>
 <-- ... -->
</imsld:components>
<-- ... -->
<imsld:role-part>
 <imsld:role-ref ref="role1"/>
 <imsld:activity-structure-ref ref="AS1"/>
</imsld:role-part>
<-- ... -->
<imsld:conditions>
 <imsld:if>
  <-- exp goes here-->
 </imsld:if>
 <imsld:then>
  <imsld:show>
   <imsld:support-activity-ref ref="A2"/>
  </imsld:show>
 </imsld:then>
 <-- ... -->
</imsld:conditions>
<-- ... -->
```

Fig. 6. Example of notation and IMS LD XML excerpt

As an example of UoL authoring, Fig. 7 shows an excerpt of the visual specification diagram corresponding to the *Learning to listen to Jazz* UoL. This is a relevant example involving IMS LD Level B features, since it addresses adaptability based on student decisions and actions. This example also provides a simple learning style evaluation, which is incarnated in how the learning path best suited for the learner's style is recommended by the UoL. In addition, the example shows how the progress on the UoL is based on the result of the work that is done in the activities.

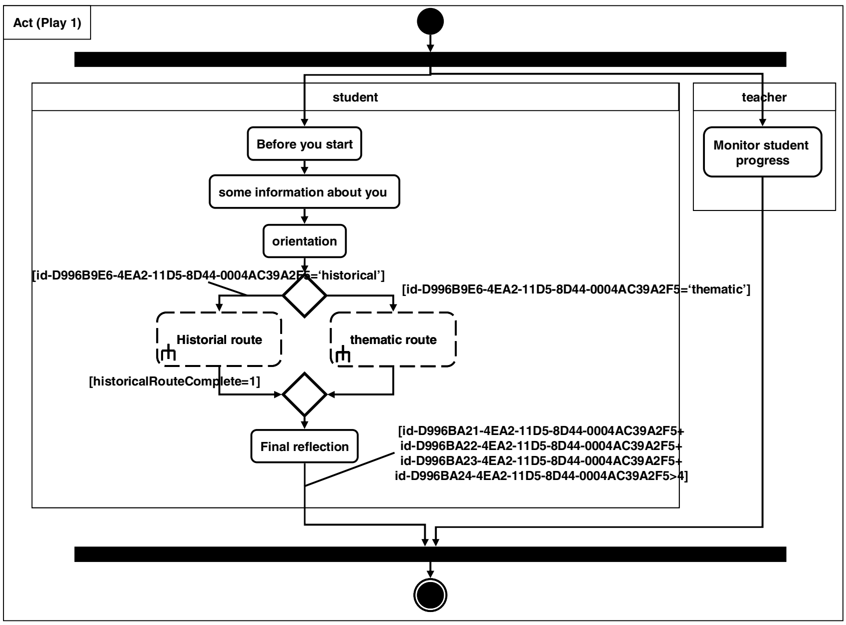


Fig. 7. Excerpt of the Learning to Listen Jazz UoL diagram with the e-LD notation

4 Conclusions and Future Work

In this paper we have presented an EML visual notation specifically oriented to simplify UoL authoring. However, it is important to note that we are not promoting yet another new EML. The key idea is to use this author-oriented notation for the authoring process, and then translate the designs to the more machine-oriented notations of standard EMLs (e.g. IMS LD) through importation/exportation processes.

As a result of the preliminary experiments we think that the graphical notation proposed simplifies the process of authoring UoLs. The creation of UoLs of the complexity of those analyzed in our practical experiments is a feat beyond the reach of most designers, but students without a previous background in using EMLs were able to recreate them using e-LD. However, further study is required, especially in reuse scenarios, where non-experts create new UoLs based on *UoL templates* or previously built UoLs.

Readers familiarized with the UML graphical notation will notice several parallelisms with the notation described in this work. This is intentional, given the background in Computer Science of the participants in the test case. However, different notations can be developed or customized for a particular stakeholder or community. Indeed, the e-LD authoring language is built using model-driven development principles [12]. On the one hand, it includes a *semantic model*, which characterizes the kind of structures that make up a learning design. This model is the base for different *graphical models*, which can be related with the semantic model using *model transformations* (see [12] for more details). The graphical notation presented in this paper is just one of these graphical models.

Our main short-term goal is to test the e-LD approach, and in particular the presented e-LD graphical notation with field users, particularly with the staff of the Spanish National Center for Information and Educative Communication (CNICE) to provide them with a support tool to help them in the design of educational templates. It will allow them to create their documentation using the e-LD's authoring tool and to use the diagrams as an explanation of the sequencing of activities. As future work, we will also explore the compatibility with other exchange EMLs like SCORM Sequencing and Navigation [2] and whether it is possible to integrate at design time the authoring of UoLs using IMS LD and SCORM.

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A Mulimodeling Framework for Complex Learning Activity Designs

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Abstract. This paper proposes a modeling framework for learning activities centered on the design of their components (pedagogical instruments). The learning activity is represented as learning object where the structural components are the reusable objects representing the pedagogical instruments. This purpose presents a new current of learning activity design based on activity theory where its design means the specification of its specific teaching materials called pedagogical instruments, this material has the mediation role between the learner and the objects presented in the activity. The outcome of the presented project should be the convergence of cognitive, didactic, interface and content designs.

Keywords: Learning activity, learning object, individualizing learning, learning to read, Multimodeling.

1 Introduction

The Current research in teaching engineering [10],[15] aims at concentrating on the learner's activity and bringing the learner to the center of research. We propose a new formalism for didactic activity representation by using the approach "learning object" where a lot of recent work has concentrated on aiming at the standardization of their indexing. The goal has been to define open technical standards for computer supported learning environments and education products. Learning objects are elements of a new type of computer-based instruction grounded in the object-oriented paradigm stemming from computer science [15]. We postulate in this paper that the design of the learning activity means the definition of its specific teaching materials called pedagogical instruments; these material has the role of a mediator between the learner and the objects presented in the activity. This paper contains in first the theoretical or conceptual foundations for our work, which falls under what is called activity theory. In the second part we develop the idea based on the multimodelling approach of the learning activity where we announce that the design of the learning activity needs to specify four models: didactic model, knowledge object model, interface model and the cognitive model. Each model comprises the sub models of the pedagogical instruments constituting the learning activity; in the final section we show how we can connect between the different models. Initially, the context of the project and its objectives will be briefly described.

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2 Context of Work

Our work is within an interactive learning-to-read environment with a multi-agent architecture 'AMICAL' which has the support of a pluridisciplinary team of professor in primary school (experts of domain), linguist, psychologist, knowledge engineer, data processing specialist. It's a theoretical and development project of a multi-agents and knowledge-based computer for teaching and learning of reading. This project aims to the realization of multimedia intelligent tools likely to contribute the individualization of learning; it is related to the mother tongue (French) and addressed to children in normal schooling on their preparatory course. The system is composed of three types of functional modules: the resource module, the exploration module and the tutorial module. The tutorial module, must lead, in a controlled way to the acquisition of knowledge by the student, to propose session of work. The sessions are the result of a process, "didactic planning", in which the system determines first an objective constructed from the knowledge it has about the student and the knowledge about the domain [3]. Then, the system determines a sequence of didactic activities with correspond to this objective. It is to be noted that the environment of tutoring module adheres to the current paradigm of multi-agent systems, which offer a good way to model a system to help define the actors, their functions and roles, and also their interactions as a society of agents.

3 Basic Principles of the Framework Methodology

The pedagogical instrument is a complex artificial object that must undertake the design and the evaluation as a didactic artifact suited to bring into play the learner's knowledge. The basic theory of this proposition is the activity theory [14]. The originality of the mediation concept is the Activity theory, which reflects that human action is mediated by tools and signs [7]. The main problem is to know how learners conduct activity in computer mediated learning environment and how they interact with content using mediating artifacts (pedagogical instrument). All the higher psychological processes are mediated through a tool. One of the most important psychological tools is language, which serves as the "prime device for rendering the world intelligible and for communicating our intentions to others" [13]. So the design of the learning activity means the specification of the nature of this mediation by the design of different layers (didactic, cognitive, knowledge objects and interface).

Rob Koper of Open University of the Netherlands proposes to describe the learning activity using a first version of the language EML, Educational Modelling Language. The specification IMS Learning Design, largely inspired by Rob Koper proposition, provides a modelling conceptual framework in which the scenario of the unit of training is represented throw a theatrical metaphor. A *unit of learning* is an abstract term used to refer to any delimited piece of education or training, such as a course, a module, a lesson, etc. It can be modelled as an IMS Content Package where the organization part is replaced by an IMS Learning Design. In our point of view the learning activity scenario will be specified by dynamic process that can be called the scenarisation of learning object. This later is characterized, first of all, by knowledge brought into play for learning. Reusability, adaptation, and composition mechanisms are, therefore, employed to structure knowledge contents. These knowledge contents are represented in the form of entities < action, knowledge unit > or <action; statute-of-learner's-knowledge; knowledge unit> such a knowledge units are regarded as parameters of individualization of the contents of learning activity and the proprieties of knowledge object (fig.1). The instantiation of these parameters represents the first stage for the scenarisation of the learning object. The basic idea is that the learning objects would be staged, (Instantiation of the content, preparing the list of the instrument to be used and finally specifying the scenario of each pedagogical instrument), a process referred to as 'scenarisation'. Our proposal lies in the use of the rational agent, which individualizes its parameters according to the student model and using three types of rules (didactic rule related to the learning domain, pedagogical rules concerned by the general teaching rules independently of learning to read domain and finally linguistic rules)

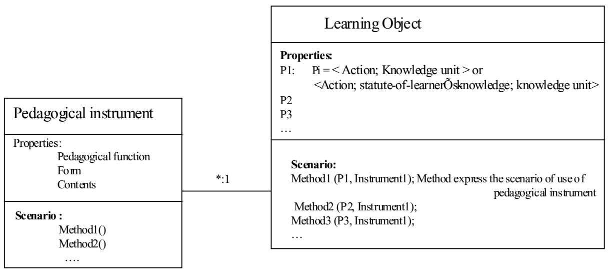

Fig. 1. Learning object meta model according to the UML Class model

4 Multimodeling of the Learning Activity

The multimodeling of the learning activity means specifying four models of each activity: The didactic model, the knowledge object model, the interface model and the cognitive model to be detailed by the actors of design. The learning activity design means the specification of the detailed submodels of each pedagogical instrument.

4.1 Pedagogical Model

There is no consensus on how to proceed and to describe a pedagogical model. However, today we know that teaching and learning approaches have been motivated by more diverse approaches based on the analysing of learning and teaching strategies that include the manner and the content of the pedagogical material to be presented and used within a wider teaching enterprise. Due to the number of input variables and pedagogical rules, we distinguish between two kinds of models: the general pedagogical model of the system and sub-models associated to each pedagogical instrument (fig.2).

The consideration of pedagogical models thus guides the overall design of the entities to be used by the system. The entities manipulated in the pedagogical model have progressive degree of smoothness (macro, meso and micro scale); the entities

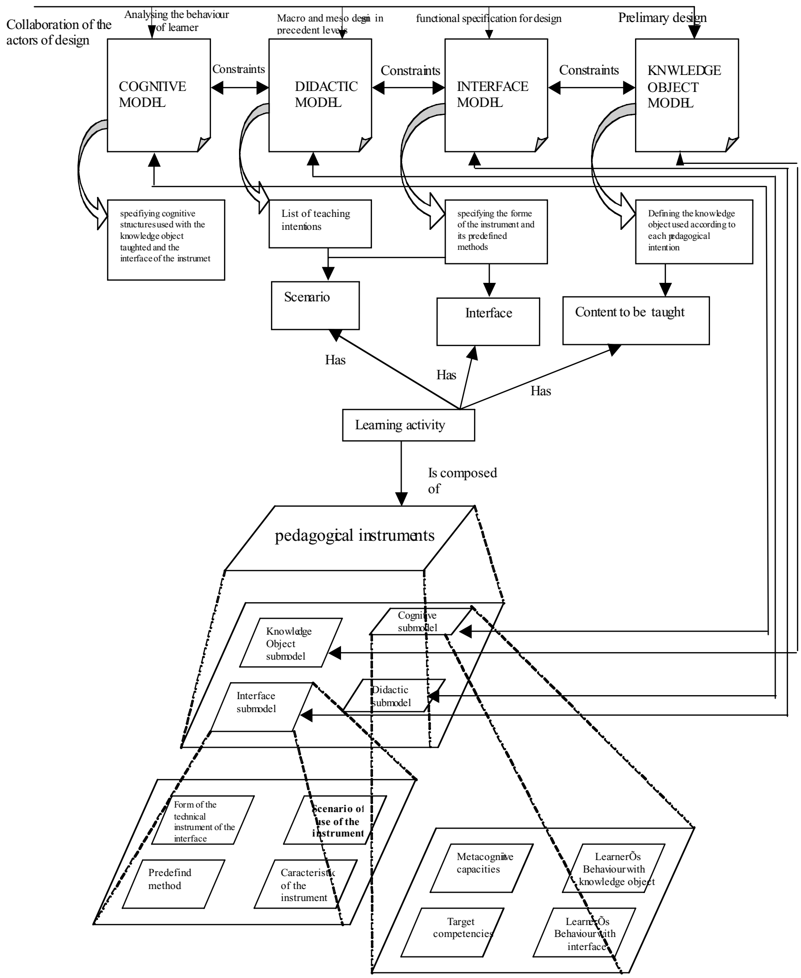

Fig. 2. Multimodeling of the learning activity

presented in macro scale are the objective units, in the meso scale we use the didactic situation type which corresponds to a certain class of didactic situation. The entities represented in the micro scale are the individualizing elements of the instantiated didactic situation which is considered as a multimedia learning object.

The parameters of the instance of the learning object can be used to individualize the object depending on the learner's model and individualizing constraints e.g. "choice of the topic of the text, choice of words, limitation or not of time, help (natural, moment and frequency of the use of help)". These parameters are incorporated in the models specifying the learning activity. The entities manipulated in this model are calculated in the preceding levels, these entities are the objective units represented in the form of couples of information: <action; knowledge unit>; or triplets : <action;

statute of learner's knowledge; knowledge unit>. The objective units represent the properties part of the learning object (Fig 1). For example, the following are valid information couples < Make acquire; sentence limits> or, < verify; Known; word >. By instantiating parameters of the contents Words will be instantiated. These couples and triplets are used to report the progress in the state of the learner's knowledge of reading, but with the assumption that this takes into account the different pedagogical factors and policies used within a learning theory (e.g. constructivist). Therefore this model is defined to provide to our system the possibility to adapt the pedagogical behaviour to a specific student. From this optic, the choice of pedagogical actions with respect to learning strategies will be more adaptive (Table.1).

4.2 Knowledge Object Model

Merrill and his colleagues in the ID2 Research Group proposed a knowledge representation scheme consisting of knowledge components arranged into knowledge objects [8]. This knowledge object framework is the same for a wide variety of different topics within a subject matter domain, or for knowledge in different subject matter domains. Knowledge object of "learning to read domain" are letters, words, sentences and texts; the micro-component of a knowledge object sentences are the components of words (letters). It would be necessary to characterize the differences between knowledge object as entity and its proprieties, for example: The knowledge objects sentences have 2 types of knowledge:

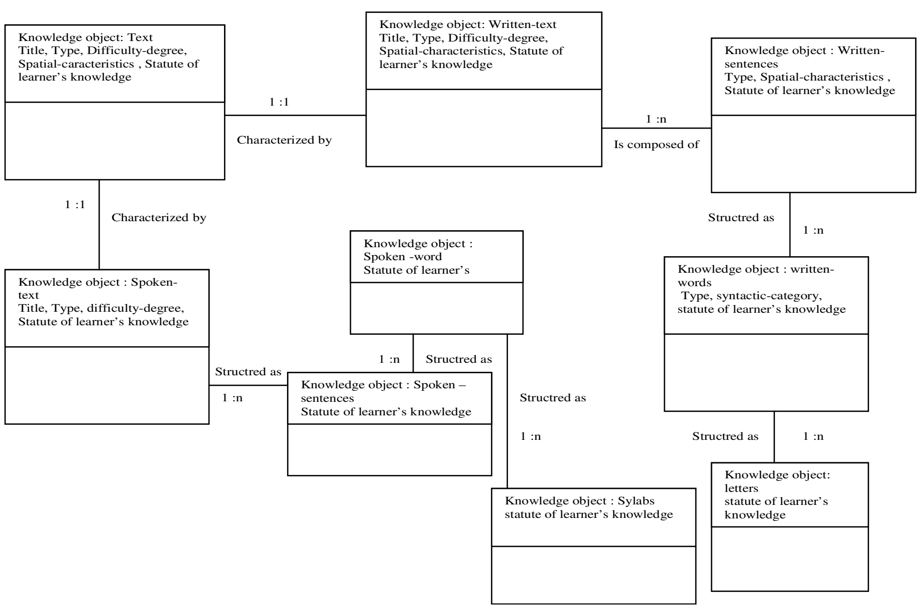

Fig. 3. Learning object model

- o Knowledge associated with properties of the object "sentence" as theoretical space for example: "The association between written/spoken sentences": association grapheme/phoneme, the noun indicates letters, the grapheme representing the word, Structure of word, syntactic categories, the relation between the verbs and the subject, the correspondence written/spoken words. These objects are highlighted systematically each time that a written sentence, is spoken out.
- o Knowledge associated with an entity as a semantic unit, which requires the knowledge of the learner about the property of this object(conceptual representation of the sentences).

The text is the most complex knowledge object related to the learning to read domain, it is related to a complex work to be realized by the learner during the reading process. These processes are concerned with a syntactic analysis of sequences of identified words and the development of its cognitive skills by the combination and integration of the significance proposals starting from various indices (morphological, morpho-syntactic and pragmatic). The knowledge object model is represented as Uml class diagram (fig 3).

4.3 Interface Model

The interfacing of the didactic activity relates to the adaptation of pedagogical instruments to be used for turning on actions of the system illustrated in the properties of the learning object (fig 1). An example of a pedagogical instrument is "the text field" that can be considered as a support of the text. The pedagogical instrument is characterized by five criteria:

- Pedagogical Function: it corresponds to pedagogical intentions represented as: < action, knowledge unit > or <Action; statute-of-learner's-knowledge; knowledge unit>.
- Scenario of use: the life cycle, number of tests and imposed or proposed help...
- Form: the shape of the instrument (Button defines; Fields of text; Word; letter, an image, colors, dimensions space...)
- Content: (the text, the word, the contents of button...)
- Effects of the instrument: it concerns the learner's way of use of the instrument (its logic of use and the effects on the progress of his knowledge and cognitive states).

We distinguish between the model of use of the interface which is a sub-model of the cognitive model and the interface model. The model of use of the interface can be considered as a set of functions, that allow communication and finalizes the form by which the system transmits information. This model is in coupled with the pedagogical, cognitive and knowledge object models. It transforms the internal representation of the system into comprehensible information for the learner. This model can transmit the same knowledge more or less clearly. Indeed, even when the pedagogical model decides the pedagogical function and contents, the interface model deals with a suitable pedagogical instrument to be used in order to propose the final form to the learner taking into account his learning style and preferences. The most popular technologies are *Hiding* for adaptive navigation support.

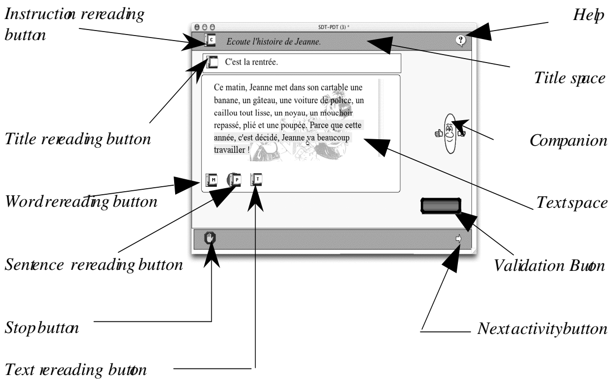

Fig. 4. Tehnical instruments of the interface

The idea of navigation support by hiding is to restrict the navigation space by hiding links to irrelevant pages [2] or to material which the user is not yet prepared to understand. For example if we can detect starting from the behavior of the learner that she/he has an impulsive character (we must hide the “Next” button until the finish of the tasks proposed by the system). The other type of learner can be called “reflexive learner” according to researchers of psychological variables of the functionality of human minds [4], [5]. The *Swassing-Barbe Perceptual Modality Instrument* has been developed by [1] to identify different learning styles visual, auditory and Kinesthetic. It is significant to understand the basic underpinnings of how individuals learn and retain knowledge. We learn using a combination of Visual Stimuli, Auditory Stimuli and Kinaesthetic Stimuli. The visual style is characterised by the effectiveness of learner’s memory in using the vision, the auditory style is related to auditory and the Kinaesthetic style concerned by all what we touch (this stimuli is concerned with pronunciation in the learning to read domain). The pedagogical instrument is the tool that activates these stimuli and allows the learner to maximize its capacities to learn.

Thus, elements of the individualization are considered as variables associated to the instruments (The visualization attribute of the button next which is considered in our case as a decision variable used by the agent). Others types of parameters can be used to individualize the scenario of use of the instrument. The different ways of the use of the instrument can be considered as methods through the object-oriented paradigm. For example if we have a text field in the didactic situation (presentation of the text) the different ways of presenting this text are the possible scenarios of use of this instrument (reading-Word-by-word; sentence-by-sentences and global reading of the text).

4.4 Cognitive Model

Many Cognitive psychologists have proposed a diversity of theories of how knowledge is represented in memory [15]. Schema theory postulates that learners represent knowledge in memory as some form of cognitive structure. A knowledge structure has a form of a schema representing the information that is required by a learner to be able to solve complex problems. If the required information (knowledge components) and the relationships among these knowledge components are incomplete, then the learner will not be able to efficiently and effectively solve problems requiring this knowledge [8]. So solving a problem requires the learner to not only have the appropriate knowledge representation (schema or knowledge structure) but he or she must also have algorithms or heuristics for manipulating these knowledge components in order to solve problems [15]. The processes of activation of a cognitive process for learner could be defined as a complex knowledge based on the other knowledge to acquire and the cognitive structure implemented at the time of learning. The use of this schema requires a high level of treatment by learner: **: to understand, to pridect, to reason, to judge, to interpret, to criticize, to determine** the main idea, **to summarize, to re-read** and self-monitoring, **to make** connections between their reading and what they already know, and **to identify** what they need to know about a topic before reading about it; prefixes, and suffixes of words for comprehension; and **to use** information from their reading to increase vocabulary and enhance language usage [6].

All these knowledge must appear in the **cognitive model** specified by the congnitien. So the pedagogical instrument is designed to be able to conduit of the learner's strategies (metacognition within the constructivism approach). An example of this conduit is to let the learner identifying word by using syntactic analysis of sequences of words to be identified (without ambiguous syntactic structures); the second stage is to let him/here acquires the development of the syntactic structure of the various components starting from various indices (morphological, morpho-syntactic, sets of themes and pragmatic) and finaly is to establish the coherence between the proposals inference starting from its knowledge bases stored in memory. he cognitive model contain all process that used by learner to manipulate the interface and to learn for example : Use logic of reading : (left to right ; high-low), apply logic of corresponding : (spoken word/ written word , spoken sentence/written sentences). More generally, this model takes care of communications between the student and the system remainder. The cognitive model contains all process that used by learner to manipulate the interface and to learn for example: Use logic of reading : (left to right ; high-low), apply logic of corresponding : (spoken word/ written word , spoken sentence/written sentences), make use of logic of the use of the interface, make use of pre-required knowledge, apply inference to understand the text, utilize strategies, Bring into play emotional situation. More generally, this model takes care of communications between the student and the system remainder. In reality the use of the instrument is interpreted by a logic implemented by learner within instrumentation process (in the sense of Rabardel [11])

5 Dynamism of the Learning Activity

The individualizing learning problem has complex nature due to the tacit knowledge having complex epistemic statutes. These knowledge-based analysis tasks are increasingly complex. The relational model of the learning object represents the dynamic of

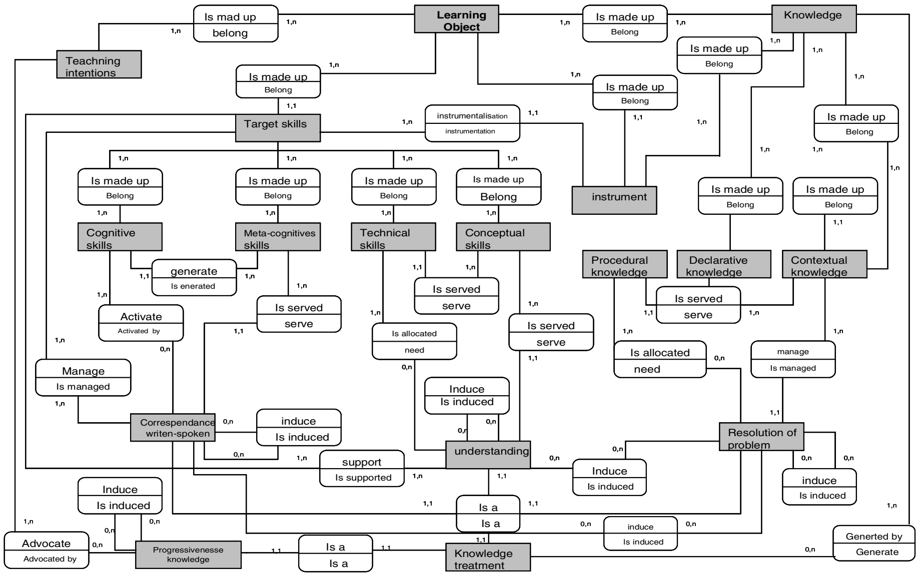

Fig. 5. Relational model for learning object

the learning activity. In the figure below, the activity is made up of four entities (Instrument, Knowledge, target Skills and teaching intentions). The entity 'Instrument' is related with the entity (target skills) by the relation (instrumentation/instrumentalisation), the instrumentalisation is related to four variations of the instrument (content to be taught, interface, mode and moment of intervention), so the enrichment of the instrument by these variations alter the specific teaching material more adaptive through the advocates teaching intentions.The variation of the mode and the moment of intervention of the instrument can let the learner decide to use its meta-cognitive skills (let the learner request the help (instrumentation process)). The system can disable certain kinds of instrument (Instrument-state.disable) to be activated by the learner (for example: listening consign), that make the learner more autonomous and develop its cognitive skills. The moment of intervention of the instrument during the activity of training provides the learner with more time to identify all what is needed to solve the problem. There are three types of knowledge (declarative, procedural and contextual knowledge), the internal relation between these type of knowledge serve as tools used to clarify the resolution of the problem by the learner (activating instrument, using method applied into the instruments …). The entity 'Progressiveness of knowledge' rest so difficult to be clarified but we can accept the assumption that it has direct relation with teaching intentions defined by the expert of domain and the learning model used by the system.

6 Connection between Models

Regardless of the learning activities tools used, once the total design is sufficiently advanced, work can start on the design of individualizing the process of learning materials, pedagogical instruments, by connecting different models. We will show in this section how we can use the different models to make decisions in the system. Pattern of edges in the knowledge object graph represents the qualitative dependencies between the variables used to individualize the content of the learning activity (presentation of text). Each knowledge content has possible statutes in the student's model: known, un-known, recognized and possible context where the student has constructed this statute or modified its value. The student's strategy required to do tasks proposed by the system according to the criterion described by the instructional designer in the pedagogical action (Table1). Quite often criteria are referred to as objectives of the agent, such a set of objectives is typically modified during model analysis. In other words, it is easy to determine separately for each criteria, which solution (text represented in the forme of Vector X) is the best one, such as the narrative text competing with the minimization of degree of difficulty to learning more. If the text is preferred by the learner that signifies it fits the motivational criterion, consequently the solution is to propose the preferred topic of text. But the system will not propose only one topic of text, for that another criterion associated with the progressiveness of the system tasks is required, accordingly a preference approach based on methods is used actually in decision theory [12] to specify the criteria. We consider that there are four criteria to be used for making this decision: - progressiveness of tasks system criteria; -motivational criteria (respecting its preferences); - progressiveness of learner's cognitive state and - progressiveness of learner's knowledge criteria.

Let us illustrate this by specifying the decision variables of our illustrative models. In the knowledge object model (Text model) we can find the vector: T(Tilte , Type, difficulty-degree, spatial-characteristic, number-of-time-of-reading); the type of text can be related to the narrative text, dialogue text, descriptive text… In the pedagogical model the decision variables are the variables associated with each type of text, for example the pedagogical intention: (present text : narrative text ; statute : new). The

Table 1. Relationship between learning and teaching strategies in 'autonomous recognition of Words' activity

Learning strategy	**Related teaching strategy**	**Parameters**
St1- Visual comparison strategy	Present text without reading ; display the word in the screen ; suggest help	The specific interface of the instrument Text : T ; Target Word , number of the target word, leanrer's statute of the word to be known; Help (reading text proposed or imposed) ; number of trying.
St2- using contextual indices strategy (spatio-semantic localization)	Present text without reading ; give set of words which have the same order appeared in the text ; suggest help	The specific interface of the instrument, Text : T ; set of ordered target Word , number of the target words, learner's statute of the word to be known; Help (reading text proposed or imposed) ; number of trying.
St3- partial graphical location strategy (locate initial capital letter)	Present text without reading ; the learner identify words which start by capital letter and don't situated in the beginning of the sentence, suggest help	The specific interface of the instrument Text : T ; set of target Word starting by capital letters , number of the target word, learner's statute of the word to be known; Help (reading text proposed or imposed) ; number of trying.
St4- using location initial syllables (locate initial syllables)	Present text without reading ; the learner identify words which start by the same syllable, suggest help	The specific interface of the instrument Text : T ; set of target Word starting by the same syllable, number of the target words, learner's statute of the word to be known; Help (reading text proposed or imposed) ; number of trying.

knowledge object model contains variables which are specified in the pedagogical model. The agent formulates a set of request to instantiate all the elements associated to the text for example: Find in the student model text with statute which is related to the learner's familiarization level with the text (the number of times where the text has been used by the learner, the number of sentences and words which have been used before by the learner).

The main decision variables are related to the preferences elements by the learner either teaching or learning strategies (Table1). The aim of this specification is to give an effective manner for personalizing these components taking into account the complex dynamism of the learning activity (Section 5).

7 Conclusion and Perspective

Research challenges for managing the complexity of future E-learning systems are not in the development or use of any one type of model. Instead, research is urgently needed in the multimodeling area. All components of the systems and solutions rely on multiple models for their design and operation. Successful complexity management, however, requires that all modelling activities be viewed within a multi formalism perspective. Some of the important research issues that stand in the way of practical multimodeling for complex systems have not been satisfactorily solved even for unitary models. The challenge posed by these issues cannot be underestimated, but there are hopeful signs, most notably the difficulty of the domain related to the individualizing learning. In fact, the history of progress in technology is also the history of progress in active multimodels. The earliest model-based decision systems incorporated unitary models; today's systems are able to control aircraft, refineries, paper mills, commercial buildings, and innumerable other engineering systems by employing several models [9]. For that we found that the design of the learning activity needs to be more focused on different fields.

Acknowledgments. Thanks to Alexandros Karatzoglou for proofreading this paper.

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Question Answering from Lecture Videos Based on Automatically-Generated Learning Objects

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Abstract. In the past decade, we have witnessed a dramatic increase in the availability of online academic lecture videos. There are technical problems in the use of recorded lectures for learning: the problem of easy access to the multimedia lecture video content and the problem of finding the semantically appropriate information very quickly. The retrieval of audiovisual lecture recordings is a complex task comprising many objects. In our solution, speech recognition is applied to create a tentative and deficient transcription of the lecture video recordings. The transcription and the words from the power point slides are sufficient to generate semantic metadata serialized in an OWL file. Each video segment (the lecturer is speaking about one power point slide) represent a learning object. A question-answering system based on these learning objects is presented. The annotation process is discussed, evaluated and compared to a perfectly annotated OWL file and, further, to an annotation based on a corrected transcript of the lecture. Furthermore, the consideration of the chronological order of the learning objects leads to a better MRR value. Our approach out-performs the Google Desktop Search based on the question keywords.

1 Introduction

The amount of educational content in electronic form is increasing rapidly. At the Hasso Plattner Institut (HPI) alone, 25 hours of university lecture videos about computer science are produced every week. Most of them are published in the online Tele-TASK archive[1]. Although such resources are common, it is not easy for a user to find one that corresponds best to his/her expectations. This problem is mostly due to the fact that the content of such resources is often not available in machine readable form, i.e. described with metadata so that search engines, robots or agents can process them. Indeed, the creation of semantic annotation neither is nor should be the task of the user or creator of the learning objects. The user (e.g. a student) and the creator (e.g. a lecturer) are not necessarily computer-science experts who know how to create metadata in a specific formalism like XML, RDF or OWL. Furthermore, the creation of

[1] http://www.tele-task.de

F. Li et al. (Eds.): ICWL 2008, LNCS 5145, pp. 509–520, 2008.

metadata is a subjective task and should be done with care. The automatic generation of reliable metadata is still a very difficult problem and currently a hot topic in the Semantic Web movement. In this paper we will explore a solution to how to generate semantic annotations for university lectures. It is based on the extraction of metadata from two data sources — the content of the power point slides and the transliteration of an out-of-the-box speech recognition engine— and the mapping of natural language (NL) to concepts/roles in an ontology. Each time period of a power point slide represents a learning object. The reliability of our solution is evaluated via different benchmark tests.

This paper is based on the research of [13]. In addition to [13], we present an automatic generation of the learning object (the video is segmented based on the power point slide transitions), the comparison of our results with a manually-generated transcript corpus (an error free transcript), the MRR evaluation dimension and the consideration of the chronological order of the learning objects in the lecture videos. Additionally, our solution is compared to the Google Desktop Search based on the question keywords.

2 Related Work

Using speech recognition to annotate videos is a widely used method [5, 11, 14, 15, 22]. Due to the fact that the slides carried most of the information, Repp et al. synchronized the imperfect transcript from the speech recognition engine automatically with the slide streams in post-processing [16]. Most approaches use out-of-the-box speech recognition engines, e.g. by extracting key phrases from spoken content [5]. Besides analytical approaches, an alternative approach for video annotation is described in [17]. There, the user is involved in the annotation process by deploying collaborative tagging for the generation and enrichment of video metadata annotation to support content-based video retrieval.

In [6] a commercial speech recognition system is used to index recorded lectures. However, the accuracy of the speech recognition software is rather low; the recognition accuracy of the transliterations is approximately 22%-60%. It is also shown in [6] that audio retrieval can be performed with out-of-the-box speech recognition software. But little information can be found in the literature about educational systems that use a semantic search engine for finding additional (semantic) information effectively in a knowledge base of recorded lectures. A system for reasoning over multimedia e-Learning objects is described in [4]. An automatic speech recognition engine is used for keyword spotting. It extracts the taxonomic node that corresponds to the keyword and associates it to the multimedia objects as metadata.

Two complete systems for recording, annotating, and retrieving multimedia documents are LectureLounge and MOM. LectureLounge [21] is a research platform and a system to automatically and non-invasively capture, analyze, annotate, index, archive and publish live presentations. MOM (Multimedia Ontology Manager) [3] is a complete system that allows the creation of multimedia ontologies, supports automatic annotation and the creation of extended text (and audio) commentaries of video sequences, and permits complex queries by reasoning over the ontology. Based on the assertion that information retrieval in multimedia environments is actually a combination of search and browsing in most cases, a hypermedia navigation concept for lecture recordings is presented in [10]. An experiment is described in [7] where automatically-extracted audio-visual features of a video were compared to manual annotations that were created by users.

3 Extraction Method

The way our processing works is described in detail in [13]. To make this paper self-containing, we briefly summarize the major ideas.

3.1 Ontology Fundamentals

It has been realized that a digital library benefits from having its content understandable and available in a machine processable form, and it is widely agreed that ontologies will play a key role in providing a lot of the enabling infrastructure to achieve this goal. A fundamental part of our system is a common domain ontology. An existing ontology can be used or one can be built that is optimized for the knowledge sources.

An ontology is basically composed of a hierarchy of concepts (*taxonomy*) and a language. In the case of the first issue, we created a list of semantically relevant words regarding the domain of Internetworking, and organized them hierarchically. In the second case, we used *Description Logics* to formalize the semantic annotations.

Description Logics (DL) [1] are a family of knowledge representation formalisms that allow the knowledge of an application domain to be represented in a structured way and to reason about this knowledge. In DL, the conceptual knowledge of an application domain is represented in terms of *concepts* (unary predicates) such as $\mathsf{IPAddress}$, and *roles* (binary predicates) such as $\exists\mathsf{composedOf}$. Concepts denote sets of individuals and roles denote binary relations between individuals. Complex descriptions are built inductively using concept constructors which rely on basic concepts and role names. Concept descriptions are used to specify terminologies that define the intentional knowledge of an application domain. Terminologies are composed of *inclusion assertions* and *definitions*. The first impose necessary conditions for an individual to belong to a concept. E.g. to impose that a router is a network component that uses at least one IP address, one can use the inclusion assertion: $\mathsf{Router} \sqsubseteq \mathsf{NetComp} \sqcap \exists\mathsf{uses.IPAddress}$. Definitions allow us to give meaningful names to concept descriptions such as $\mathsf{LO}_1 \equiv \mathsf{IPAdress} \sqcap \exists\mathsf{composedOf.HostID}$.

The semantic annotation of five learning objects is shown in figure 3.1, describing the following content:

$$\begin{aligned}
\mathsf{Protocol} &\sqsubseteq \exists \mathsf{basedOn.Agreement}\\
\mathsf{TCPIP} &\sqsubseteq \mathsf{Protocol} \sqcap \exists \mathsf{uses.IPAddress}\\
\mathsf{Router} &\sqsubseteq \mathsf{NetComponent} \sqcap \exists \mathsf{has.IPAddress}\\
\mathsf{HostID} &\sqsubseteq \mathsf{Identifier}\\
\mathsf{NetworkID} &\sqsubseteq \mathsf{Identifier}\\
\mathsf{AddressClass} &\sqsubseteq \mathsf{Identifier}\\
\mathsf{IPAddress} &\sqsubseteq \mathsf{Identifier} \sqcap \exists \mathsf{composedOf.HostID}\\
&\quad \sqcap \exists \mathsf{composedOf.NetworkID}\\
&\quad \sqcap \exists \mathsf{partOf.AddressClass}
\end{aligned}$$

Fig. 1. Examples of networking terminology

$$\begin{aligned}
\mathsf{LO}_1 &\equiv \mathsf{IPAddress}\\
\mathsf{LO}_2 &\equiv \mathsf{TCPIP} \sqcap \exists \mathsf{uses.IPAddress}\\
\mathsf{LO}_3 &\equiv \mathsf{IPAddress} \sqcap \exists \mathsf{composedOf.HostID}\\
\mathsf{LO}_4 &\equiv \mathsf{IPAddress} \sqcap \exists \mathsf{composedOf.NetworkID}
\end{aligned}$$

Fig. 2. Example of terminology concerning learning objects

LO_1: general explanation about IP addresses,
LO_2: explanation that IP addresses are used in the protocol TCP/IP,
LO_3: explanation that an IP-address is composed of a host identifier,
LO_4: explanation that an IP-address is composed of a network identifier,

Some advantages of using DL are the following: firstly, DL terminologies can be serialized as OWL (*Semantic Web Ontology Language*) [20], a machine-readable and standardized format for semantically annotating resources (see section 3.5). Secondly, DL allow the definition of detailed semantic descriptions about resources (i.e. restrictions of properties), and logical inference from these descriptions [1]. Finally, the link between DL and NL has already been shown [18].

3.2 Natural Language Processing

The way our NL processing works is described in detail in [9]. To make this paper self-containing, we will briefly summarize the major ideas.

The system masters a domain dictionary L_H over an alphabet Σ^* so that $L_H \subseteq \Sigma^*$. The semantics are given to each word by classification in a hierarchical way w.r.t. a taxonomy. This means, for example, that words such as

"IP-address", "IP adresse" and "IP-Adresse" refer to the concept $\mathsf{IPAddress}$ in the taxonomy. The mapping function φ is used for the semantic interpretation of a NL word $w \in \Sigma^*$ so that $\varphi(w)$ returns a set of valid interpretations, e.g. φ("IP Addresse") $=\{\mathsf{IPAddress}\}$.

The system allows a certain tolerance regarding spelling errors, e.g. the word "comXmon" will be considered as "common", and not as "uncommon". Both words "common" and "uncommon" will be considered for the mapping of "comXXmon". In that case the mapping function will return two possible interpretations, so that:

$$\varphi(\text{"comXXon"}) = \{\mathsf{common{,}uncommon}\}.$$

A dictionary of synonyms is used. It contains all relevant words for the domain — in our case: networks in computer-science — and at least all the words used by the lecturer (audio data) and in the slides.

3.3 Identification of Relevant Keywords

Normally, lectures have a length of around +/- 90 minutes, which is much too long for a simple learning object. If a student is searching for particular and precise information, (s)he might not be satisfied if a search engine yields a complete lecture. Therefore, we split such lectures in shorter learning objects. We defined that each power point slide is a learning object. The synchronization of the transcript could be done in an pre-processing with a software that is integrated in the presentation or with a post-processing algorithm [16].

For us, a learning object is composed of two data sources: the audio data and the content of the slides. In the case of the first issue, the audio data is analyzed with an out-of-the-box speech recognition engine. After a normalization preprocessing — i.e. deleting stop-words and stemming of the words — the stems are stored in a database. This part of our system has already been described in [13, 16].

Formally, the analysis of a data source is done with the function μ that returns a set of relevant words in their canonical form, written:

$$\mu(\mathsf{LO}_{source}) = \{w_i \in L_H, i \in [0..n]\} \backslash S$$

where *source* is the input source with $source \in$ {audio only, slides only, audio and slides}, and S is the set of stop words, e.g. $S =${"the", "a", "hello", "thus"}.

3.4 Ranking of Relevant Concepts and Roles

Independent of the data source used (audio only, slides only, audio and slides), the generation of the metadata always works the same way. The relevant keywords from the data source identified by the function μ are mapped to ontology concepts/roles with the function φ as explained in section 3.2.

It is not useful to map all identified words to ontology concepts/roles because this would create to much overload. Instead, we focus on the most pertinent metadata for the particular learning object. Thus we implemented a simple ranking algorithm.

The algorithm works as follows: We compute for each identified concept/rule its hit-rate h, i.e. its frequency of occurrence inside the leaning object. Only the concepts/roles with the maximum (or d^{th} maximum) hit-rate compared to the hit-rate in the other learning objects are used as metadata. E.g. the concept Topology has the following hit-rate for the five learning objects (LO_1 to LO_5):

	LO_1	LO_2	LO_3	LO_4	LO_5
h	0	4	3	7	2

This means that the concept Topology was not mentioned in LO_1 but 4 times in LO_2, 3 times in LO_3 etc.

We now introduce the rank d of the learning object w.r.t. the hit-rate of a concept/role. For a given rank, e.g. $d = 1$, the concept Topology is relevant only in the learning object LO_4 because it has the highest hit-rate. For $d = 2$ the concept is associated to the learning objects LO_4 and LO_2, i.e. the two learning objects with the highest hit-rate.

3.5 Semantic Annotation Generation

The semantic annotation of a given learning object is the conjunction of the mappings of each relevant word in the source data written:

$$\mathsf{LO} = \prod_{i=1}^{m} rank_d\ \varphi(w_i \in \mu(\mathsf{LO}_{source}))$$

where m is the number of relevant words in the data source and d the rank of the mapped concept/role. The result of this process is a valid DL description similar to that shown in figure 3.1. In the current state of the algorithm we do not consider complex role imbrications, e.g. $\exists R.(A \sqcap \exists S.(B \sqcap A))$, where A, B are atomic concepts and R, S are roles. We also try to use a very simple DL, e.g. negations $\neg A$ are not considered.

One of the advantages of using DL is that it can be serialized in a machine readable form without losing any of its details. Logical inference is possible when using these annotations. The example shows the OWL serialization for the following DL-concept description:

$$\begin{aligned}\mathsf{LO}_1 \equiv\ & \mathsf{IPAddress} \sqcap \\ & \exists \mathsf{isComposedOf}.(\mathsf{Host\text{-}ID} \sqcap \mathsf{Network\text{-}ID})\end{aligned}$$

defining a concept name (LO_1) for the concept description saying that an IP address is composed of a host identifier and a network identifier.

4 Evaluation Criteria

4.1 Prearrangement

The speech recognition software is trained with a tool in 15 minutes and it is qualified by some domain words from the existing power point slides in 15 minutes. So the training phase for the speech recognition software is approximately 30 minutes long. A word accuracy of approximately 60% is measured. The *stemming* in the pre-processing is done by the porter stemmer [12].

We selected the lecture on Internetworking (100 Minutes) which has 62 slides, i.e. multimedia learning objects. The lecturer spoke about each slide for approximately 1.5 minutes. The synchronization between the power point slides and the erroneous transcript in a post-processing process is explored in [16], if no log file exist with the time-stamp for each slide transition. The lecture video is segmented into smaller videos — a multimedia learning object (LO). Each multimedia object represents the speech over one power point slide in the lecture. So each LO has a duration of approximately 1.5 minutes.

A set of 107 NL questions on the topic Internetworking was created. We worked out questions that students ask, e.g. "*What is an IP-address composed of?*", etc. For each question, we also indicated the relevant answer that should be delivered. For each question, only one answer existed in our corpus. Owl files from the slides (S), the transcript from the speech recognition engine (T), the transcript with error correction (PT) and the combination of these sources are automatically generated. The configurations are the following:

$$[< source >]_{ranking}$$

where $< source >$ stands for the data source (S, T, or PT), and $< ranking >$ stands for the ranking ration (0 is no ranking at all, all concepts are selected, i.e. $d = 0$, and r ranking with $d = 2$). E.g. $[\mathrm{T+S}]_2$ means that the metadata from the transcript (T) and from the slides (S) are combined (set union), and that the result is ranked with $d = 2$.

Additionally, an owl file (M) is a manual annotation by the lecturer.

4.2 Search Engine and Measurement

The *semantic search engine* that we used is described in detail in [8]. It reviews the OWL-DL metadata and computes how much the description matches the query. In other words, it quantifies the semantic difference between the query and the DL concept description.

The *Google Desktop Search*[2] is used as a keyword search. The files of the transcript, of the perfect transcript and of the power point slides are used for the indexing. In three independent tests, each source is indexed by Google Desktop Search.

The *recall* (R) according to [2] is used to evaluate the approaches. The top recall R_1 (R_5 or R_{10}) analyses only the first (first five or ten) hit(s) of the result set.

The *reciprocal rank of the answer* (MRR) according to [19] is used. The score for an individual question was the reciprocal of the rank at which the first correct answer was returned or 0 if no correct response was returned. The score for the run was then the mean over the set of questions in the test. A MRR score of 0.5

[2] `http://desktop.google.com`

can be interpreted as the correct answer being, on average, the second answer by the system. The MRR is defined:

$$MRR = \frac{1}{N}\sum_{i=1}^{N}(\frac{1}{r_i})$$

N is the amount of question. r_i is the rank (position in the result-set) of the correct answer of the question i. MRR_5 means that only the first five answers of the result set are considered.

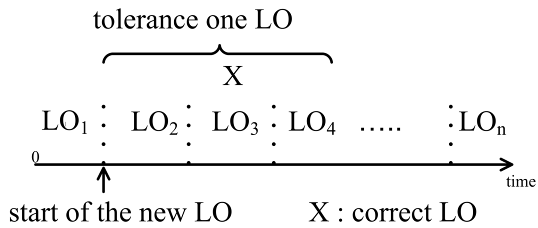

Fig. 3. Learning object (LO) for the **second test**

5 Test and Result

Two test is performed to the owl files:

The **first test** (Table 1) is to analyse which of the annotations based on the sources (S, T, PT) yields the best results from the semantic search. It is not surprising that the best search results were achieved with the manually-generated semantic description (M), with 70% of R_1 and 82% of R_5. Let us focus in this section on the completely automatically-generated semantic description ([T] and [S]). In such a configuration with a fully automated system $[T]_2$, a learner's question will be answered correctly in 14% of the cases by watching only the first result, and in 31% of the cases if the learner considers the first five results that were yielded. This score can be raised by using an improved speech recognition engine or by manually reviewing and correcting the transcripts of the audio data. In that case $[PT]_2$ allows a recall of 41% (44%) while watching the first 5 (10) returned video results. A MRR of 31% for the constellation $[PT]_2$ is measured.

In practice, 41%(44%) means that the learner has to watch at most 5 (10) learning objects before (s)he finds the pertinent answer to his/her question. Let us recall that a learning object (the lecturer speaking about one slide) has an average duration of 1.5 minutes, so the learner must spend — in the worst case — $5 * 1.5 = 7.5$ minutes (15 minutes) before (s)he gets the answer.

The **second test** (Table 2) takes into consideration that the LO (one slide after the other) are chronological in time. The topic of the neighboring learning objects (LO) are close together and we assume that answers given by the semantic search engine scatter around the correct LO. Considering this characteristic and accepting a tolerance of one preceding LO and one subsequent LO, the

Table 1. The maximum time, the recalls and MRR_5 value of the **first test** (%)

	R_1	R_2	R_3	R_4	R_5	R_{10}	MRR_5
time	1.5 min	3 min	4.5 min	6 min	7.5 min	15 min	-
LO (slides)	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	10 (10)	-
M	70	78	79	81	82	85	75
$[S]_0$	32	49	52	58	64	70	44
$[T]_2$	14	23	26	30	31	35	21
$[PT]_2$	25	33	37	40	41	44	31
$[T+S]_2$	36	42	46	50	52	64	42
$[PT+S]_2$	32	43	48	49	51	69	40

MRR value of $[PT]_2$ increased by about 21% ($[T]_2$ about 15%). Three LO are combined to make one new LO. The disadvantage of this is that the duration of the new LO object increases from 1.5 minutes to 4.5 minutes. On the other hand the questioner has the opportunity to review the answer in a specific context.

Table 2. The maximum time, the recalls and MRR_5 value of the **second test** (%)

	R_1	R_2	R_3	R_4	R_5	MRR_5
time	4.5 min	9	13.5 min	18 min	22.5 min	-
LO(slides)	1 (3)	2 (6)	3 (9)	4 (12)	5 (15)	-
$[S]_0$	42	57	62	66	70	53
$[T]_2$	22	43	50	55	56	36
$[PT]_2$	43	54	62	64	65	52
$[T+S]_2$	47	51	53	59	62	52
$[PT+S]_2$	43	54	65	66	70	53

The **third test** (Table 3) takes into consideration that the student's search is often a keyword-based search. The query consists of the important words of the question. For example, the question: "*What is an IP-address composed of?*" has got the keywords: "*IP*","*address*" and "*compose*". We extracted from the 103 questions the keywords and analysed with these the performance of Google Desktop search. It is clear that if the whole question string is taken, almost no question is answered by Google Desktop Search.

As stated in the introduction, the aim of our research is to give the user the technological means to quickly find the pertinent information. For the lecturer or the system administrator, the aim is to minimize the supplementary work a lecture may require in terms of post-production, e.g. creating the semantic description.

Let us focus in this section on the fully automated generation for semantic descriptions (T, S and its combination [T + S]) of the **second test**. In such a configuration with a fully automated system $[T + S]_2$, a learner's question will be answered correctly in 47% of the cases by reading only the first result, and in

Table 3. The maximum time, the recalls and MRR_5 value of the Google Desktop Search, **third test** (%)

	R_1	R_2	R_3	R_4	R_5	R_{10}	MRR_5
time	1.5 min	3 min	4.5 min	6 min	7.5 min	15 min	-
LO (slides)	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	10 (10)	-
S	41	44	47	48	48	50	44
T	12	22	22	23	23	24	17
PT	18	27	27	28	28	28	23

53% of the cases if the learner considers the first three results that were yielded. This score can be raised by using an improved speech recognition engine or by manually reviewing and correcting the transcripts of the audio data. In that case $[PT + S]_2$ allows a recall of 65% while reading the first 3 returned results. In practice, 65% means that the learner has to read at most 3 learning objects before he finds the pertinent answer (in 65% of cases) to his question. Let us recall that a learning object has an average duration of 4.5 minutes (**second test**), so that the learner must spend — in the worst case — $3 * 4.5 = 13.5$ minutes before (s)he gets the answer.

Comparing the Google Desktop Search (**third test**) with our semantic search (**first test**) we can point out the following:

- The search based on the power point slide yields approximately the same result for both search engines. That is due to the fact that the slide always consists of catch-words and an extraction of further semantic information is limited (especially the rules).
- The semantic search yields better results if the search is based on the transcript. Here a semantic search out-performs the Google Desktop Search (MRR value).
- The power point slides contain the most information compared to the speech transcripts (perfect and erroneous transcript).

6 Conclusion

In this paper we have presented an algorithm for generating a semantic annotation for university lectures. It is based on three input sources: the textual content of the slides, the imperfect transliteration and the perfect transliteration of the audio data of the lecturer. Our algorithm maps semantically relevant words from the sources to ontology concepts and roles. The metadata is serialized in a machine readable format, i.e. OWL. A fully-automatic generation of multimedia learning objects serialized in an OWL-file is presented. We have shown that the metadata generated in this way can be used by a semantic search engine and out-performs the Google Desktop Search. The influence of the chronology order of the LO is presented. Although the quality of the manually-generated metadata is still better than the automatically-generated ones, it is sufficient for use as a reliable semantic description in question-answering systems.

We are working on a more intelligent extraction of the concepts and rules from the data sources. All activity applications, e.g. newscasts, theater plays or any kind of speech being complemented by textual data, could be analyzed and annotated with the help of our proposed algorithm.

This project was developed in the context of the Web University project[3] which aims to explore novel internet and IT technologies in order to enhance university teaching and research.

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An Overview on Mobile E-Learning Research of Domestic and Foreign

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Abstract. Mobile e-Learning is based on the combination of mobile data communication technology and wireless Internet. It is important to study and analyze mobile e-Learning research of domestic and foreign, because it will drive the future education and learning markets. This paper summarizes the research on Mobile e-Learning around the whole world and shows clearly construction directions needed toward in China. A systematic discussion and analysis of e-learning providers, educational institutions, and their cooperation is also presented.

Keywords: Mobile e-Learning, Wireless Technology, Research Status.

1 Introduction

Mobile e-learning (m-Learning) is the exciting art of using mobile technologies to enhance the learning experience (Http://learning.ericsson.net/mlearning2/index.shtml). Mobile phones, PDAs (Personal Digital Assistants), Pocket PCs and the Internet can be blended to engage and motivate learners, any time and anywhere. It is not an online course on a cell phone. For one thing, existing bandwidth and processing power limitations make cell phones better suited for handling conversations and real-time data exchange. While third-generation (3G) services [1] make it easier to share applications such as videos and movies on, a mobile phone handset, and the small form factor can make viewing high-fidelity content on a small screen a less-than-satisfying [2] experience.

The e-Learning Guild in its recent Mobile Learning report defines mobile learning (or m-Learning as it is also known) as (Http://www.c4lpt.co.uk/handbook/mobilelearningl.html):

- "Any activity that allows individuals to be more productive when consuming, interacting with, or creating information, mediated through a compact digital portable device that the individual carries on a regular basis, has reliable connectivity, and fits in a pocket or purse."

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- "Portable devices" could be phones, iPhones, smart phones/PDA as well as iPods (and other MP3 players).

M-Learning offers a powerful and practical solution to many learning and training challenges (Http://www.ctad.co.uk/content/view/185/277/). For example, it can be used: in collaborative projects and fieldwork; as a classroom alternative to books or computers where learners are widely dispersed; to engage with learners who in the past have felt excluded; in promotional and awareness campaigns, for ‘just-in-time’ employee training [3].

2 Technology

The application of m-Learning is mostly based on the technology of WAP (Wireless Application Protocol), 3G and Bluetooth. The following sections introduce these three kinds of technologies separately.

2.1 WAP

WAP is an open international standard for applications that use wireless communication. Its main use is to enable access to the Internet from a mobile phone or PDA. A WAP browser provides all of the basic services of a computer which is based on web browser, but simplified to operate within the restrictions of a mobile phone, such as its smaller view screen. WAP sites are websites written in, or dynamically converted to, WML (Wireless Markup Language) and accessed via the WAP browser. WAP is a protocol for wireless devices like multi media mobile:

- The bottom-most protocol in the suite is the Wireless Datagram Layer (WDL), which is an adaptation layer that makes every data network look a bit like UDP to the upper layers by providing unreliable transport of data with two 16-bit port numbers (origin and destination). WDL is considered by all the upper layers as one and the same protocol, which has several "technical realizations" on top of other "data bearers"
- Wireless Transport Layer Security (WTLS) provides a public-key cryptography-based security mechanism similar to TLS (Transport Layer Security). Its use is optional.
- Wireless Transaction Layer (WTL) provides transaction support (reliable request/response) that is adapted to the wireless world. WTL supports more effectively than TCP on the problem of packet loss, which is common in 2G wireless technologies in most radio conditions.
- Wireless Session Layer (WSL) is best thought of on first approach as a compressed version of HTTP.
- This protocol suite allows a terminal to emit requests that have an HTTP or HTTPS equivalent to a WAP gateway; the gateway translates requests into plain HTTP.
- Finally, Wireless Application Environment (WAE), in this space, application-specific markup language is defined. The primary language of the WAE is WML, which has been designed from scratch for handheld devices with phone-specific features [4].

2.2 3G

3G is the third generation of mobile phone standards and technology, superseding 2G.

The International Telecommunication Union (ITU) defined the demands for 3G mobile networks with the IMT-2000 (International Mobile Telecommunication) standard. An organization called 3rd Generation Partnership Project (3GPP) has continued that work by defining a mobile system that fulfills the IMT-2000 standard. This system is called Universal Mobile Telecommunications System (UMTS). Until October 19, 2007, there are three mainstream wireless interface standard on 3G technology: W-CDMA (Wideband Code Division Multiple Access), CDMA2000, TD-SCDMA (Time Division -Synchronous CDMA), they are proposed and applied mostly in Europe, Korea (Japan and America), and China respectively.

3G technologies enable network operators to offer users a wider range of more advanced services while achieving greater network capacity through improved spectral efficiency. Services include wide-area wireless voice telephony, video calls, and broadband wireless data, all in a mobile environment. Additional features also include HSPA (high speed packet access) data transmission capabilities, and are able to deliver 14.4Mbit/s on the downlink and 5.8Mbit/s on the uplink.

Unlike IEEE 802.11 networks, 3G networks are wide area cellular telephone networks which evolved to incorporate high-speed internet access and video telephony. IEEE 802.11 (common names Wi-Fi or WLAN) networks are short range, high-bandwidth networks primarily developed for data [5].

2.3 Bluetooth

Bluetooth is a wireless protocol utilizing short-range communications technology, facilitating both voice and data transmissions over short distances from fixed and/or mobile devices, creating wireless personal area networks (PANs). It provides a way to connect and exchange information between devices such as mobile phones, Telephones, laptops, personal computers, printers, GPS receivers, digital cameras, and video game consoles over a secure, globally unlicensed Industrial, Scientific, and Medical (ISM) in 2.4 GHz short-range radio frequency bandwidth.

Bluetooth is a standard and communications protocol primarily designed for low power consumption, with a short range (power-class-dependent: 1 meter, 10 meters, 100 meters) based on low-cost transceiver microchips in each device. Bluetooth enables these devices to communicate with each other when they are in range. The devices use a radio communications system, so they do not have to be in line of sight of each other, and can even be in other rooms, as long as the received transmission is powerful enough. Bluetooth device class indicates the type of device and the supported services of which the information is transmitted during the discovery process [4].

Sections below are applications of overseas research on m-Learning as well as Mobile e-learning in China.

3 Overseas Research of M-Learning

Overseas research of m-Learning has emerged in recent four years. At the beginning of 21st century, with the increasing number of companies specialized in e-Learning, organizations of m-Learning are also welling up [6], for example: some educational institutions and companies of Britain, USA, Ireland, Canada, Norway, Germany, France, Italy and so on carry out and research m-Learning, by wishing first to find the best way of technology respectively, in order to realize applying m-Learning broadly to satisfy people around the whole world in the near future [7].

Divided from the goal and organizations of m-Learning these years, overseas researches on m-Learning projects are mainly divided into two kinds [8]: developed by E-learning providers of commerce or educational institutions.

3.1 E-Learning Providers

E-Learning providers are making every effort to use the original e-Learning system, by profiting from the experience of e-Learning; they want to push e-Learning to the market in enterprise training, IT curriculum and e-commerce curriculum [9], which to develop mobile e-Learning. The supporting technology is WAP and WML (Wireless Makeup Language), for example:

- ISOPIA Inc. (which has been acquired by Sun Microsystems, Http: //www.sun.com/training/) is now applying WAP technology in e-Learning system, in order to train staff; meanwhile, learners could use mobile telephones or PDA to visit their e-Learning system, querying learning activity, curriculum information and so on, while the system is based on WAP programming model and compiled by WML.
- Global Knowledge (a company specialized in IT and business training, Http://www.globalknowledge.com), choose the most three popular IT courses: networking, programming, and Cisco Authenticate: CCNA. It develops mobile learning by transforming these curriculums suited in PDA equipment.

3.2 The Cooperation between Educational Institutions and Companies

M-Learning initiated by educational institutions is based on school education; they attempt to cooperate with enterprise and companies, on the purpose of improving management, teaching and learning with the technology of WAP, 3G and Bluetooth synthetically [10]. The scope of research involved is very comprehensive and multiform, which manifests some new technologies including: WAP Push, new 3G wireless services and security of Bluetooth [11]. The experiments have been carried out in some universities and middle schools, and discussions on feasibility applied in education of mobile technology and equipment are also under exploring.

Ninestiles School (Http://www.ninestiles.bham.sch.uk/) in British cooperates with Enterasys and Microsoft. The school adopts an infrastructure (Http://www.ninestiles. bham.sch.uk/) of local area network (LAN) from Enterasys's solution, and provides notebook computers to 1400 students and 95 teachers respectively which to support wireless information resources by project named AAL (anytime anywhere learning). With applying information technologies in the daily curriculum teaching, the motivation, study efficiency and skill of students are highly strengthened.

The University of Mississippi (Http://www.olemiss.edu/) has cooperation with Microsoft and Proxim Wireless Corporation; they developed a project named Mobile

Classroom, which focuses on the future education and development of teaching, with configuring Bluetooth in hand-held PCs (HPCs) which are provided by Microsoft, wireless Modem by Proxim. Each student of Mississippi have a HPC to visit curriculum through wireless network which transmitted documents by infrared port, the virtual mobile classroom saves a lot funds and spaces for The University of Mississippi.

3.3 Mobile E-Learning Research

In Asia, NSEAD (The National Society for Education in Art and Design is a professional association and an independent trade union, Http://www.nsead.org/home/index.aspx), NOKIA and ICUS (International Conference on the Unity of the Sciences) have formed an organization on mobile learning research [12], performing its own duty respectively. NSEAD provides curriculum, ICUS is engaged in on-line teaching design and educational model compiled by WML, while NOKIA provides the technology on WAP (Wireless Application Protocol) and is responsible for market business. They will develop e-Business and e-Course together which is customized by WAP Push message, and suitable for WAP handsets produced by NOKIA. The related digital devices are: Palm Pilot IIIc and Nokia6210 WAP mobile phone, meeting with the need of wireless and wired, users could gain curriculum conveniently and efficiently not only through WAP handset, but also through PC machine, which highly integrated with WEB and WAP.

In 1998, Ericsson, IBM, Intel, Toshiba, and Nokia, formed a consortium and adopted the code name Bluetooth for their proposed open specification. In December 1999, 3Com, Lucent Technologies, Microsoft, and Motorola joined the initial founders as the promoter of Bluetooth Special Interest Group (SIG). It is a privately held, not-for-profit trade association with headquarters in Bellevue, Washington. As of January 2008, the SIG is composed of over 10,000 member companies that are leaders in the telecommunications, computing, automotive, music, apparel, industrial automation, and network industries, and a small group of dedicated staff in Hong Kong, Sweden, and the USA. SIG members drive the development of Bluetooth wireless technology, and implement and market the technology in their products varying from mobile phones to printers [13].

4 Mobile E-Learning in China

At present research on m-Learning in China involves several main directions: communication, wireless network, mobile library, WAP Push message (in Chinese and English) and Bluetooth in campus. On the whole, m-Learning is on the stage of research, it has not launched to business activities in large-scale, but from the end of 2005, especially in 2006, m-Learning entered into a stage of commerce application [14], because National university committee on educational technique in China addressed "Mobile Education Project", meanwhile, "Theory and Application of Mobile Education" was also initiated into experiment by National Ministry of Education [15], which indicates significance of m-Learning and mobile education, the concrete manifestation is following below：

4.1 Mobile E-Learning Research

The High Education Department in China has released a notice which was about the theory and application of “Mobile Education” which has two thesis: First, establishment of network by using short message platform of China Mobile, and GPRS to afford students and teachers with WAP push services, including: information on education and scientific research, teaching resource, management message and so on. Second, service station is being established to provide all kinds of services for learners, which is getting more perfectly in application.

In 2002, Mobile Education Laboratory of Modern Education Technology Center in Beijing University undertook the experimental project [16]: “Theory and Application of Mobile Education”, which has been last for 4 years. At present, directions of research include that: education platform based on WAP push, communication, mobile computing, database as well as website in WML and so on, the education platform developed by them has been put into practice.

4.2 The Cooperation between Educational Institutions and Companies

New Oriental Education & Technology Group has already reached an agreement with Nokia in May 2007; they would promote a mobile learning program [17], which permitted students visiting New Oriental curriculum content specifically by their own handset. New Oriental would provide learning materials designed in specialty: English in short sound byte which is advantageous for learners to listen to. Users could visit it through the new style of Nokia handset which equipped by preassemble teaching program which can also downloaded from website: *http://mobile.edu.cn* and *http://koolearn.com.*

4.3 E-Learning Providers

At the same time, Sina, 163, Sohu, TOM and so on well-known websites in China, promoted coach service of foreign language study successively in WAP or its own handset short message [18], several million as high as daily message reach, which becomes a dark horse on foreign language learning in China.

Beijing Dig-idea Software Technology Development Co., Ltd., Unbounded Learning Inc. and so on companies are concentrating on developing software resources on learning which could run on the handset. There are many other domestic companies are making effort on the development of learning platforms based on handset, for example, WangTi Company provides products and services including: mobile teaching assistant platform, m-Learning platform integrated by service, WAP push message platform, handset courseware manufacture system and so on (Http://www.chinaonlineedu.com/info/news_special.asp?id=10487). Except for this, there are also many other learning resources on handset developed by m-Learning fans, learning resources based on Java, Symbian, Windows Mobile and Palm OS platforms, which has formed a new group of platform exploiters, supporters and users respectively. There will be massive kinds of mobile learning platforms and m-Learning resources in the near future.

Early in 2006, TD-SCDMA technology finally became 3G standard in China; it is the first intellectual property rights on international standard of Chinese, with about 14,000 base depots constructed, eight Olympic Game cities in china opened TD numbers for 3G service On April 1, 2008, and was successfully introduced to users. At present, CDMA of China Unicom and GPRS of China Mobile have already provided data transporting speed as high as 114kB/s, in future, it could be 2MB/s provided by CDMA or more faster by 3G technology [19], which could be highly satisfied with the transmission of multimedia learning materials.

5 Conclusion and Prospecting Mobile Learning

Research and applications on mobile e-Learning of overseas in depth and breadth is far better than that of China, mobile learning is a new field appears in our country [20]. Not only research on m-Learning is rarely few but also applications, both concrete and perfect application of m-Learning has not realized yet [21], but through the action of comprehension, summary and analysis of m-Learning research overseas dynamically, we should strengthen m-Learning construction in the following several aspects:

- Architecture of mobile learning systems;
- New emerging wireless technologies, such as GPRS, CDMA, 3G and so on;
- Ubiquitous computing and integrated learning environments;
- Innovative use of wireless and mobile technologies for learning;
- Mobile agents for learning;
- Practical uses of wireless and mobile technologies;
- Group ware solutions for collaborative learning [22];
- Learner-supportive interfaces for mobile applications;
- Evaluation of mobile learning systems [23].

Mobile technologies are having a profound global impact on business, education, and culture. As an e-Learning professional should consider the learning possibilities made available by mobile devices [24]. E-Learning strategy may not require it now, or even soon, but m-Learning is quickly becoming a reality in business, government, and education (Http://www.elearningguild.com/research/archives/index.cfm). To some extent, China is lag behind with other advanced countries, we can expect developing in terms of connectivity, bandwidth, services, and availability in the near future.

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A Semiautomatic Content Adaptation Authoring Tool for Mobile Learning

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Abstract. A lot of studies about automatic content adaptation have been done and are proposed to overcome the drawbacks of browsing regular content with handheld devices such as pocket PCs and smartphones. But we argue that the total automatic adaptation algorithm designed by an engineer to transform Web Page presentation is still appropriate to be applied on educational content. Therefore, this paper proposes a learning content adaptation tool that provides different adaptation templates to help the author automatically and efficiently reproduce high-quality learning content for specific handhelds. Furthermore, the author will not only be able to preview the adaptation result before publishing the course but also be able to adjust the template parameters manually to affect the process if they are not satisfied with the current result. Finally the new adapted content can be packaged with original content as a multi-version learning course.

1 Introduction

The need to adapt content for use on handhelds has been long recognized 34, and both manual and automatic approaches to implement the content adaptation have been proposed. This research 5[6]79 mostly focused on adapting normal Web Pages such as commercial web sites or portal sites. There have been a lot of automatic approaches designed to provide a real time content adaptation system for browsing Web Pages on handhelds. On the other hand, manual adaptation techniques, such as WAP89, have high cost for data producers who are required to maintain multiple versions of the content.

We believe that automatic and manual mechanisms are equally important for adapting learning content. Adopting the total automatic approach for adapting content without supervision by educators or authors may lead to the adapted result becomes unpredictable and unexpected even results possibly lose its educational essence. Contrarily, requiring a teacher to manually reproduce and maintain courses for a variety of mobile learning platforms is not intelligent. Because it does exist, an optimal adaptation approach that can perfectly satisfy various adaptation requirements, as well as existing learning material should never be adapted due to their educational characteristics or

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author's will. So, the main purposes of our project[1] are specifically listed as follows, (1) we propose a web-based content adaptation tool that uses templates to automatically and efficiently adapt content for mobile learning; (2) through adjusting the template's parameters, users can easily manipulate the process and change the result if they are dissatisfied; (3) the tool allows user to preview the adapted content and decide whether it is appropriate to read on handhelds.

2 Related Works

The proposed authoring tool allows authors to produce the adapted content for the sake of appropriately displaying it on specific mobile learning platforms. After finishing the editing phase, the author has alternative way to package the new adapted content: creating another totally independent course package or packaging the adapted content associated with the original content package. Despite what kinds of packaging way to handle the adapted content, the package formats are following the international e-learning standard: ADL SCORM 1 and IMS Common Cartridge 2.

2.1 IMS Common Cartridge Package File Structure

The diagram in figure 1 shows the overall layout of the common cartridge package interchange file structure.

- imsmanifest.xml
  The standard IMS manifest file that is a mandatory XML file describing the package itself. In the absence of this file, the package is not an IMS package

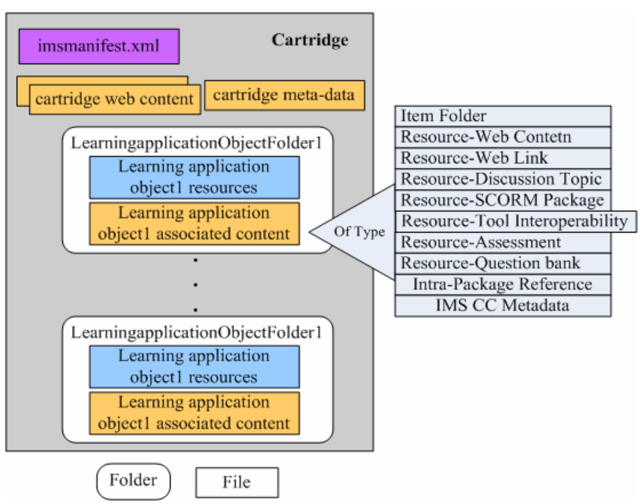

Fig. 1. Common Cartridge package interchange file

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and cannot be processed. It is required the name be kept, as above, in all lowercase letters.

- Learning Application Object Resources
  These are resources that describe the attributes of a particular Learning Application Object. Examples include SCORM packages, QTI files and discussions top descriptors. The information will generally be parsed on input and transformed into internal data structures in the Learning Management System (LMS).
- Web Content Resources
  These represent standard web content types such as HTML files, images, movies etc. Two main scopes for web content resources are supported: Cartridge scoped web content and Learning Application Object scoped web content. These web content resources can be organized into directories in the package interchange file and the directories will be included in the importing LMS to ensure relative links between web content continue to work.
- Using Directory in Package Interchange File
  File system directory can be used to organize content within the package interchange file. It is required that the resources specific to a given Learning Application Object are packaged in a distinct directory in the package interchange file.

2.2 Related Literatures

Adaptation is a well-studied topic in mobile and pervasive computing for years [10][11]. Hwang et al. proposed a transcoding framework [12] that represents a Web page as a modified tree structure to efficiently analyze and transcode pages. It is based on html syntax analysis and structure-aware techniques that intend to make complex Web pages accessible and reflect the relative importance of Web components during the transcoding process.

The design guidelines for such PDA devices are also introduced and discussed in [13]. These guidelines can be classified according to which aspect of the Web media they are related: software/hardware, content and its organization, or aesthetic and layout.

On the other hand, refer to textual web content summarization [14], the methods for summarizing are introduced to handle the textual Web pages and HTML forms. A Web page is separated into text units that can each be hidden or partially displayed. Six different display modes are introduced that utilizes the progressive displaying textual units with keyword extraction and paragraph summarization to gain an overview of a page. They found that the combination of keywords and summaries provides the most significant improvements in access time and number of required pen actions.

Usage-AwaRe Interactive Content Adaptation (UARICA) and Feedback-driven Context Selection (FCS) [15] made adaptation prediction for a user based on the history of the community of users and reflect both the user's context and content's usage semantics. Iqbal et al. think optimal adaptation is a challenging problem because it often depends on the usage semantic of content, as well as the context of users (e.g., screen size of device being used, network connectivity, location, etc.) Their works included an automatic techniques, UARICA that allows a user who is unsatisfied with the adaptation prediction to take control of the adaptation process and make changes until the content is suitably adapted for his/her purpose. Moreover, FCS takes advantages of user interaction to determine those contextual characteristics that have the most impact on the adaptation requirements of an object, and therefore should be the basis of grouping users into communities.

3 Proposed Learning Content Adaptation Models

Our proposed adaptation framework is composed of three main adaptation models. First, the textual adaptation model is responsible for handling the complicated textual body that may make users feel confused or lost while reading on a restricted small screen. Precisely speaking, our content adaptation tool will summarize textual body and utilize progressive disclosure presentation to revel the original content. We referenced Buyukkokten's [14] progressive disclosure for text, it combined with keywords and a summary help present the original content incrementally, has the best improvement of average I/O expenditure and completion time across all tasks they had experimented.

Second, the image adaptation model takes into account the requirement for adapting image size when displaying it on a handheld. Briefly speaking, an image will be automatically shrunk if it is too big to display on a handheld, as well as expanded if it is too small. Finally, the layout adaptation model is able to reorganize the layout of adapted elements properly according to the display ability of different handheld devices. But there are a few questions associated with previous descriptions. Exactly which textual body is needed to be summarized? How do we evaluate and decide whether a picture is required to be shrunk or expanded? Consequently, before we continue to detail each adaptation module, the presentation unit (PU) and screen unit (SU) will first need to be introduced.

3.1 Screen Unit (SU) and Presentation Unit (PU)

The adaptation process begins by partitioning the content into presentation unites (PUs). A content page will be separated into several PUs, which instead of presenting in the actual HTML, each PU is a rectangle around a section which typically presents a paragraph, list, table, image, etc. Accordingly, each PU is considered as a basic unit of the adaptation process. Because each PU contains various contents, the question is which SU should execute the adaptation process. We will define the other unit, namely screen unit (SU), that helps us to evaluate and decide which PU is required to be adapted.

Figure 2 shows the display area size of a PU is varies because it may contain a paragraph or an image. On the contrary, a SU is a virtual rectangle presentation block where the boundary is fixed according to different handhelds displaying ability. Precisely speaking, the size of a SU is matched to correspond to the screen sizes of handhelds. For example, pocket PC's and Smartphone's in which the typical resolution are 240*320 and 176*220 respectively.

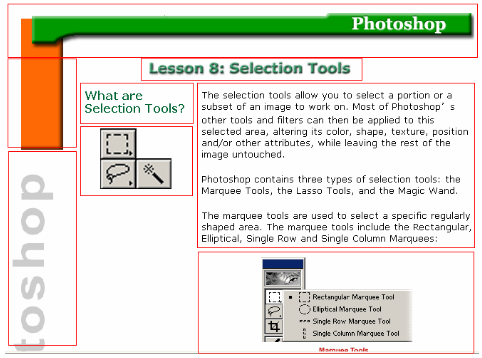

Fig. 2. Dividing a html-based content page into several PUs

The content of each PU will be retrieved then filled into each SU. The main concept is that it does not need to adapt a text or image within a PU if it can be entirely displayed within a single SU without additional scrolling. Mathematically, we evaluated whether a PU is required to be adapted with a simple formula that calculates a threshold value. We defined a value, textual information density (TID) as follows:

$$\text{TID} = \text{number of words in a PU} / \text{area of a SU} \tag{1}$$

The area of a SU is constant according to which adapted target platform is required by a user. The default value of TID is allowing a PU to present the maximum number of words without additional scrolling. Users are also allowed to adjust the TID, which will affect which PU is required to be adapted. For example, a larger TID allows a good deal of textual information located in a PU without any summarization so that the user may need more necessary scrolling actions for reading.

3.2 Textual Adaptation Model

This need for frequent scrolling can seriously degrade the learning efficiency and performance. Providing a simplified overview is another important adaptation guideline as well.

Therefore, for text summarization, we referenced Buyukkokten's approach to extract keywords from web pages. Their content adaptation approach utilizes keywords and summary sentences to partially represent the original text, then disclose information progressively as figure 3.1 shows. The main difference is that our adaptation unit is a PU and only when its TID is higher than the chosen threshold value will it trigger the adaptation process. Next, the details of how to extract keywords and summary sentences will be introduced.

3.2.1 Keyword Extraction

Keyword extraction from a text body relies on an evaluation of each word's importance. The importance of a word W is dependent on how often it occurs within the body of text, and how often the word occurs within a larger collection that the text is part of. Intuitively, a word in given text will be considered as the most important one if it occurs frequently within text, but infrequently in the larger collection. The formula is shown as follows:

$$Wij = Tfij * log2\ N/n \text{ where} \tag{2}$$

Wij = weight of term Tj in document Di

Tfij = frequency of term Tj in document Di

N = number of documents in collection

n = number of documents where Tj occurs at least once

The documents of the formula must be modified as a individual package. The N of the collection in our case is learning content repository and the parameter n in this formula requires knowledge of all words within the collection that holds the text material of interest.

For calculating each word's importance, we need to construct a dictionary that contains the information of how frequently it occurs across course packages in learning content repository.

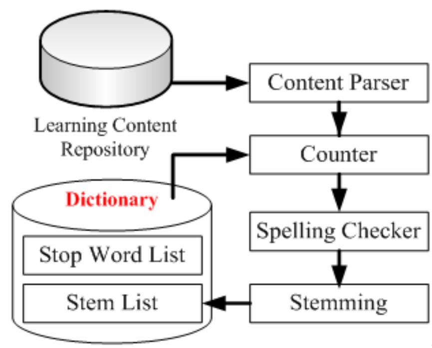

Fig. 3. Construct a dictionary of weighted words

Figure 3 shows each step of constructing the dictionary of weight words from our learning content repository. It begins from the content parser which fetches learning courses from the repository and extracts all the words from each course, unless the frequent stopped words such as "is", "are", "and", etc.

Then, each uniquely extracted word will be tagged by a counter module with a number and keeps track of the number of courses where the word occurred. Once the counting is complete, the words that occurred less than a chosen threshold value across all the courses are eliminated. The value is required to be tuned because it depends on the size of the repository. It would conserve too many insignificant words if the value is too large. On the contrary, it is probable to remove rare words that may quite important and have the potential to become keywords. The remaining words are passed through a spell checker and finally, words that have the same grammatical stem are combined into single dictionary entries. For example adaptive and adapted, would share an entry in the dictionary. Accordingly, the size of the dictionary will continually shrink.

When the significant keywords must be extracted from a PU, all the words in the PU are stemmed. For each word, the module will search the dictionary to discover the frequency with which the word occurs in the course. The word's frequency within the course package that contains the PU is found by scanning the course package in real time. Finally, these values are computed for the word's TF/IDF weight. Words with a weight beyond the chosen threshold are selected as significant.

A special situation arises when a word is not in the dictionary, either because it was discarded during our dictionary-pruning phase or it was a specific word that has never been shown in other learning contents. Such words are probable more rare than any of ones that survived pruning and were included in the dictionary. Therefore these words are considered as special keywords in this course and as important as any of the words we retained.

Finally, notice that our implementation directly extract and store the words as important ones if they are somehow highlighted with bold, italic, different color, specific punctuation marks, etc.

3.2.2 Summary Sentence Extraction

Rather than summarizing the input text automatically, we can only pick up a few significant sentences to represent the text summary. Because of the previously revealed keywords in a PU a user intends to explore the portion of the content's summary due to his/her interesting. A sentence will be intuitively considered significant if it contains one or more keywords. Therefore, the method of extracting summary sentences is based on keyword extraction result.

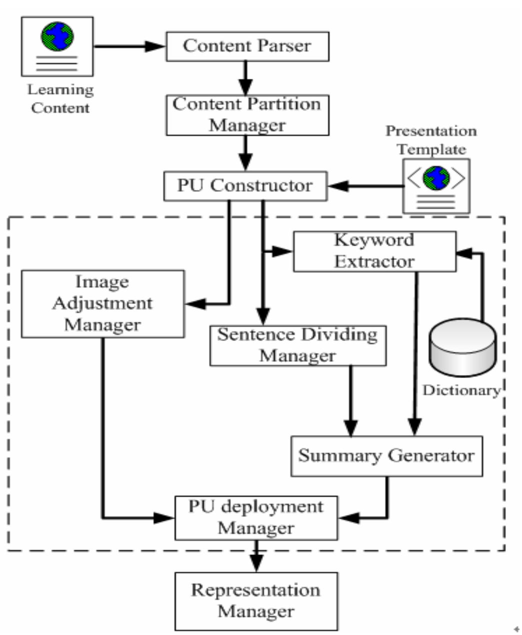

Fig. 4. Processing of the learning content adaptation

The procedure of summary sentence extraction is as shown in figure 4 Each sentence in a PU will be extracted by a sentence dividing manager, and then passed to the summary generator. Meanwhile, the previous extracted keywords are also passed through the summary generator in which each sentence will be extracted and listed in order if it contains the matched keywords.

Although the method selects the summary sentences rapidly, the number of summary sentences becomes unpredictable due to the uneven distribution of keywords within a text. The extreme cases occurred under the following situations;

1. Only one summary sentence identified if all keywords are included in a sentence
2. The summary sentences are exactly the same as the original text if the keywords are equally distributed in each original sentence. We have found a few extreme cases in our implementation, but most others are acceptable.

3.3 Image Adaptation Model

Similarly, image adaptation replies on comparing its size to a SU's. Recall the definition of SU. It is a rectangle displaying unit and its presentation area is the same as a physical screen area of required handhelds. An image may not be able to adapt its size to perfectly match the proportion of a SU and reside in it. Hence, a large image (its height and width are all exceed a PU's) might be shrunk proportionately until its width is fit to display in a PU without additional horizontal scrolling action. The entire adapted content will have the default displaying in a single column where vertical scrolling for browsing is necessary, so the height of a image beyond a SU's is acceptable. Such that the height of a PU is consequently extended for the image in our implementation. Accordingly, a small image will be enlarged proportionately until its width, is at least fit, to display in a PU without additional scrolling actions.

3.4 Presentation Adaptation Model

The presentation adaptation mode provides two main functions for user to reedit the content's layout. One is allowing users to pick up PUs to delete, the other is let users rearrange PUs' position manually. The procedure is as illustrated in figure 3.3. After the previous automatic adaptation, each PU should contain appropriate displaying content-content that has either been adapted or not. A few PUs might be required to be eliminated, because they may present relatively insignificant objects such as pictures decorated only for aesthetic purposes in its original content. Besides, users may decide to delete certain PUs considered unnecessary for learning according to their editing experience, and consequently reduce the content's size. On the other hand, the default adapted layout rearranges PUs in an orderly single column presentation. Lari Kärkkäinen [11] mentioned a design guideline for a small display screen; put as much important content as close to the top of the hierarchy as possible. Each PU is a unit of presentation, such that the PU deployment manager allows users to manually rearrange each PU's displaying position to satisfy user's specific requirement and construct a preference layout.

3.5 Multi-version Course Package

The purpose of the authoring tool is producing the adapted content and appropriately displaying it on specific mobile learning platforms. Therefore after the editing phase, the author may create plural content versions such as pocket PC version and smart-phone version. The authoring tool allows the author to save each version as an individually new SCORM course package or integrate all related versions adapted from the same content as a Common Cartridge course package.

The IMS Common Cartridge defines a profile for the use of four following specifications which have been widely implemented and in use across the community.

- IEEE LOM v1.0[IEEE LOM, 05]
- IMS Content Package v1.1.4[CP, 04]
- IMS Question & Test Interoperability v1.2.1[QTI, 03]
- SCORM 1.2/2004 [SCORM]

The Common Cartridge can support various resource types and also be able to include plural content packages such as SCORM. Therefore, the authoring tool utilizes the significant characteristic of Common Cartridge to compose a multi-version course package. The figure 5 shows the Common Cartridge file structure having a learning application object folder that includes three different SCORM course versions for corresponding learning platforms: pocket PC, Smartphone and regular PC.

Fig. 5. Multi-version course package

4 Implementation

We implemented the content adaptation Tool as a web-based application with Ajax and Microsoft .NET framework technologies. In figure 6, the block 2 allows the user uploading a SCORM-compliant course that is composed of html-based contents then block 1 lists the current courses are ready to execute adaptation process. The uploaded course will be saved at our backend server that is responsible for conducting

Fig. 6. Uploading learning contents to on-line adaptation application

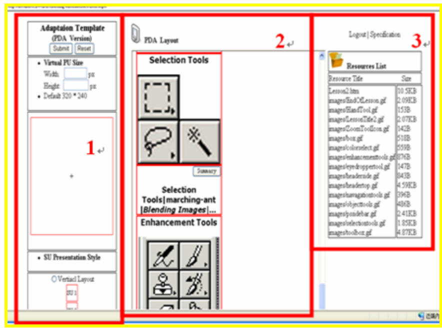

Fig. 7. Adapting Content according to the pocket PC template

the entire adaptation process. The block 3 shows there are two adaptation templates we have currently developed; the pocket PC version and the Smartphone version. The user only needs to click on the icon to decide which adaptation process begins. The block 4 shows the original content page and block 5 displays the aggregation tree of this course.

The system will automatically accomplish the adaptation requirement according to the parameter configure of the template. Figure 7 demonstrates the html-based content has been adapted properly to be displayed in a PU and arranged by a default singular column layout in block 2. Next, users can manually delete the PUs, which contain relatively significant contents that have to be determined by users themselves. The adaptation result relies on configures of the template parameters as shown in the block 1. Users can adjust the adaptation parameters, including the value of the TID, size of a PU and PU rearrangement panel for changing the layout manually. The block 3 lists the included resources information of the adapted page.

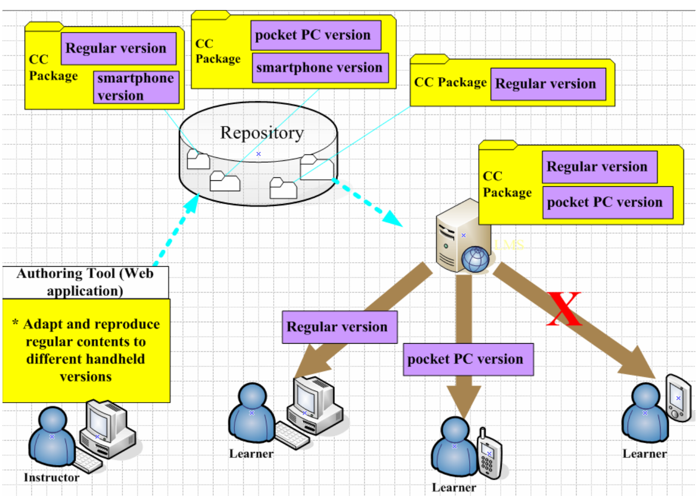

Fig. 8. An adaptive content delivering architecture

5 Conclusion and Future Work

In this paper, we develop a web-based content adaptation tool that focus on adapting html-based learning materials composed of texts and images. Instead of real-time adapting general Web pages on Internet, we believe automatic and manual adaptations are equally important for learning contents. Authors can not only utilize the proposed adaptation templates automatically and efficiently to adapt the learning content for handhelds but also adjust the template parameters to influence the adapted result, as well as the educational quality is assured by authors themselves. Although, the mobile devices are becoming more and more powerful, there still have been a lot of various multi-media resources cannot be properly displayed such as Flash files and specific format videos. As a result, how to adequately adapt or represent the multimedia resources included in learning contents is one of our future works.

Another primary future work is combining an adaptive content delivering system with our authoring tool that has the perception of learners' platforms. Utilizing the context-aware technology, the server can correctly delivering the required and corresponding course package to learners as shown in figure 8.

The Common Cartridge packages with multi-version courses created by our proposed authoring tool are stored in a course repository. The LMS filters the request and decides whether delivering the content to the learner's learning platform. The LMS will send a message to strongly suggest the user canceling the learning request if no corresponding version exists in this course. The advantage of the architecture is that the course package is assured by the author, and some content should never been displayed on specific devices even after the adaptation process. As a result the learner will never waste the significant time and bandwidth to download an appropriate course for their learning platforms.

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An Optimized Scheme for Mobile Learning on IP-Based Network Using SIP

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Abstract. With the fast development of wireless technology, the concept of e-learning has been constantly evolved into mobile learning(m-learning), which means to use mobile technologies to enhance the learning experience by blending mobile terminal devices and network to engage and motivate learners at any time and anywhere. However, current m-learning systems are mainly based on HTTP, which is static and limits in Web access, thus are insufficient in support of the various new mobile devices and wireless access methods. SIP(Session Initiation Protocol) is a signal protocol with excellent mobility support on both personal and service levels. The key reasons for SIP's popularity as a protocol for mobile applications are discussed in this paper. An optimized m-learning system architecture based on SIP is proposed. The mobility support of the m-learning system based on the new architecture is presented. Tests show that the new system is dynamic and mobile, with high performance in real time connection and interactivity.

Keywords: SIP, e-learning, m-learning, mobility.

1 Introduction

The WWW and other IP-based collaborative tools have significantly enhanced the ability to train and educate electronically. A web course, having a teacher and registered group of students, brings together a community of learners into a virtual educational environment where they can view course contents and interact with each other [1]. At the present age, with the increasing use of mobile devices and wireless networks, there will be more requirements for new models of mobile learning and teaching. Meanwhile, most of the courseware online are simply HTML files shifted from textbook, or PowerPoint, doc files that can be downloaded onto local server. This is obviously not compatible with the rapid development of multimedia technology, which enables teachers to use live and vivid multimedia courseware and other teaching materials. SIP is a signal protocol that is designed for multimedia communications sessions with great mobility support [2]. In this paper we will discuss the application of SIP in m-learning systems. Our goal is to find an optimized scheme for mobile multimedia teaching using SIP.

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2 Background on M-Learning and SIP

2.1 Attributes of M-Learning

M-learning is a natural extension of e-learning. It can be defined as learning that is mediated by mobile devices such as mobile phones, personal data assistants, handhelds, wearable devices and laptops. M-learning has made an exponential leap from theory explored by academicians to a real contribution to learning in a short span of years. The heightened interest in m-learning can be attributed to the following three main factors:

First, there are more wireless networks, services, and devices than ever before. Using mobile devices like cell phones, PDAs, and laptops becomes more commonplace. People are increasingly connected and are digitally communicating with each other in ways like GPS, Wi-Fi, and 3G. It is certainly reasonable to use the wireless technologies for improving learning, teaching, and research processes.

Second, people want "anytime, anywhere" connections to be educated more than ever before. With the rapid development of world economy, more people are feeling higher pressure on self-education. Demands for resource, instruction, training, and education anytime and anywhere are being shaped by people who want to catch up with the fast pace of modern high-tech society. M-learning is just the solution for their requirements.

Third, consumers are demanding better and more mobile experiences. As more people gain greater comfort with simple mobile applications like SMS text-messaging and mobile Web-surfing, the greater will be the demand for more mobile services, like MMS(Multimedia Messaging System). In fact, as bandwidth increases and media players like Flash continue to improve users' experiences, the more rapidly will mobile applications continue to increase in number.

Compared with traditional e-learning systems, a rich m-learning system should include the following unique attributes, provoked by its mobility.

Access: Contrary to e-learning, which supposes always-on connection, m-learning systems can be accessed anytime, anywhere with possible interruptions.

Richness: Multimedia educational files like video, sound and animations can be subscribed and played in a smooth and seamless manner, and can be presented properly on various mobile devices despites of their small screen size [3].

Interactivity: The system allows mobile users to interact freely with the display and the content.

Flexibility: Educational contents designed for use with one kind of mobile device or operating system can be played on other devices with some expectation of comparable quality. The system is accessible through different wireless access methods.

Security: The interactive mobile devices are protected from malevolent attacks. The shared content and dialogues between educators and learners are protected from being intercepted by unintended recipients [4].

Based on the above studies of m-learning, we can see that the existing architecture of current e-learning systems must be revised to provide more mobility and richness, that's why we introduce SIP technology into this research.

2.2 SIP Advantages for Mobile Learning

SIP is a signal protocol on the application level that is used for managing multimedia sessions between participants on IP-based networks. Approved as an official standard of IETF in 1999, SIP's popularity has risen recently. Today, SIP applications are installed everywhere, from large-scale mainframes, PC, to small embedded devices like PDA and smartphone. In section 4 of this paper, we will give examples of detailed SIP signal flow on m-learning applications. Here we simply focus on SIP's advantages in constructing mobile applications.

2.2.1 SIP's Advantages as a Communication Protocol

After detailed research and more than two years' application of SIP, we sum up its advantages as a communication protocol as following five key reasons:

First, as SIP is text-based protocol similar to HTTP and SMTP, it is very easy to read and parse the various SIP commands. Compared with binary encoded protocols like RTP [5], SIP is more convenient to be logged and analyzed, thus easier to be implemented.

Second, SIP uses ABNF [6] as its protocol grammar. This makes SIP extensible. In fact, SIP has been extended to complete many works today, from sending instant message, subscribing presence information, to intelligent electric appliance control.

Third, the SIP message body is independent of the SIP protocol and can contain anything. For example, SDP [7] is often carried in SIP message body to describe the related media, but if needed, another protocol could easily replace SDP to complete the same function. In many cases such as 3GPP, XML messages are commonly included in SIP body.

Finally, SIP offers various security mechanisms. TLS could be integrated with SIP seamlessly in transport level. In user level, HTTP digest mechanism is used for authentication and authorization.

2.2.2 SIP's Advantages in Mobility Support

Commonly, MIP is used to provide terminal mobility for maintaining transport level connections, say, TCP connection, when terminal moves and changes its access point [8] [9]. Unlike MIP, SIP provides excellent personal mobility in higher level by registering a single SIP URI with different transport addresses. This ensures any registered SIP entities be routed regardless of their locations and access methods. SIP also provides service mobility. This means when the SIP agent moves, the SIP service, like a SIP session will be continued [10]. Consider that we will mainly use UDP to carry RTP media stream and SIP signal message, the mobility support by SIP is enough to meet the needs of our system, MIP will not be integrated.

For all of the above reasons, we choose SIP as the main protocol to construct our m-learning system.

3 Architecture Design for Mobile Learning

The m-learning architecture based on SIP should support the requirements of traditional e-learning processes, which include registration, message communication,courseware subscription, and other methods that will fully engage the students in the learning process through an interactive, dynamic environment involving the student, on-line materials and teacher. As discussed in section 2.1, the new architecture should also support the unique requirements of m-learning, which include enough flexibility and mobility. At the same time, it should have high multimedia data exchange capacity[11]. The architecture proposed in this paper is illustrated in figure 1.

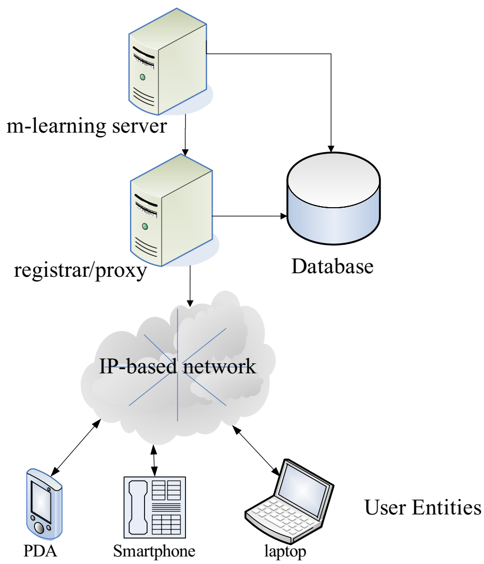

Fig. 1. Architecture for m-learning system

As illustrated in figure 1, four elements will be included in our system: registrar, proxy, m-learning server and user entity. A registrar is a server that accepts learners and educators' registration and provides m-learning server with proper information. A proxy server primarily plays the role of routing. It receives SIP message and decides the next hop. M-learning server is used to provide users with functions such as courseware subscription and play, presence subscription, and so on. The user entity is a logical entity that can act as both UAC(user agent client) and UAS(user agent server). Installed at user's terminal devices, the user entity is implemented as a client software for accessing m-learning services.

With the increasing use of SIP in various fields, there are already many developed SIP software and applications. We will reuse these resources to implement our m-learning system. For example, SER(SIP Express Router) is a free SIP server licensed under the open-source GNU license. We will use SER as registrar and proxy in our system. The development of m-learning server and user entity will be based on oSIP, eXosip and oRTP, which are open source SIP software.

4 System Implementation and Message Flow

In this section, we will discuss the detailed implementation of the m-learning system using SIP. The flow charts of main processes are given, together with primary SIP messages.

4.1 Register Process

The registrar is an administrator for a specified SIP domain. Any user in this domain who wishes to get an m-learning service, should register to the registrar with its AOR (address of record) and contact address. The procedure of register includes challenge and response steps based on HTTP digest [12]. Once the user is authenticated and authorized, the contact address will be used by proxy for routing future SIP requests. The register process and message example are shown later in figure 6, together with re-register process. Note that we only include the main part of SIP message in all examples.

4.2 Message Route Process

The proxy is a center node between all SIP users and m-learning server. On receiving a request, the proxy will decide which destination it should be sent to. Commonly, it is completed mainly by analyzing the request URI in SIP request. For example, if the URI of a request is something like sip:alice@nbut.cn, which is a user URI in this domain, the request will be directed to the contact address (got from registrar) which the user Alice registered with. However, if the URI is something like sip:courseware@nbut.cn, this request will be directed to m-learning server. In the m-learning system, only two functions are related with proxy: instant message and common SIP call. Considering for system simplicity and cost, the proxy and registrar are implemented in one software in our system (SER is used as both registrar and proxy) and located in one single PC server. The message sending process is shown in figure 2.

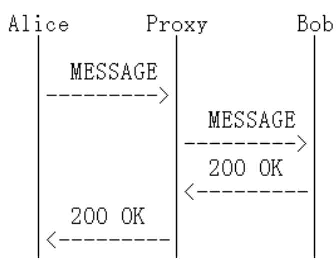

Fig. 2. Process of message sending

In this process, Alice sends a SIP MESSAGE request with a request URI of sip:bob@nbut.cn to proxy which will route it to Bob. When the user entity of Bob receives the request, it responds Alice with a SIP response message of 200 OK and prompts Bob with the message body, which is “Hello.”. The detailed SIP message is as follows:

```
MESSAGE sip:bob@nbut.cn SIP/2.0
From:
<sip:alice@nbut.cn>;tag=dvR+vtR+rrK2a59Rc5ayhgsQfo
To: <sip:bob@nbut.cn>
Call-ID: nJ3dNL3du.MqeF.jgFc-139qC4@192.168.0.100
Content-Type: text/plain


Hello.


SIP/2.0 200 OK
From:
<sip:alice@nbut.cn>;tag=dvR+vtR+rrK2a59Rc5ayhgsQfo
To: <sip:bob@nbut.cn>;tag=4c78dd21
Call-ID: nJ3dNL3du.MqeF.jgFc-139qC4@192.168.0.100
```

4.3 The Implementation of M-Learning Server

The m-learning server is an application server providing m-learning functions. It implements three basic functions, including accepting subscription for user presence information, accepting subscription for courseware list, and providing real time playing of a specific courseware. The first two processes are illustrated in figure 3 and figure 4. The process of courseware real time playing is shown later in figure 6.

The process in figure 3 shows that when the user entity of Alice starts, it will subscribe all users’ presence info from m-learning server. The server will then return the presence information, such as “Tom is online” and “Marry is offline”, by sending a SIP NOTIFY request message. Once a new user, say, Bob, registers to the registrar, the registrar will inform m-learning server by some method (commonly not SIP). The m-learning server will then generate a new NOTIFY message with Bob’s online information in its body and send it to Alice. The process in figure 4 is very similar with that in figure 3.

4.4 The Implementation of User Entity

The user entity is implemented as a client software at user’s terminal devices. User will be required to configure the address of registrar and proxy when the software is installed at the first time. Once the user entity begins to run, it will register to the registrar and subscribe for other users’ presence information and available courseware. If the subscriptions are accepted, the user entity will maintain a user list and courseware list in the software user interface and display them to the user. When another user is registered or deregistered to the registrar, the m-learning server will send a NOTIFY message to the user entity, which will refresh its user list (someone online or offline). If someone in the user list is online, the user could send him an instant message or make a call. The courseware subscription and notifying process is in most part like the pro-cess of presence subscription and notifying, except that the courseware information is maintained by a system administrator, not by a registrar. When a courseware is available, it can be played in user's terminal devices.

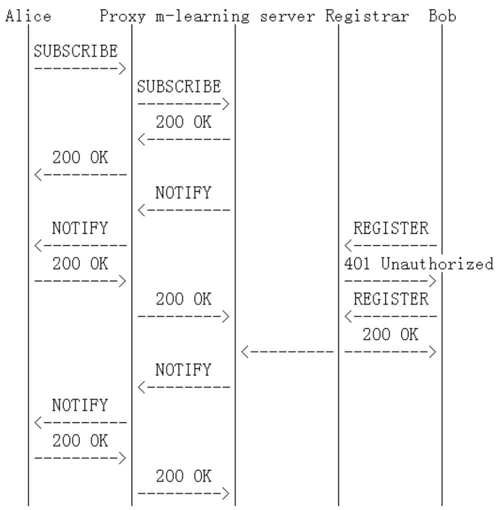

Fig. 3. Process of subscribe presence

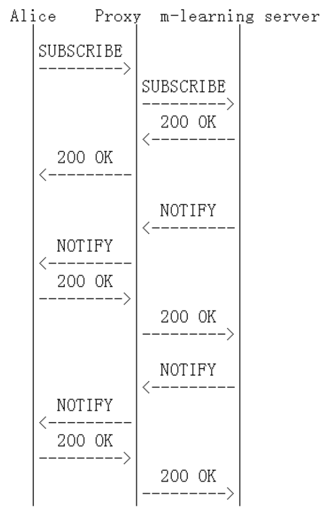

Fig. 4. Process of subscribe courseware

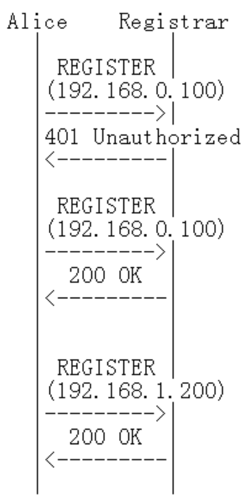

Fig. 5. Process of register and re-register

The user entity is also responsible for implementing mobility. Once the user entity detects that the terminal device has changed its network connection, it will re-register to the registrar with the new network address of the terminal device as the new contact address, ensuring that the future requests of the user entity will be routed to the new address. If the user entity is already in a SIP session, say, having a call with someone or playing a courseware, it will begin an update flow to refresh the contact address and the media address in SDP, so that the media stream will be continued with only a short interrupt. The register and reregister flow is illustrated in figure 5. The session update flow is shown in figure 6.

In this flow, the user entity of Alice registers its contact address of 192.168.0.100 to the registrar. On receiving the SIP REGISTER message, the registrar will authenticate the message originator by responding the user entity with a SIP response message of 401 Unauthorized. The user entity gets the challenge information in this response message and calculates a challenge response based on challenge, user name, password and other information. A new REGISTER message containing this response will be sent again to the registrar. The registrar will check this challenge response. If the response matches the one in registrar, which means the authentication is succeeded, the registrar will return a response message of 200 OK to Alice. If anytime the network connection changes, which results in IP address changing to 192.168.1.200, the user entity of Alice will re-register to registrar with a new contact address of 192.168.1.200 and an old challenge response. The registrar will save the new address in its database and response Alice with 200 OK. The SIP message details are as follows:

```
REGISTER sip:nbut.cn SIP/2.0
From: <sip:alice@nbut.com>;tag=nVfdNPfdu7qq_tnj*t4-
U39aC8
To: <sip:alice@nbut.com>
Call-ID: fverVterCnrc.PmB9P5OeciLSb@192.168.0.100
Contact: <sip:alice@192.168.0.100:7060>


SIP/2.0 401 Unauthorized
From: <sip:alice@nbut.cn>;tag=nVfdNPfdu7qq_tnj*t4-
U39aC8
To: <sip:alice@nbut.cn>;tag=7849
Call-ID: fverVterCnrc.PmB9P5OeciLSb@192.168.0.100
WWW-Authenticate: DIGEST realm="nbut.cn", algo-
rithm=MD5,nonce="dd2de673348f1d19337082e347115bf1"

REGISTER sip:nbut.cn SIP/2.0
From: <sip:alice@nbut.cn>;tag=nVfdNPfdu7qq_tnj*t4-
U39aC8
```

```
To: <sip:alice@nbut.cn>
Call-ID: fverVterCnrc.PmB9P5OeciLSb@192.168.0.100
Contact: <sip:alice@192.168.0.100:5060>
Authorization: Digest user-
name="alice@nbut.cn",realm="nbut.cn",nonce="dd2de673348
f1d19337082e347115bf1",uri="sip:nbut.cn",response="a487
130029eae4a850da14342dfaf682",algorithm=MD5

SIP/2.0 200 OK
From: <sip:alice@nbut.cn>;tag=nVfdNPfdu7qq_tnj*t4-
U39aC8
To: <sip:alice@nbut.cn>;tag=6101
Call-ID: fverVterCnrc.PmB9P5OeciLSb@192.168.0.100
Contact: <sip:alice@192.168.0.100:5060>;expires=3600

REGISTER sip:nbut.cn SIP/2.0
From: <sip:alice@nbut.cn>;tag=ImJMioJMu7qq_tnj*t4-
V.QmE_
To: <sip:alice@nbut.cn>
Call-ID: xgA5+eA5H+Pdgz4AeznPA.Q_E8@192.168.0.100
Contact: <sip:alice@192.168.0.100:5060>
Authorization: Digest user-
name="alice@nbut.cn",realm="nbut.cn",nonce="dd2de673348
f1d19337082e347115bf1",uri="sip:nbut.cn",response="a487
130029eae4a850da14342dfaf682",algorithm=MD5

SIP/2.0 200 OK
From: <sip:alice@nbut.cn>;tag=ImJMioJMu7qq_tnj*t4-
V.QmE_
To: <sip:alice@nbut.cn>;tag=6792
Call-ID: xgA5+eA5H+Pdgz4AeznPA.Q_E8@192.168.0.100
Contact: <sip:alice@192.168.0.100:5060>;expires=3600
```

In the flow of playing courseware and updating session as illustrated in figure 6, Alice chooses to play a courseware, which could be retrieved from her courseware list. This triggers the user entity to send a SIP INVITE request message to the m-learning server, with a courseware URI such as sip:coursewareA@nbut.cn in its request URI and an IP address of 192.168.0.100 both in contact head field and SDP. After receiving this message, the server will prepare for playing this courseware. After it is done, the server will respond with a 200 OK message to Alice, and Alice will send back an ACK message to acknowledge the receiving of 200 OK. After the

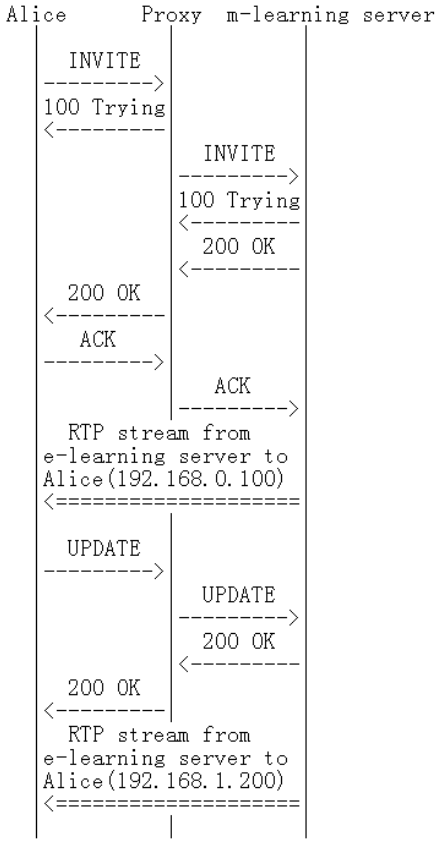

Fig. 6. Process of playing courseware and updating session

three-way SIP signal is completed, an RTP media stream will be sent directly to Alice from m-learning server. The stream can be either audio or video. The user entity of Alice will properly play it for Alice. If Alice moves and IP address changes to 192.168.1.200, the user entity will send an UPDATE message with a new address of 192.168.1.200 both in contact head field and SDP to update the SIP session. Then the RTP stream could be sent to the new address and the future SIP message in the same session could be sent to Alice correctly.

5 Conclusion and Future Work

In this paper we first analyzed the attributes that a general m-learning system should cover, then explored the advantages of applying SIP in m-learning systems. An optimized scheme for m-learning using SIP is proposed after that. We can see that by introducing SIP, we get excellent personal mobility and service mobility that are impossible to get in traditional m-learning systems using HTTP. More interactive and real-time m-learning applications can be implemented based on the optimized architecture. Courseware is available to be subscribed and played anytime and anywhere, sessions could be continued and updated seamlessly with the movement of users. However, SIP mobility cannot support TCP connections, while there are still many m-learning applications running on TCP, such as HTTP and FTP services. This problem can be solved by integrating Mobile IP technology into SIP. The integration of SIP and MIP on m-learning is left for future study. Moreover, the current m-learning system only includes basic e-learning functions, more complex applications, like multi-party conference, courseware sharing, and virtual whiteboard, can be added in the future.

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