Applications of a Time Sequence Mechanism In the simulation Cases of a web-based Medical Problem-Based Learning System

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ABSTRACT

The prevalence of Internet applications nowadays has led many medical schools and centers to incorporate computerized Problem-Based Learning (PBL) methods into their training curricula. However, many of these PBL systems do not truly reflect the situations which practitioners may actually encounter in a real medical environment, and hence their effectiveness as learning tools is somewhat limited. Therefore, the present study analyzes the organization of a computerized PBL teaching case, and considers how a clinical teaching case can best be presented to the user. Specifically, this study attempts to develop a web-based PBL system which emulates the real clinical situation, in which a practitioner will ascertain the true nature of a patient’s condition over a period of time, by introducing the concept of a “time sequence” within each teaching case. The proposed system has been installed in the medical center of National Cheng Kung University in Taiwan for testing purposes.

Introduction

Recently, many medical schools and centers had adopted a variety of approaches in an attempt to address various problems of the traditional medical training methods. In particular, as the Internet becomes prevailing, one such approach has been to introduce computerized Problem-Based Learning (PBL) techniques using a browser (DxR, 2006; Norman, & Schmidt et al., 1992). (It is acknowledged that the word “PBL” may be regarded by some as controversial. Nevertheless, its use is retained by the current authors since it is not the main concept addressed within the present paper.) In the medical field, this approach involves the presentation of clinical cases as a means of learning basic medical and clinical science (Bryce, & King et al., 1999; Joines, & Barton, 2000). Previous studies have confirmed that implementing PBL techniques on computer networks provides an effective training tool for physicians or students in medical schools, and enables these users to acquire the necessary knowledge and experience required to perform accurate diagnoses in their actual clinical practices (Diana, & Dolmans et al., 2002; Barrows, & Tamblyn, 1980). The basic three steps (Barrows, 1985) of a computerized PBL system within the medical training field are as follows: (1) Students are puzzled and challenged by the patient’s problems that are given all at once. (2) The system will provide some selection types of questions for the students to get more information needed, such as questioning the patients and ordering some laboratory tests. After the students’ selection, the corresponding answers to the questions will be provided so that the students can get more information about the patient’s status. For instance, the system enables the users to select any kind of laboratory tests and provides the answers to them to emulate the real clinical situation. (3) The students can repeatedly interact with the system interactively and work on their ways in an attempt to diagnose and cure the patient’s problem. Current web-based PBL systems do help students’ learning to some extents, they suffer from several serious drawbacks, which degrade their effectiveness as learning aids. For example, they do not truly reflect the typical clinical situation, in which a patient’s condition may evolve over time. This drawback basically arises from the manner in which the data related to a particular teaching case is presented to the user.

Consequently, this present study considers how a computerized PBL teaching case should best be presented to the user such that it serves as a truly effective learning tool (Gülseçen, & Kubat, 2006; Cheng, & Chen et al., 2003;
Segers, & Bossche et al., 2003). The theoretical aspect of the computerized PBL has been studied extensively in (Herrington, & Oliver, 2006; Herrington, & Oliver et al., 2003) which described it as online authentic learning. This study focuses on how the theoretical concepts described above can be designed and implemented in a real system for a specific learning environment of the medical education. The study also discusses the implementation of a prototype system, which is currently being used to test the approach proposed. In Section 2, we briefly describes the concept of the teaching case template adopted by the proposed system. Furthermore, the background to the most commonly available computer-based or web-based PBL systems (Rolf, & Uno, 2003; Kimball, & Shin et al, 2003; Hjelm, & Lee et al., 2002) is discussed, and their relative drawbacks are analyzed. The adoption of a time sequence concept within the computerized PBL teaching cases as a means of addressing these limitations is also discussed. Section 3 adopts the concept of a time sequence in proposing various storage and presentation formats for medical teaching cases. In order to really demonstrate the idea of the time sequence, we also implement the idea in a web-based computerized PBL teaching case system that allows users to simply use a WWW browser to browse the contents of the system. Section 4 discusses the architecture of the proposed system and its implementation, and Section 5 describes the results of our experiments with the proposed system. Finally, we give some brief conclusions of the present study in Section 6.

![Figure 1. The layout of the main HINTS windows](image)

**Relevant background**

**Description of HINTS**

For explanation purposes, we first briefly give an example of how HINTS works. The main window of HINTS is shown in figure 1. The left panel of the window is the display of the teaching cases organized as a tree-structure. The right panel of the window is the display of the sections of a given teaching case. The student is supposed to select a case first, then select one of the sections for browsing the selected case. The contents of the corresponding section will be displayed at the center portion of the window. The HINTS is basically a PBL system in which the student is challenged by the initial status of a patient and works his way toward a correct final diagnosis (by browsing through several sections) followed by patient management until the patient is completely cured. In other words, HINTS is a simulation system that allows the users to diagnose and cure the virtual patient in the system. In the HINTS, the student is first challenged by the patient's chief complaints and reads the patient's basic information section where the patient's height, weight, age and so on are described. Then, in the present illness section the system will present to the student many questions to ask the patient. The student is supposed to select which questions are critical to ask in order to reach a correct diagnosis for this particular case and the corresponding answer to the selected question will be shown by the system. In the Physical Examination (PE) section, the system presents a patient's figure as
shown in figure 2(a). The student is supposed to first select one of the PE types: Inspection, Palpation, and Auscultation followed by clicking on the portion of the human body where the selected PE should be carried out. The system will respond with the associated multimedia information, such as the heart beat sound for the auscultation of a certain point on the patient's chest, and the picture of the skin for the inspection of a certain portion of the patient's body. In the laboratory section, the student is supposed to enter a hypothesis – a disease name followed by clicking on various test items as shown in figure 2(b) to test against the hypothesis. The system will display the associated test results, such as Computed Tomography (CT) images or Ultra-sound images. The same process can be repeated over and over again. In the course of this diagnosis procedure, the student can go back and forth among these sections until he or she gets enough information and feels comfortable to give a correct final diagnosis followed by the patient management section.

2(a) the section on Physical examination

2(b) the section on Laboratory tests

Figure 2. The presentation of the Physical examination and Laboratory test
The HINTS is a complicated multimedia simulation system that allows students to deal with the virtual patient in the system to emulate dealing with a real clinical case.

**The concept of teaching case templates**

In order to explain how the developed prototype system is implemented, it is first necessary to introduce the concept of the PBL teaching case template. The developed PBL teaching case system is essentially a multimedia CAI (Computer Aided Instruction) system. Generally speaking, such systems comprise three basic models, namely a knowledge model, a student model, and a tutor model (Clancey, 1987).

**Knowledge model**

The knowledge model is a database containing the knowledge of specific topics which an expert in that particular domain could reasonably be expected to possess. The data stored within the knowledge model represent the knowledge which is to be taught to the student, and should ideally be stored in an abstract fashion such that the model is capable of dealing with different learning situations in a flexible and intelligent manner. Therefore, the current knowledge model utilizes a number of “teaching case templates” (Cheng & Chen et al., 2003) to form an abstract model of the domain knowledge. In other words, the templates outline the main contents of the various teaching cases, and serve as the directories of each case. A typical medical teaching case might well include the following sections: (1) basic personal information such as the patient's age and gender, (2) a brief case history, (3) reported complaints, (4) results of physical examinations, (5) findings, (6) the diagnosis, (7) relevant cases, (8) discussions, (9) comments, and (10) learning points (i.e., learning goals of the teaching case). The details of all sections of the template can be presented via hypermedia techniques. The authors of the PBL system are provided with the tools required to create a case template or select a case template from an existing case template database, in which each template has a defined name and an appropriate set of titled sections, e.g. History, Diagnosis, etc as described above. If necessary, each of these sections can be further partitioned into several sub-sections. It is noted that a single teaching case template may be used by many teaching cases of the same type. Each teaching case within the system identifies the particular case template which it uses.

**Student Model**

For each student this model includes the following: (1) student profile, i.e. basic information about each student, including name, ID, department, student level, etc, (2) records of the case categories which that student is interested in, (3) records of the cases which that student has reviewed, and (4) performance evaluation results.

**Tutor Model**

This model mimics a human tutor, and is responsible for managing the overall learning environment (Cheng & Chen et al., 2007).

**Discussion of the drawbacks of the current computerized PBL teaching case systems, and an introduction to the concept of time sequence in a teaching case**

In many computer-based or web-based PBL teaching case systems (Rolf & Uno, 2003; DxR, 2006; Giardina & Oubenaissa et al., 2002) as briefly described in three steps before, the user is first presented with basic patient information and details of the patient's principal complaints. He is then provided with the means to specify the sources from which he wishes to get relevant information to the case, e.g. history taking information, laboratory examination items, etc. The detailed information, as the answer to the selected items, is then retrieved and presented to the user, who can then select whichever information he feels to be necessary to make an appropriate final diagnosis. Once the user has provided his diagnosis, the system will assess his performance in completing the teaching case.
In this type of computerized PBL teaching case, all of the relevant information relating to a particular case is lumped together within the system. However, in practice, it is far more likely that this information will be accumulated gradually over a long period of time. In other words, conventional computerized PBL techniques do not include the concept of a “time sequence” of events within their teaching cases. For reasons of convenience, this type of teaching case will be referred to as a “lump-teaching case” throughout the remainder of this paper. Although this type of teaching case may be of some value for training purposes, it is nevertheless rather unrealistic, and suffers from the following drawbacks:

- In many cases, a medical practitioner is unable to make a final diagnosis after the patient’s first visit. Several patient visits may be needed before the final diagnosis can be made. During the on-going course of diagnosis and treatment, the results of the physical examinations, and the patient’s response to the prescribed medicine, may lead the practitioner to consider or to discount various diagnoses. Each stage in the medical decision-making process has its own reasoning and inference procedures. To accurately represent the medical situation described above, and to emulate the associated decision-making processes, it is important that the PBL teaching case presents the various events in an appropriate time sequence. The overall diagnosis and treatment of a patient may well involve a series of treatments and physical examinations, and hence the diagnosis and treatment process can be regarded as a series of events taking place at different points along a time axis instead of happening all at once as described in most of the current computerized teaching cases found on the web.

- There are some other situations where the concept of time sequence in a teaching case is necessary. For instance, in many actual cases, local regulations may prevent the medical practitioner from scheduling physical examinations at will, or at least not unless the patients are willing to meet the cost of these examinations from their own pockets. For example, in Taiwan, the National Health Insurance Scheme, which is administered by the central government, does not permit a medical practitioner to schedule certain physical examinations until other preliminary tests have first been performed to confirm that the further examination is truly necessary. This policy exists to avoid wasting limited insurance fund resources, and furthermore, to protect the patient’s general health, since some examinations may cause physical discomfort, or even physical harm. Although the example cited above refers specifically to Taiwan, the same situation is common in many other countries which operate similar health insurance policies, or to cases where private insurance companies will meet the cost of the examination.

- From a purely clinical perspective, the physical examinations should be sequenced in such a way that the cheaper, non-invasive, and safer examinations are performed first. The more expensive, invasive and riskier examinations are performed at a later stage in the course of treatment if and when they are called for. In most computerized teaching cases which lump all of the information together, it is difficult to determine whether or not a student is following the correct line of thought in scheduling the appropriate examinations in an appropriate sequence.

The main point of the preceding discussions is that each of the events within a course of treatment occurs at a discrete time, and hence this sequence of events and the corresponding accumulation of the thinking processes should somehow be emulated within the computerized PBL system. The theoretical aspect of the computerized PBL has been studied extensively in (Herrington, & Oliver, 2006; Herrington, & Oliver et al., 2003) which described a practical framework for the design of learning environments. The framework includes nine situated learning design elements. The present study tries to incorporate the nine design elements of that framework through the concept of the time sequence in the proposed teaching case system. The system provides “time-sequence teaching cases” in which each individual event is recorded, and presented, as part of an overall sequence of events distributed along a time axis.

**Different formats of PBL teaching cases**

As indicated above, the clinical teaching case materials can either be arranged in a lump teaching case format or in a time-sequence teaching case format. From a more abstract point of view, for each format just described, there are two further formatting issues to be considered, namely the format in which the teaching materials are stored in the computer system, and the format in which these materials are then presented to the end user. For the sake of convenience, these formats are referred to as “the storage format” and “the presentation format”, respectively. The relationships of the storage and presentation formats are depicted in figure 3. This two-layer arrangement of the teaching materials allows for the de-coupling of the storage and presentation formats, e.g. a teaching case can be stored in one format and presented to the end user in the same format, or it can be re-formatted using web-based or
artificial intelligence technologies at run time and presented to the user in a manner which best meets his training needs. Thus, this arrangement greatly enhances the flexibility of the system and maximizes the usage of the data stored within it.

In the same way that there exists two storage formats, i.e. lump-storage and time-sequence, there also exists two presentation formats, i.e. lump-presentation and time-sequence presentation. Combining these various formats results in a total of four different formats, namely lump-storage lump-presentation, lump-storage time-sequence-presentation, time-sequence-storage lump-presentation, and time-sequence-storage time-sequence-presentation. The appropriate storage format for a particular case is specified by the author at the time of editing the teaching case materials into the system. However, the presentation format, which dictates how the materials within the teaching case will be displayed to the user, can be specified at run time. The various storage-presentation format combinations are described in more detail in the following paragraphs.

As described in section 2, the teaching case template represents the meta data of a teaching case, i.e. it is the basic model of the teaching case. The case template is also used to model the information associated with each patient visit, and is referred to as the “visit page”. A typical visit page includes several sections, e.g. history taking, chief complaints, physical examinations, tentative diagnoses, final diagnosis, treatment, etc. It is noted that the notation of “patient visits” is adopted as an abstract means of reflecting the time sequence of the various events which may take place during a short period of time for a particular patient. In other words, the term “second visit” may actually represent the second day of a patient’s stay in the hospital or a second separate visit to the medical practitioner.

In the lump-storage lump-presentation format, all of the case materials are stored within a single visit page. The user can then order whichever examinations he feels necessary to make a diagnosis, and can view the examination results immediately. The user can repeat this procedure continuously until he feels confident about making a final diagnosis. This format is similar to that provided by the commercially available computer-based or web-based teaching case systems described previously, and is particularly suitable for novice users who are developing their diagnosis skills. This format is also suitable for the majority of medical image teaching cases (Wong, & Hoo, 1999; Dev, 1999) in which the diagnosis procedure can be performed in “one shot”. It is noted that the adoption of this particular format greatly simplifies the author’s task in composing the teaching case.

In the time-sequence-presentation format, the user specifies whichever examinations he feels to be necessary and submits some tentative diagnoses. However, the results of the examinations are not made available to the user until he has completed the tentative diagnoses section. Once he has done so, the system automatically displays the next patient visit page, and the user can view the examination results via the “the results of the examinations” section, which is the first section in the case template for this visit page. This procedure emulates the actual situation encountered in a genuine clinical setting, and can be repeated by the user until he feels able to provide a final diagnosis. During this iterative process, the system records the user’s actions at each step such that his thinking
processes can be analyzed. For example, the system records the number of patient visits required before the user provides a correct diagnosis. In the lump-presentation format, the user is able to order several examinations at the same time, but there is no means of verifying whether he intends to perform all of them at one time (i.e., in one visit), or if he is planning to schedule them over several patient visits. Clearly, these two scenarios imply different thinking processes. In the time-sequence-presentation format, the examination orders are set out clearly along a time axis, and consequently it is far easier to track and analyze the user’s thinking process.

In the lump-storage time-sequence-presentation format, the user can order specific examinations and check the results at the next visit in an iterative fashion until he is in the position to make a final diagnosis. In this arrangement, although all of the necessary data are stored in the system in a lump format, the system still allows the user to interact with the system over a series of patient visits. This format is particularly useful when the correct final diagnosis of a particular teaching case can be reached by following a variety of different thinking processes. In other words, this format tests the ability of the user to order the correct examinations and to provide the correct diagnosis, rather than his ability to simply follow a single “correct” path of reasoning. This format is also suitable for the situation where all of the data in a teaching case can be presented in “one shot”.

In the time-sequence-storage time-sequence-presentation format, a typical teaching case consists of several visit pages of information, where each page represents the data relating to a particular patient visit at a certain point in time. This format most closely resembles the genuine clinical situation, such as the patient’s condition keeps changing over time, and gives the student a strong feeling for the actual clinical environment. Furthermore, this format is particularly suitable for those medical cases which have a standard (or predetermined) diagnosis procedure and corresponding course of treatment.

In the event that a teaching case with this particular format is beyond the ability of a novice, the time-sequence-storage lump-presentation format can be used to enable the user to browse the case in a lump-presentation format. In this learning environment, the original teaching case in a time-sequence-storage format is simply pre-processed into a corresponding lump-storage format by removing the time factor. The teaching materials are then compiled and presented to the user in a lump-presentation format.

**Implementation issues**

The implemented system contains editing tools which allow the authors to edit both the case templates and the teaching case materials. We use teaching case template as the schema of teaching case database. The case templates and the teaching case materials are then stored in the teaching case databases. When a particular case is activated, the relevant data, i.e. the associated case template and the applicable case contents, are retrieved from the databases and made available for presentation processing in accordance with the required presentation format.

As described previously, the proposed system allows for four different types of data storage and presentation formats. Therefore, it is necessary to cater for various situations at run time. One way to solve the presentation problem is to separate the mechanism which provides a specific effect for presentation purposes from the policy which determines when that specific effect should take place. In other words, the system should incorporate a series of mechanisms which can provide all the possible presentation effects which might be required without actually having to decide which particular effect should be activated. The policy which decides which presentation mechanism should be activated is established through a completely separate decision-making process. Once the mechanisms themselves have been defined, this decision-making policy may be specified at any time after the case has been installed within the system, or even at run time.

In the implementation of the proposed system, a rule table is used to specify the policy as to how a case should be presented, while switch flags are employed as mechanisms to present the same set of teaching materials in different formats or manners at run time. In the implementation, the switch flags are in fact several bits each of which controls a certain presentation function to be turned on or off so that the specific effects can take place. This is because the implementation of a presentation format involves many different switch mechanisms in the presentation flow of a teaching case. Each switch mechanism can be controlled by a switch flag. In other words, a presentation format corresponds to several switch flags each of which controls the presentation mechanism at run-time.
Regarding the teaching case presentation policy, the implemented system has two databases:

- A user profile database which records each individual user’s major (e.g. Internal Medicine) and his level of ability (e.g. “Intern”, “Specialist”, “Medical School Student”, etc.).
- A view-rule database comprising the following fields: (1) user level, (2) user major, (3) case template ID, (4) section name, (5) presentation format (i.e. lump-presentation or time-sequence-presentation), and (6) a switch flag which records how each section of the teaching case should be presented. Items 1 to 5 are used as indexes to retrieve the appropriate switch flag, which then specifies how the corresponding section is to be presented.

The user profile database must be populated by the system administrator, and the view-rule database by the authors, before the teaching cases can be published on the website. The overall architecture of the proposed system is shown in Figure 4. It is noted that all of the multimedia documents associated with the various teaching cases are stored in a teaching case database within the system in order to simplify their management.

When a user accesses the web browser and logs into the system, the system will first retrieve that individual’s major and default user level from the user profile database. When the user activates a teaching case for interactive browsing, the system will use the user’s level and major, the case template ID (stored in the case), and the specified presentation format, and based upon this information will then determine the appropriate switch flags from the view-rule database such that the data within each section is presented in the appropriate format. As shown in Figure 5(a), the system presents all of the section names associated with the particular case template in the form of push buttons on the right side of the screen. Meanwhile, in a sub-window on the left side of the screen, all of the teaching cases which the user can access and browse are displayed in the form of a hierarchical structure. It is noted that this sub-window can be closed by the user at any time if it becomes necessary to free up additional screen space to display the contents of the current teaching case (as shown in Figure 5(b)). When a particular section is activated, the system acts in the same way as a web service application system responding to a web browser’s request, and retrieves the appropriate contents from the teaching case database, references the corresponding switch flag, and then presents the contents of that particular section in the required format.

Figures 5(b) and 5(c) show typical screens relating to the second and third visits. From the discussions above, it can be seen that the switch flag corresponding to each section governs how that particular section should be presented at run time. As a result, a single teaching case can either be presented in a lump-presentation format or in a time-sequence-presentation format. Furthermore, for a given teaching case, this mechanism enables the system to present a different subset of the same teaching materials to different users. For example, if the user is a medical school
student, when he accesses the tentative diagnosis section of a case, the system can show six potential tentative diagnoses and can then prompt the user to select one of them. However, for an intern user, who is reasonably expected to possess a greater medical knowledge and more clinical experience, the system could prompt the user to enter his own tentative diagnosis -- spell out the tentative diagnoses, i.e., a fill-blank type question as opposed to a selection type question. In other words, for a single section in a teaching case template, the system has the ability to present the relevant teaching materials in many different ways. This is a highly valuable by-product of the system mechanism which was originally designed solely to implement the time sequence concept within teaching cases.
Experimental results

HINTS has been up and running in the medical center of National Cheng Kung University for 3 years. Currently, they have many practical training courses in the medicine department. The objective of the courses is to learn the skills of how to face a real patient, order laboratory test, make a diagnosis, and give treatment to the patient. We use these teaching cases in the HINTS to emulate the real cases. Currently, there are 50 teaching cases in the system for the clinical practice training of the medical school students. The system was implemented on Microsoft Internet Information Server version 6.0 (IIS) using both Microsoft ASP (Active Server Page).Net, and SQL database technologies. Students can simply use the WWW (World Wide Web) browser to login to the HINTS and browse the teaching cases at the computer center in the medical school or at home, if a wide bandwidth Internet connection is available. Before the mechanism of time sequence was installed in the system, there were more than 200 medical school students from the 5th to 7th grades (equivalent to 1st to 3rd grade students in a medical school in the American medical education system) had experienced in using the system.

1. Understand all items
2. Define the problem
3. Analyses the problem
4. Synthesize
5. Define learning objective
6. Self-study
7. Report back

1-5: pre-discussion  7: post-discussion

Since the main purpose of this study is to investigate how a teaching case that have multiple visits should be implemented in a real computerized simulation learning environment, such as the HINTS, we need to find out whether the designed time sequence in teaching case is really effective in particular for the training of the thinking
process. The participants of the experiments are fifty medical students ranging from Grade 5 to Grade 7. The learning process is structured according to the seven-jump procedure (Segers, & Bossche, 2003), as shown in figure 6.

Procedures

Prior to the experiment, we demonstrated the HINTS operation including the time-sequence-presentation to all the students and made sure the students could use HINTS without difficulty. At the beginning (the first classroom lecture for a case), the instructor gave the students some background knowledge about the particular case in the classroom. There were 6 teaching cases used in the experiments: 2 simple ones, 2 mediocre ones, and 2 difficult ones. The students browsed through these cases sequentially. Then, the students browsed through the case including reading through the basic information and chief complaints sections in the HINTS, specifying which part of the patient body should be examined, what questions should be asked, and what laboratory test should be ordered to get more information and insight about the patient’s status from the HINTS. They went through several patient visits as time went on, and finally gave their final diagnoses for the exercise.

Furthermore, right after the students finished their browsing of the six teaching cases, they were asked to fill in an on-line questionnaire to collect the system evaluation data. The questions in the questionnaire were designed simply to see whether our design and implementation of the time sequence mechanism in teaching case was effective or not. In order to obtain a reliable survey result, expert validity was adopted in this study. The questions in the questionnaire were reviewed, revised, and eventually approved by 6 experts including three medical education experts, one statistics expert, and two information science experts. In the second classroom lecture, the instructor and students discussed their results computed by the HINTS and experiences”.

Results

Table 1 uses a five-point Likert Scale and summarizes the student responses to a series of questions posed by the current researchers. The students have also made a variety of comments after using the various teaching cases in the system. The principal results of this study may be summarized as follows (some of the results are provided by the instructors).

<table>
<thead>
<tr>
<th>Question</th>
<th>Percentage of Respondents % (n=50)</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice can improve the individual learning process?</td>
<td>28 72 0 0 0 4.28 (0.45)</td>
<td></td>
</tr>
<tr>
<td>The use of multiple visits can simulate the real clinical situation?</td>
<td>6 94 0 0 0 4.06 (0.24)</td>
<td></td>
</tr>
<tr>
<td>The operation of the multiple visits cases was easy?</td>
<td>6 72 22 0 0 3.84 (0.50)</td>
<td></td>
</tr>
<tr>
<td>The multiple patient visit cases enable you to learn and trace more about the patients’ condition?</td>
<td>12 88 0 0 0 4.12 (0.32)</td>
<td></td>
</tr>
<tr>
<td>The system can improve the capability of the clinical service?</td>
<td>12 88 0 0 0 4.12 (0.32)</td>
<td></td>
</tr>
<tr>
<td>The limited number of patient visits makes the case more interesting and more challenging?</td>
<td>28 44 28 0 0 4 (0.75)</td>
<td></td>
</tr>
<tr>
<td>Do you think the time-sequence-presentation case better resemble the actual clinical setting and provide better feeling for what actually takes place in an authentic clinical environment than the lump-presentation case?</td>
<td>36 64 0 0 0 4.36 (0.48)</td>
<td></td>
</tr>
</tbody>
</table>
All of the students feel that the teaching cases presented using the time-sequence-presentation format approach better resemble the actual clinical setting, and provide a better feeling for what actually takes place in an authentic clinical environment than the cases presented using the lump-presentation format.

All of the students believe that the system can significantly develop their skills for dealing with real clinical cases. Furthermore, when a patient’s condition evolves over time, it is felt that the concept of a time sequence within the teaching case is particularly meaningful especially, for those complex teaching cases.

All of the case templates within the implemented system include a learning points section, which can be accessed by the user after he has completed a particular teaching case. All of the students believe that this is a highly useful function.

72% of the students think that if the system limits the number of patient visits a student can have during the diagnosis procedure of a teaching case, it will cause the teaching case to become more interesting and more challenging.

Through the analysis of the logs of the HINTS server, the students spent 58 minutes for browsing a case with the time-sequence-presentation while they spent 29 minutes for a case without the time-sequence-presentation on average. When we interviewed the students for collecting their opinions about the system, they expressed that it took a long time to finish a case. They thought that the reasonable time duration for browsing such a case should be around 45 minutes. This suggestion is useful for the future development of the teaching case with the time sequence mechanism built-in.

The time-sequence-presentation of a teaching case enables the teacher to check whether the student has ordered the appropriate physical examinations at the appropriate stage of the diagnosis process, i.e. from cheap, non-invasive, and safe examinations during the initial stages, towards more expensive, invasive, and riskier examinations towards the latter stages. Additionally, the system also presents statistics relating to the provision of correct and incorrect answers, and therefore allows the teacher to analyze a student’s progress in adhering to an appropriate diagnosis procedure as his training program continues.

**Conclusion**

This study has incorporated the theoretical framework of online authentic learning (Herrington, & Oliver, 2006; Herrington, & Oliver et al., 2003) and has proposed the concept of a time-sequence in the storage and presentation formats of computerized PBL teaching cases. An interactive PBL teaching case system has been implemented which introduces this concept by separating the mechanism which provides the required presentation effect from the policy which specifies which mechanism to activate. Experimental results have indicated that users feel strongly about the way in which cases are presented to them.

Furthermore, the users have confirmed that the teaching cases are more interesting and challenging when the time sequence concept is used, and that these cases provide a better feeling for the actual clinical environment which they will work within in the future. Using the same framework which enables the system to provide different presentation formats, the system can also be customized to meet an individual user’s particular training requirements. Although this paper has presented a series of preliminary experiments involving the time sequence concept, it is acknowledged that the long term impact of the proposed system for medical education as a whole still remains to be seen.

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