E-LEARNING: INTEGRATING ADAPTIVE HYPERMEDIA AND INTELLIGENT TUTORING SYSTEMS

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ABSTRACT
Web-based education has been implemented widely in recent years. However, one limitation of most current web learning systems is that they provide the same page content and same set of links to all users. There is a need to add “intelligence” to web based learning to tutor the students intelligently and adapt to their needs. Adaptive hypermedia systems offer a solution by using of adaptive methods such as adaptive presentation, adaptive content selection and adaptive navigation support to enable users to navigate through or search interlinked items based on a user’s needs, knowledge, goals and interests. The Intelligent Tutoring Systems (ITS) is defined as a “computer based training systems that incorporate techniques for communicating or transferring knowledge and skills to students”. Initially ITS provided users with questions and answers to evaluate their level of understanding. It did not provide access to a lecturer’s notes and reading materials. Its main functions were to act as a support mechanism for students. The required knowledge is assumed to have been acquired from outside the system. It is possible to integrate technologies and techniques from both adaptive hypermedia and ITS to create an intelligent online learning systems. Therefore this research aims to investigate the feasibility of integrating adaptive hypermedia and intelligent tutoring systems to produce an intelligent adaptive hypermedia on-line learning system. This system will take into account users’ learning methods and styles in its user model. An investigation into the relationship(s) between adaptive methods such as navigation support and content selection techniques, and users’ characteristics such as learning methods and styles will also be carried out.

INTRODUCTION
Web-based learning has been implemented widely in Malaysia in recent years. As Internet technology is advancing and becoming more prevalent, more and more universities and colleges are using e-learning as part of their teaching tools and strategies. The advantages of web-based learning lie in the fact that they are classroom independent. However, one limitation of most current web learning systems is that they provide the same page content and same set of links to all users. There is a need to add “intelligence” to web based learning to tutor the students intelligently and adapt to their needs. Developers in the past have created systems that are capable of offering intelligent tutoring and adapting contents to users’ needs. They are Intelligent Tutoring Systems (ITS) and
Adaptive Hypermedia Systems. ITS is defined as a “computer based training systems that incorporates techniques for communicating or transferring knowledge and skills to students. This system has emerged from a combination of Computer-Aided Instruction and Artificial Intelligence” (Martha 1998).

Adaptive hypermedia systems offer a solution by using adaptive methods such as adaptive presentation, adaptive content selection and adaptive navigation support to enable users to navigate through or search interlinked items based on a user’s needs, knowledge, goals and interests. When adapting to learners, many existing systems try to adapt web pages to the learners’ skills, knowledge, understanding of the topics, etc (Brusilovsky 1996). However, it is also possible to adapt to users’ individual traits in a web-based learning system.

This research aims to investigate the feasibility of integrating adaptive hypermedia and intelligent tutoring systems to produce an intelligent adaptive hypermedia on-line learning system. New techniques for integrating these systems will be developed. The integrated system will take into account of users’ learning methods and styles. An investigation into the relationship(s) between adaptive methods such as navigation support and content selection techniques, and users’ features such as learning methods and styles will also be carried out.

BACKGROUND

Intelligent Tutoring Systems

The Intelligent Tutoring Systems (ITS) is defined as “a computer based training system that incorporates techniques for communicating or transferring knowledge and skills to students.” Early Intelligent Tutoring Systems consisted of four software components (Martha 1998). The components are Expert Module, Tutor Module, Student Module and the User Interface.

The diagram below shows a description of the components:

Figure 1. Components of ITS (Martha 1998)

The expert module acts like a human expert. It interfaces with the domain knowledge. The Domain Knowledge embedded in the system represents an expert knowledge and problem solving characteristics. The knowledge will typically be stored and maintained in a database by an expert system.

The Student Module is one of the most important components of the ITS. In the student module, a student’s understanding of the domains knowledge is captured. The student module can be considered as an advanced profiling of the student. The accuracy and detail of this profile is determined by the bandwidth of the student module. For example, the quality and quantity of the input to be modelled.

The Tutor Module or Instructor Module contains teaching strategies and important instructions. The strategies must be tailored to this module in accordance with the student’s needs without the intervention of a human tutor. To be effective, the Tutor Module will monitor the students’ progress, and it will provide coaching to the students when they need assistance or when they are struggling with the subject. The main purpose of the
module is to reduce knowledge differences between the expert and the student to a minimum or to none.

Early ITS provided users with questions and answers to evaluate their level of understanding. Based on users’ performance, the ITS will determine the topics that are relevant to the students, or the strategies that are suitable for them. As a result, it gives students very little control over the system. It is in the authors’ views that there is a need for students to have more control over the system.

**Adaptive Hypermedia**

Adaptive hypermedia systems (AHS) are hypermedia systems that are adaptable to their users in terms of their preferences, knowledge, goals, needs, and interest (Brusilovsky 1996). They combine hypermedia with ITS guidance through the adaptation of the information presented, the layout of the presentation or the way in which the information units are visited. Brusilovsky defines AHS as “hypertext and hypermedia systems which reflect some features of the user in the user module and apply this module to adapt various visible aspects of the system to the user” (Brusilovsky 1996).

Brusilovsky classifies adaptive techniques as Adaptive Presentation and Adaptive Navigation Support (Brusilovsky 1996). The idea of adaptive presentation is to present the contents of the page to the users based on their goals, current knowledge and other characteristics. For example, if an AHS is tutoring C++ to its users, the system might present a page with an introduction to programming for someone who has never done programming before. However, for someone who has done programming before but with other related languages such as Java, it will show a page that goes straight to basic programming syntax.

The adaptive navigation support aims to help users by providing guidance to find their paths in hyperspace by adapting the way of presenting links to goals, knowledge, and other characteristics of the users. An example of adaptive navigation is the use of direct guidance in Web Watcher (Brusilovsky 1996). In Web Watcher, the system visually outlines to the users the link to the most suitable node to the users.

The user Model (Student Module or Student Model in ITS) is one of the most important components in Adaptive Hypermedia Systems. In order to adapt hypertext pages to the specific needs of the users, it is necessary to elicit the user’s requirements. These requirements are stored in a profile or user model which must be updated to reflect the ongoing requirements of the user. Brusilovsky (1996) mentions that it is not only the developers who have a role in the user modelling process. Users have quite an important role as well in the user modelling process of adaptive hypermedia. Most existing AH systems cannot rely on “classic” automatic user modelling and must use external sources of information about the user. Many of the systems enhance traditional “look and browse” hypermedia interface with special features that allow users to provide more information about their goals, knowledge, and preferences (Brusilovsky, 1996).

The promising approach here is to let users have more control over the system by allowing them to modify the adapted hypermedia pages. This means that when students do not agree with the pages assigned to them by the system, then they should be allowed to make changes to the systems in terms of the choice of presented hypermedia pages. The users’ changes would then be taken into account and updated in the user model.

**Future work on adaptive hypermedia**

Most of the current adaptive systems developed
are only capable of considering a very limited number of user’s features for the adaptation (Brusilovsky 1996). There are also not many systems that are capable of allowing dynamic generation of hypermedia systems which provide the users with information in a personalised way, as well as facilitating the reuse and maintenance of its components.

There are also only a few tools that assist teachers or designers in the process of designing and specifying adaptive hypermedia systems. Furthermore, there is a need for more experiments to evaluate the usefulness and quality of the adaptive hypermedia systems developed. To evaluate, we should concentrate on checking not only the quality of the adaptive system but also the relationship between the relevance of the type of adaptation and the characteristics of the user.

There are studies being carried out with the purpose of automatically detecting the possible needs of modification of an adaptive hypermedia system. In order to do so, agents observe and control the system usage and make the appropriate suggestions about the possible improvements that can be done. Other studies are focused on the distribution of hypermedia systems and resources. Distribution makes possible the sharing of educational resources as well as the use of information about the users while interacting with different systems. In order to share resources it is vital to provide support that facilitates communication among different systems. This research area is currently being explored by some researchers (Brusilovsky, 1996).

In adaptive educational hypermedia systems, some needs directly related to the educational use of hypermedia have arisen. It is desirable to specify the educational strategies that should be used when presenting information to the users. Adaptive hypermedia should be able to provide the tools for allowing the specification of educational strategies, as well as the mechanisms for implementing these strategies when users are accessing these systems. Due to the fact that education is such a broad subject, there are various types of educational strategies. When applying educational strategies to the systems, it is important to know the relationships between the strategies chosen with the adaptive techniques used. It is also important to consider the students’ views when deciding the educational strategies that will be used in the system.

From the authors’ views, many existing systems are evaluated using the summative evaluation technique, whereby, the evaluation is conducted at the end of the system development. A more formative evaluation approach should be adopted, with the evaluation conducted during the design and development stage of Adaptive Hypermedia. By using a formative approach, students’ feedback during the design phase of the tutoring system will be useful in developing a tutoring system that is catered to students’ needs.

Learning Styles

People differ in the way they prefer to learn. Some people learn serially and prefer step-by-step guidance. Some people like pictures while others prefer words. Some people learn best by action/practical application. It is therefore important to know the learning styles of the learners. Learning styles has been defined by Keefe (1979) as “the characteristic behaviours of learners that serve as relatively stable indicators of how they perceive, interact with, and respond to the learning environment.” It is useful for students to be aware of their own preferred learning styles, because

1. they will know what type of learning process will make learning easier for them
2. They will become aware of other learning processes they are not taking full advantage of.

There are numerous models of learning styles available in the market. The two learning style models described here are Felder and Soloman's “Index of Learning Styles” (ILS) and Honey and Mumford’s learning styles model.

The Index of Learning Styles is an on-line instrument used to assess the learning styles of users. The Index of Learning Styles was created in 1991 by Richard M. Felder, a professor at North Carolina State University, and Barbara A. Soloman, then the coordinator of advising for the North Carolina State First-Year College. The four learning style dimensions of the instrument were adapted from a model developed in 1987 by Dr. Felder and Linda K. Silverman, both educational psychologists then, at the University of Denver.

The Index of Learning Styles classifies users into 4 dimensions. They are active/reflective, sensing/intuitive, visual/verbal, and sequential/global (Felder and Solomon, 1992). Active learners tend to retain and understand information best by doing something active with it, like discussing or applying it or explaining it to others. Reflective learners however, prefer to think about it quietly first.

Sensing learners tend to like learning facts while intuitive learners often prefer discovering possibilities and relationships. They often like solving problems by well-established methods and dislike complications and surprises; intuitors like innovation and dislike repetition. Sensors are more likely than intuitors to resent being tested on material that has not been explicitly covered in class. Sensors are patient with details and good at memorising facts and doing hands-on (laboratory) work; intuitors may be better at grasping new concepts and are often more comfortable than sensors with abstractions and mathematical formulations. Sensors tend to be more practical and careful than intuitors; intuitors on the other hand, tend to work faster and are more innovative than sensors. Sensors don’t like courses that have no apparent connection to the real world; intuitors do not like “plug-and-chug” courses that involve a lot of memorisation and routine calculations.

Visual learners remember best when they see diagrams, flow charts, time lines, films, and demonstrations. Verbal learners get more out of words - written and spoken explanations. Everyone learns more when information is presented both visually and verbally.

Sequential learners will understand more in linear steps, with each step following logically from the previous one. Global learners however, will learn in large jumps, absorbing material almost randomly without seeing logical connections. Sequential learners tend to follow logical stepwise paths in finding solutions; global learners may be able to solve complex problems quickly or put things together in novel ways once they have grasped the big picture, but they may have difficulty explaining how they did it.

Honey and Mumford’s Learning Styles Questionnaire is one of the oldest and most popular type of learning style questionnaire due to its validity through studies by people. Honey and Mumford believe that people prefer different methods of learning and will move between four different states of learning, which they have classified as activist, reflector, theorist, and pragmatist. These four states relate to their own version of the learning cycle whereby people have an experience, reflect on it, draw their own conclusions and then put the theory into practice to see what happens. Based on the result they then repeat the cycle again if required until they are successful. They suggest a range of activities that will enable people with different learning styles to learn more effectively, which are obviously of use for identifying appropriate training methods, and
also use a questionnaire to help individuals identify their prominent learning style.

Activist prefers to learn by practical application. They will fully involve themselves and without being biased in new experiences. Activists are typically open minded, and they are enthusiastic when they are trying anything new. The pragmatist is interested in what works, what gives results. This means they are keen on trying out ideas, theories and techniques to see if they work in practice. The theorist prefers to have a conceptual framework to make sense of new information. Theorists tend to solve problems in a step by step logical way. The reflector likes to absorb information and think about it. They will stand back to ponder on experiences and observe them from different perspectives.

ADAPTING HYPERMEDIA PAGES TO LEARNING STYLES

User Modelling can include user’s individual traits. User’s individual trait is a group name for user features that together define a user as an individual. Examples are personality factors (e.g. introvert/extrovert), cognitive factors, and learning styles (Brusilovsky, 1996).

Adaptive hypermedia researchers have been trying to explore the use of individual traits for adaptation in several areas. Although most researchers agree on the importance of modelling and using individual traits, there is little agreement on which features can and should be used, or how to use them. Several experimental studies that have aimed at assessing the value of treating users with different individual traits differently have not found any conclusive results (Brusilovsk, 1996). This proposed research will concentrate on adapting learning styles.

There are two approaches for adapting learning styles to users in existing adaptive hypermedia systems. The first type involves gathering user information during initial tests, and classifying a learner into a fixed style or learner model. This is an ITS technique as it attempts to quiz students and classify students based on their answers. The second type attempts to treat user traits as a black box and attempts to model them and adapt to them using machine learning techniques. The problem with the first approach is that it does not take into account the fluctuations in learning styles. It is argued that learning styles are not actually stable, but vary with the task the learner encounters. The second approach in using machine learning for User modelling have the following problems: 1) The need for large data sets. The learner model will only acquire an acceptable accuracy when it has a large number of examples. 2) In order to achieve adaptation, relevant data are needed. Such useful data however, may not be readily apparent by using automatic user modelling techniques and by observing user behaviours.

LEARNING STYLES AND ADAPTIVE TECHNIQUES

Although there have been research on how to implement different adaptive techniques to cater to different learning styles, there has not been any significant research into the relationships between the learning styles and adaptive techniques. A research into this area is important as it will tell us what type of adaptive techniques will be suitable for different learning styles, e.g. an active Learner might learn better if shown a page using Adaptive Presentation. As a result, when implementing ITS or Adaptive Hypermedia that tries to adapt to learning styles, it is important to realise the relationships between them to cater to the learner’s styles.

PROBLEMS OF INTEGRATING ITS AND AH TECHNOLOGIES

The user model of an adaptive hypermedia
system normally contains information about users' interests, knowledge, goals and needs, while an intelligent tutoring system is normally based on users' current knowledge about curricula or concepts. Although many people use an ITS approach when building AHS by having the Student, Tutoring, and Expert Modules, problems may arise when we attempt to integrate these two technologies. For example, it is possible that the User Model will have problems when it presents information for components from these two systems. An example of this is ISIS-Tutor (Brusilovsky, 1994), which is a hypermedia-based intelligent learning environment. The system integrates a tutoring component for directing study which presents problems to the students, a hypertext component which allows for user driven knowledge acquisition, and a learning environment which allows for experimentation with the material being taught.

ISIS-Tutor uses the hypermedia manual as a component for student-driven browsing of domain knowledge (Brusilovsky, 1994). Students working with the system spend a large amount of time learning with hypermedia on their own. The results of student’s work in the hypermedia will have to be reflected in the student model. The problem is that in an adaptive learning environment, although each module in the system uses the student module for the purpose of adaptation, each module can influence the student module in turn. Thus the diagnostic component has to lose the traditional ITS monopoly for student module updating. Unfortunately, it appears to be quite difficult to coordinate several sources of student module update in the simple architecture.

Another problem is that the student module of a classic ITS that is used by ISIS-Tutor was designed to accumulate and process the information about the student according to the needs of the tutoring module. The information stored in the central module is relevant for tutoring/coaching purposes, but other modules need different information about the student according to the kind of adaptation they provide. The main problem is that processing the information about the student into a form oriented to one of the modules will lead to the loss of information important to some other modules. For example, the hypermedia component needs information on how often the tutoring component presents a particular hypermedia page to the student. This information is used to update some counter in the student module and then it will be erased. Because the information is erased, it cannot be reconstructed from the student module and as such other modules that require this information will not be able to obtain it.

RESEARCH
This Ph. D research will be carried out in 3 stages. Besides the literature review, the first stage will determine the learning styles and methods of a sample of students to be known as users. Honey and Mumford’s learning styles model of categorising learners into activist, pragmatist, theorist and reflector will be used. Felder-Solomon’s Index of Learning Styles (ILS) of categorising learners into active/reflective, sensing/intuitive, visual/verbal, and sequential/global will also be used. This group of users will be given a set of questionnaires to determine their learning styles. Interviews and discussions will also be carried out to find out their perception of how they prefer to learn. The information acquired from these sources will be used to build a new user model for the proposed intelligent adaptive hypermedia on-line learning system.

At stage 2, new techniques for integrating adaptive hypermedia systems and intelligent tutoring systems so as to produce an intelligent adaptive hypermedia on-line learning system will be developed. The techniques will ensure
that the user models of the integrated systems will enhance adaptation. The integrated system will also be built at this stage.

A concept in networking (a topic in Computer Science) will be used as the content to be taught by the system. The system will adapt the contents of the hypermedia pages to the users based on their learning styles. At stage 3 (the final stage), various standard evaluation techniques will be used to evaluate the integrated system. These will include questionnaires, interviews and the collection and analysis of appropriate statistical information such as the number of times some concepts have been visited and the performance of users on on-line tests. An investigation into the relationship(s) between adaptive methods such as navigation support and content selection techniques, and some users’ features such as learning methods and styles will also be carried out.

CONCLUSION
At the end of the research, new techniques for building student models that will ensure adaptation when integrating Adaptive Hypermedia and Intelligent Tutoring Systems will be built. An Online Intelligent Learning Systems based on techniques from both ITS and AHS will be built. The system aims to use Learning Styles in its User Model and it will adapt differently to users based on their learning styles. However, unlike a few existing systems which have failed to show that adapting learning styles to users have effective outcome, this system hopes to demonstrate integrative approaches that will effectively adapt learning styles to different users. Findings from an investigation into the relationship(s) between adaptive methods such as navigation support and content selection techniques, and the learning methods and styles of users will help future developers adapt learning styles effectively in their online learning systems.

REFERENCES


