Web-based Learning Support Systems

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Abstract

With the rapid development of the Internet and advances in multimedia technologies, web-based educational systems are becoming popular. Due to different types of learners using these systems, it is necessary to provide them with an individualized learning support system. A framework of web-based learning support system (WLSS) is presented by focusing on learning process and activities, as well as the technology support needed. Based on the learner-centered mode, we demonstrate an online course design and development that supports the students with the flexibility and the adaptability. We present an approach on the use of check point analysis mechanism which guide them to the relevant learning materials in order to achieve their learning goals effectively.

1. Introduction

Web-based educational systems are becoming more and more popular and are used for teaching and learning. However, most systems are still limited to dissemination of teaching materials [1]. The learning process is more complex than navigating between different static pages and reading them. There is a need for mechanisms that modify the navigation alternatives by some sort of adaptation, so that the students can be guided to achieve their learning goals.

Not all students have the same ability and skills to learn a subject. Students may have different background knowledge for a subject, which may affect their learning. Some students need more explanations than others. Other differences among students related to personal features such as age, interests, preferences, etc. may also affect their learning [1]. Moreover, the results of each student’s work during the learning session must be taken into account in order to select the next study topics to the student [2].

It is very important to design learning support systems in order to maximize the strength of the WWW and fully utilize the functions that support interactive, personalized and collaborative learning.

In this paper, we first briefly discuss the concept of web-based learning support systems (WLSS) and examine the main functions and characteristics of such systems. Based on the general guideline, we report our experience in the design and implementation of a web-based learning support system for teaching an undergraduate course.

2. Learning and Learning Support Systems

A definition of learning is given by Gagne : [3]

“a process of which man and the animals are capable. It typically involves interaction with the external environment (or with a representation of this interaction, stored in the learner's memory). Learning is inferred when a change or modification in behavior occurs that persists over relatively long periods during the life of the individual.”

Learning is an interactive, dynamic and active feedback process with imagination driving action in exploring and interacting with an external environment [4]. There are two main learning styles: group learning and individual learning. Group learning is used in the traditional classroom learning. Teacher and students communicate in real time manner. This is the teacher-centered form of education. Feedback is the two-way communication between teacher and students. It requires high operational cost. Individual learning is student-centered form of education. In this learning style, learners study the material individually, and the teacher acts as a supporter, such as web education. This learning style provides personal flexibility with low cost.

2.1 Web-based Instruction

The major difference between the web-based and conventional instruction system is that students can choose their own paces for learning. They can skip those materials that they have already learned or known. They can replay the course that they were not thoroughly understood. However, most of web-based courses are not as “flexible” as human instructor [5]. Typically, course material is a network of static hypertext pages with some media enhancement. Neither the teacher nor the delivery system can adapt the course presentation to different students. As a result, some students waste their time...
learning irrelevant or already known material, and some students fail to understand (or misunderstand) the material and consequently overload a distance teacher with multiple questions and requests for additional information. Therefore, the web-based system needs to overcome the deficiencies of inflexible instruction from conventional face-to-face group learning, and potential inflexibility from not having face-to-face feedback from students to instructors.

2.2 Characteristics of Web-based Learning Support Systems

Building a web-based learning support system is relatively easy from the technical point of view. However, analyzing, designing and implementing the system to achieve better teaching and learning result is a difficult process. The system should consider the following features.

- Complexity of learning support:

Obtaining knowledge means going through a process of learning. The learning process is complex. Many human senses interact and collaborate. Already obtained knowledge and experiences are used to prove and verify the new cognition [5]. Discussions are used for information exchange, and examples help to strengthen and solidify skills. Different learning styles complicate the situation. Without taking these into consideration, the knowledge is often presented in a fixed manner. Neither textbooks nor online texts can actually answer questions. The student is provided with only information.

- Individuality and adaptability support:

Individuality means that a WLSS must adapt itself to the ability and skill level of individual student. Adaptive methods and techniques in learning have been introduced and evaluated since the 1950’s in the area of adaptive instruction and the psychology of learning [6]. Adaptive instructional methods adapted the content of the instruction, the sequencing of learning units, the difficulty of units, and other instructional parameters to the students’ knowledge. These methods have been empirically evaluated and shown to increase learning speed and to help students gain a better understanding through individualized instruction.

According to Brusilovsky [3], there are several goals that can be achieved with adaptive navigation support techniques, though they are not clearly distinct. Most of the existing adaptive systems use link hiding or link annotation in order to provide adaptive navigation support. Link hiding is currently the most frequently used technique for adaptive navigation support. The idea is to restrict the navigation space by hiding links that do not lead to “relevant” pages, i.e., not related to the user's current goal or not ready to be seen. Users with different goals and knowledge may be interested in different pieces of information and may use different links for navigation. Irrelevant information and links just overload their working memories and screen [3].

De Bra [7] presented a course that uses a system they developed to track student progress and based on that, generate document and link structure adapted to each particular student. Links to nodes that are no longer relevant/necessary or links to information that the student is not yet ready to access are either physically removed or displayed as normal text.

Da Silva et al [8] use typed and weighted links to link concepts to documents and to other concepts. The student’s knowledge of each concept is used to guide him/her towards the appropriate documents.

- Interaction support

The web-based learning support system must be interactive. Students must be able to communicate with the system. Users should be able to add personalized annotations and notes to the prepared knowledge base. It should allow the students asking questions and automatically retrieving a proper answer. WBIRSS (Web Based Information Retrieval Support System) may be a useful solution to this problem [9]. Discussion group is an important feature of the support system to improve the learning efficiency.

- Activity and assessment support

One of the most difficult challenges of web-based learning mechanism is the assessment of students’ learning process. It is hard to judge the behavior of a student since the instructor is separated spatially from the students. Testing and check points are important from the point of view of evaluating and assessing the student progress [10].

Examples and exercises are used to strengthen the students understanding through practice. The system should provide the students the possibility not only to look at the examples, but also be able to modify them, try them out and get feedback on their solutions.

3. Implementation of a WLSS Using WebCT

The design of on-line courses involves different actors. These actors have different requirements. The teacher needs a tool easy to use in order to create the educational
material. The student needs something more than a mere transfer of a book in electronic format. They need some sort of guidance, a high level of interactivity and a tool for accessing the learning process. The site administrator, finally, needs an easy to maintain system for updating the content and the information about the users.

WebCT (Web Course Tools) is a web-based instructional delivery tool, which facilitates the construction of adaptive learning environments for the web. It enables instructors to create and customize their courses for distance education [11]. It provides a set of educational tools to facilitate learning, communication, and collaboration.

The system can facilitate active learning and handles diverse learning styles. It allows the instructor to present his/her course materials using a variety of mediums to make the course dynamic and interactive. By creating a module of selected material and having a quiz at the end, the instructor can selectively release course materials based on the quiz score from the previous module. The student tracking within the Content Module allows the instructor to observe individual student activity. This can be used for online grading based on participation.

Using WebCT, a core computer science course “data structure and algorithm analysis” has been designed. In order to provide an in depth understanding of the fundamental data structures and to motivate the students, a web-based adaptive course with analysis tool based on student learning styles has been proposed. The course has been designed with adaptability and it has been taken into considerations for student individual learning styles. The web learning course structure can be better understood through Fig. 1. One of the screen shot of the course material is shown in Fig. 2.

![Figure 1: The design structure for the course](image1)

The WebCT system uses a client/server architecture. This model is based on the distribution of functions between two types of independent and autonomous processes: client and server. The system consists of WebCT software and a number of hierarchically organized files for each course. The user accesses the data on the server through a web browser. All the WebCT software resides on and runs off a server, which means any changes made to courses are accessible to students immediately after the change is made. The system provides an environment to cover all aspects of a course such as tools for creating the course materials, lectures, assignments, quizzes, and discussion groups.

In the following sections the structure of the web course and how this structure contributes to our approach to provide adaptation will be presented.

The students’ goal of taking the course is to learn all or most of the course materials. However, the learning goal can be differentiated among different students according to both their expectations with respect to the course and their knowledge about the subject being taught, the latter
being the most important user feature in web-based educational system [3].

Our approach utilizes the adaptive navigation support system in WebCT. At the current stage, the structure of the course is organized around chapters that consist of several concepts. The contents of the course is designed and implemented as a collection of modules (under Content Module). Each module has well defined learning objectives. Figure 3 shows the adaptive menu of the web course material.

At the end of each chapter, the web course provides a quiz with automatic feedback. The quiz consists of a set of questions with predefined answers, and the result obtained by the student will have influences over the presentation of the subsequent course contents. The web course system allows the students to test his/her level of knowledge and understanding of the concepts and also permits the dynamical paths among the contents of the course.

![Figure 3: Screen shot of the demonstration of the adaptive course material](image)

For example, as showed in Figure 3, if the student complete the Chapter One, he need to take the quiz, which will determine whether or not he acquired the minimum level of knowledge required to moving forward to the next stage of learning. This process will identify the next chapter to be presented. Therefore the following subsequent chapters are set up as conditional.

These chapters are only presented when the student satisfy the basic requirement. In the case the student has failed the quiz, the student will be recommended to go back and study the same content one more time. The questions contained in the quiz are designed to determine whether or not the student has acquired the required level of knowledge for the chapter. The difficulty levels of the individual question associated to the content have been taken into account. Hence each question has different weighting towards the total grade of the quiz.

4. Check Point Analysis

The notion central to our implementation of the web-based support system is check point analysis. We divide the learning process into many stages. The success of a student is checked at many points.

Several software systems have been designed with online testing [12][13]. Most of these systems provide automatic grading for quizzes with multiple choice and true/false questions. WebCT has been designed to perform online testing of answers whose correct syntax can be specified as regular expressions. The online grading system provides limited feedbacks towards the students learning problems with the course materials. As mentioned earlier, if the student has failed the quiz, he has to go back and study the material again. However, these systems do not provide the specifics on which section he needs to spend more time to study and which concepts he has difficulty to understand.

A primary concern for web-based learning support system is the design of an appropriate structure so that a student can easily and naturally find the most relevant information depending on his/her needs.

| Table 1. The relationships between questions and concepts for algorithm analysis module |
|---------------------------------|---|---|---|---|---|---|---|---|
| q1 | x |    |    |    |    |    |    |    |
| q2 | x |   | x  | x  |    |    |    |    |
| q3 | x |    |    |    |    |    |    |    |
| q4 |    |    |    |    |    |    |    |    |
| q5 |    |    |    |    |    |    |    |    |
| q6 |    |    |    |    |    |    |    |    |
| q7 |    |    |    |    |    |    |    |    |
| q8 |    |    |    |    |    |    |    |    |
| q9 |    |    |    |    |    |    |    | x  |
| q10|    |    |    |    |    |    | x  |    |
Table 2. The description of concepts and the related questions

<table>
<thead>
<tr>
<th>Concept</th>
<th>Description</th>
<th>Associated questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>c₁</td>
<td>Big O</td>
<td>1</td>
</tr>
<tr>
<td>c₂</td>
<td>Empirical method</td>
<td>2,3</td>
</tr>
<tr>
<td>c₃</td>
<td>Simulation method</td>
<td>2,4</td>
</tr>
<tr>
<td>c₄</td>
<td>Analytical method</td>
<td>2,5</td>
</tr>
<tr>
<td>c₅</td>
<td>Complicated computer model</td>
<td>6,7,8</td>
</tr>
<tr>
<td>c₆</td>
<td>Simplified computer model</td>
<td>7</td>
</tr>
<tr>
<td>c₇</td>
<td>Recursive functions</td>
<td>9</td>
</tr>
<tr>
<td>c₈</td>
<td>Repeated substitution</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 3. The questions and the related concepts

<table>
<thead>
<tr>
<th>Questions</th>
<th>Associated Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>q₁</td>
<td>c₁</td>
</tr>
<tr>
<td>q₂</td>
<td>c₂, c₃, c₄</td>
</tr>
<tr>
<td>q₃</td>
<td>c₂</td>
</tr>
<tr>
<td>q₄</td>
<td>c₃</td>
</tr>
<tr>
<td>q₅</td>
<td>c₄</td>
</tr>
<tr>
<td>q₆</td>
<td>c₅, c₆</td>
</tr>
<tr>
<td>q₇</td>
<td>c₅</td>
</tr>
<tr>
<td>q₈</td>
<td>c₅</td>
</tr>
<tr>
<td>q₉</td>
<td>c₇</td>
</tr>
<tr>
<td>q₁₀</td>
<td>c₈</td>
</tr>
</tbody>
</table>

In order to aid the students to improve their study effectiveness and efficiency, a check point analysis mechanism is adopted in the online course design. As demonstrated in Tables 1, 2 and 3, the students will be provided with these three tables in each module that clearly indicate the relationships between the questions and the related concepts in the course materials.

For example, Algorithm Analysis module, in Table 1, question q₆ is related to concepts c₅ and c₆. In Table 2, concept 5 is related to “complicated computer model”, concept 6 is associated with “simplified computer model”; Table 3 lists all the questions that related to concept 6.

If a student has failed the quiz, and the most marks have been deducted from the question 6, he can look up the tables to analyze his weak point. First he would find out that the question 6 is related to concept 5 and 6, which is related to “complicated computer model” and “simplified computer model”. This tells the student that he needs to spend more time on these two concepts related sections in the course contents. If the student has more than one question wrong, the table can show him whether these questions are fall into the same category of concepts or different ones. Therefore students can select the relevant part of the course materials to study.

These tables also provide very important information about the course and student learning to the instructors too. The instructor will be able to use the error rate to redesign the course material and analyze the students learning in order to provide relevant support.

Figure 4 shows the example of Object Oriented Design module with the check point analysis.

5. Conclusions

The introduction of the web offers new opportunities and challenges for educators. It opens a new door for computer-aided instruction. Web-based learning support systems (WLSS) are designed based on the student-centered philosophy. Such systems assist students in every stage of learning.

The basic features and ideas of WLSS are discussed in this paper. To illustrate those ideas, we implemented a learning support system for helping the students’ study of the data structure and algorithm analysis course.

Our primary goal is to provide an adaptive learning support environment that will effectively accommodate a
wide variety of students with different skills, background, and learning styles.

A model for check point analysis has been presented. The system allows the students to analyze their learning progress, and guides them towards the relevant course contents to achieve their learning goals during their learning process. The model also provides important information about the course and student learning to the instructor too. The instructor will able to use the error rate to redesign the course material and analyze the students learning in order to provide relevant support.

Neural network and data mining techniques may be applied in our future work to analyze the students learning patterns, and provide the instructors or designers to organize the online course more effectively.

6. References


