ILASH: Incorporating learning strategies in hypermedia

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Abstract

This paper describes the main ideas behind the adaptation and architecture of an educational hypermedia system called ILASH that incorporates learning strategies into hypermedia. The paper describes a computational framework designed to provide adaptive support for learning by using ILASH. The framework includes different adaptive techniques embedded in the text and link structure to scaffold and encourage the use of strategies and a dynamic student model. The pedagogical rationale underlying the study and adaptive features employed in the system are presented.

1. Introduction

Adaptive hypermedia systems make an attempt at scaffolding learners, by adapting and matching the content presentation and interaction to their goals. Many such systems tend to be designed in such a way that supports the learner interaction. They facilitate the activities of the learner by adapting to some learner preferences. However, there is a need to acknowledge the importance of supporting the learners in applying their effective learning strategies. Incorporating the most effective strategies into hypermedia systems takes the instructional designers one step closer to developing learning resources that match the learner's profile more closely.

Individuals tend to develop learning strategies in order to deal with learning materials and therefore these strategies can be regarded as "cognitive tools, which enable students to complete tasks and solve problems" (McLoughlin, 1999). Weinstein and Mayer (1986) defined learning strategies as "behaviours and thoughts that a learner engages in during learning". The most effective learners will use multiple strategies to ensure that they monitor their comprehension. Frequent comprehension checks are an important part of an effective learning process. This is particularly important in a hypermedia environment, where students can get easily distracted and "lose coherence of what they are reading" (Foltz, 1996). Applying an inappropriate learning strategy or not knowing how to apply a learning strategy, may prove a big stumbling block for some students and is likely to hamper their comprehension. Foltz (1996) points out that "a model of hypertext comprehension must consider both the information the reader gains from the text and how that information can affect the readers choice of strategies for proceeding through the text". Jonassen (1988) suggests extending the learner's cognitive approaches to learning through adaptive, intelligent use of computer courseware and learning materials.

The consequences of learning strategy differences have not been pursued in the field of adaptive educational hypermedia. According to Hammond (1993) basic hypermedia systems may fail to provide students with the support, direction and engagement that learning requires. This failure suggests implications for the design of hypemedia-based learning and introduction of adaptivity. With an adaptive hypermedia-based system we can individualize the learning process and allow students to apply a learning strategy that is proving to be the most effective for a given task. The success of adaptive systems can be measured if they can cognitively adapt to the student. The adaptive system can attempt to emulate actual processes employed by the students for effective learning processes.

The focus of adaptation in ILASH is to provide a representation of an appropriate strategy for students while learning, whether it is summarising or questioning.

2. Learning strategies

The reviewed literature shows that a large number of learning strategies have now been identified and teachers have been encouraged to enable students to use a variety of learning strategies in secondary education. A number of definitions of learning strategies have been used in the field of educational psychology. The research has acknowledged the importance of learning strategies and many studies examined their efficacy. There is a need to take into account the fact that students differ and that these differences and preferences in learning need to be taken into account. One method or learning strategy may be ineffective for some students who could learn more effectively using a different strategy (McKeachie, 1995). Jonassen (1998) suggested that learning strategies could be embedded inside a hypermedia program. Effective learning involves knowing when to use a specific strategy, how to access that particular strategy, as well as when to abandon an ineffective strategy (Jones, Palinscar *et al.* 1987). Having said that, many students are not aware of what strategies work for them. Some students may experience difficulty in selecting the main idea or the concept and supporting details. They treat each sentence with the same importance. "Learning will be easiest when there is a strong correlation between the way in which new material is presented to us and our learning preferences. Conversely, we find learning more difficult when there is a large disparity between our learning strategy preference and the supplied learning presentation. Styles are fixed but strategies are adaptable processes we can use to respond to the demands of a learning situation" (Laing 2001). According to Nist and Simpson (2000), research validated strategies are small in number, however, extensive research for the past two decades indicates that some of the strategies for constructing meaning are more significant than others (Dole et al., 1991). A previous study has been conducted to examine which learning strategies students use (McLeod, Heiko and Lockwood 1998). It was found that many students made good use of 'higher order' learning strategies such as "questioning" and "summarisation" strategies.

One of the definitions of learning strategies used by the students was described by Garner (1987), who suggested that 'text summarization is a tool for making a cognitive process and for monitoring it. As a cognitive strategy, it allows learners to synthesize information from multiple sources and diverse perspectives". Research indicated that embedding learning strategies in software is effective. The students using the software with the learning strategies embedded, performed better (Thornburg and Pea, 1991). Hsiao (1997) conducted a combined study in which learning strategies were embedded into hypermedia based system (such as note-taking, summarisation, reflective questions). They also embedded prompts to encourage strategy-use, combined with the application of field–dependent and field-independent cognitive styles. The "**summarizing**" strategy (S) provides the opportunity to identify, paraphrase, and integrate important information. The "**questioning**" (Q) strategy enables students to generate questions and identify the kind of information that is significant enough that it could provide the substance for a question. Students pose this information in a question form and self-test themselves to ascertain that they can indeed answer their own question. While studies in effective learning strategies continue to emerge, the relevance of applying these strategies in the field of adaptive hypermedia learning has not been determined. Bull (2000) created an adaptive system that recommended individual language learning strategies in order to help students become more effective learners. The model combined representations of learning styles and current strategy use. A new strategy was recommended based on the information obtained from the student model. The recommended strategies were from cognitive, metacognitive and memory domain.

3. System description

The system contains courseware targeted at GCSE[1]-level students. The Physics courseware has been adapted from Fullick (2001). The chapters chosen for the study contain scientific concepts, principles, and theories that are used to explain observations of the natural world. The first (adaptive) session contains the courseware on “The behaviour of waves” and the second (non-adaptive) session contains the courseware on “The Solar System”. Each session contains the same number of pages, and the student’s knowledge is accessed at the end of each lesson. As part of the system usage, the students browse the adaptive session first and then complete the post test, followed by a non adaptive session and second post-test. The post tests contain the same number of questions, and they are tied to lesson objectives and three levels of Bloom’s taxonomy (1956)[2]. The results of the post tests between adaptive and non adaptive sessions are compared.

Page layout

The basic structure of the page layout is that the pages are divided into two formats: S_type (corresponding to the “summarising strategy” and Q_type (corresponding to the “questioning” strategy). Three factors were viewed as essential and sufficient to design the layout of an environment conducive to studying: the learning strategy, the text and link presentation and the structural signals. The S_type pages have a top-down approach where the material is presented with key-points summarised at the end of each page. The S_type page presentation provides contextual clues to help students with getting the gist of information (by using headings, diving text in small chunks etc). The aim is to provide the students with some elements of a summarising strategy.

The Q-type pages have a question asked after each paragraph (which contains an explanation of a concept). Arburn and Bethel (1998) suggest that directing the attention to deliberate questioning activities may encourage the students to confront misconceptions which they have grown comfortable with, so that in resolving their discrepancies more meaningful learning may occur.

Adaptive features of the system

The system allows the user interface, linking and content structure to change according to student’s knowledge state. Student’s recall and understanding of content is continuously checked and an appropriate strategy is selected. The adaptive techniques used in ILASH are adaptive presentation (adaptive layout presentation) and adaptive navigation support[3] (adaptive annotation and hiding of links) in the table of contents and the adaptive side bar (See Figure 1 and 2). For adaptive presentation a set of pedagogical rules of knowledge prerequisites is created, that determines which layout and which pages should be presented.

These rules also determine which ‘additional information’ should be presented along with a concept and which ‘examples’ should be shown. Students are prevented from jumping to pages for which they lack prerequisite knowledge. (The pages that describe concepts are divided into prerequisite concepts by the author). The case is similar for the additional material related to the concepts (such as ‘examples’, ‘science people’ sections, ‘interesting facts’, ‘ideas’ etc.). Some pages have examples of concepts associated with them and some do not. The links to the pages that the student is ‘not ready to learn’ become hidden and a ‘cross’ icon is placed next to them. The links to lessons that the student is ready to cover are displayed in the table of contents with a ‘green tick’ icon next to them. The percentage of completed material is also displayed in the table of contents. Previously viewed chapters, currently available pages and newly available links to chapters are presented in the adaptive side bar (See Figure 2).

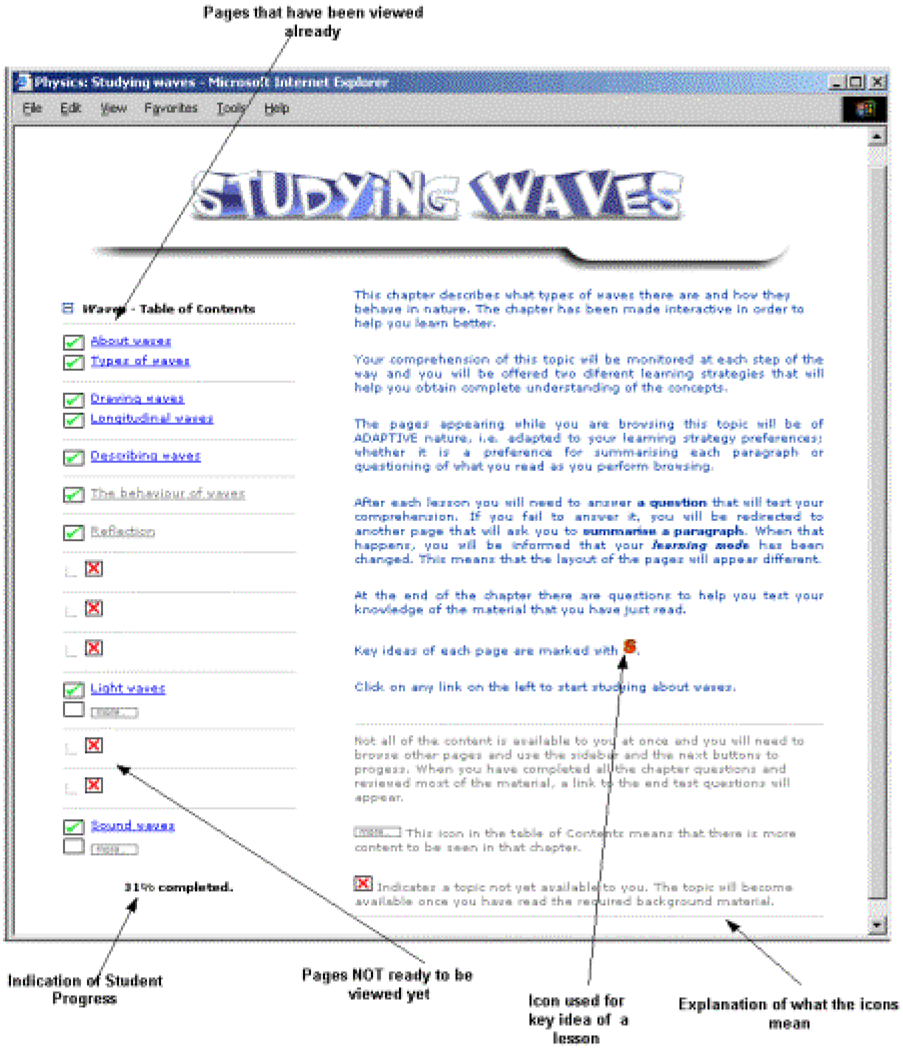

Fig. 1. User interface with adaptive table of contents

Student model (SM)

The student model is used to adapt the display characteristics of the interface and the appropriate learning strategy, to the needs of the student. Student’s interaction is reflected immediately in the system and in the learning strategy selection. The knowledge that the student has attained is collected through direct questioning methods. The student model is dynamically updated and triggers the system to select the most appropriate learning strategy for each lesson. The student model contains the following information: *Student _ID, History of visited links, time spent on each page, learning strategy preference and the number of switches between the two strategies.*

Adaptation algorithm

The following algorithm was used to determine the student model in relation to the student's knowledge:

For each of the lessons

If score after each lesson is correct

THEN

The Learning strategy is preferred by the student, keep on using pages with that preference

ELSE

The Learning strategy is NOT preferred, a different strategy needed

ENDIF

The system monitors the history of visited pages and supplies strategies at different points. The students are free to 'jump' between paragraphs. The technique follows a pattern of supplying different strategies adaptively, depending on student's progress. In the adaptive version of the system, each page had the following links available in the adaptive sidebar:

- *Index,* takes the student to the table of contents page, providing an overview of the lessons
- *Search,* allows the student to find clarification for keywords
- *Examples,* takes students to an example of a concept
- *Science people,* presenting more detailed information on the scientist mentioned in a lesson
- *Ideas and evidence,* presents the key points summarised for the concept
- *Back,* taking students to the previous page
- *Next,* with a description on what the next page is about
- *Glossary* links, providing students with definitions of terminology used in the content
- *Adaptive chapter links*: these links change in the adaptive part of the system to describe previously visited links, currently viewed links and next links available for viewing.

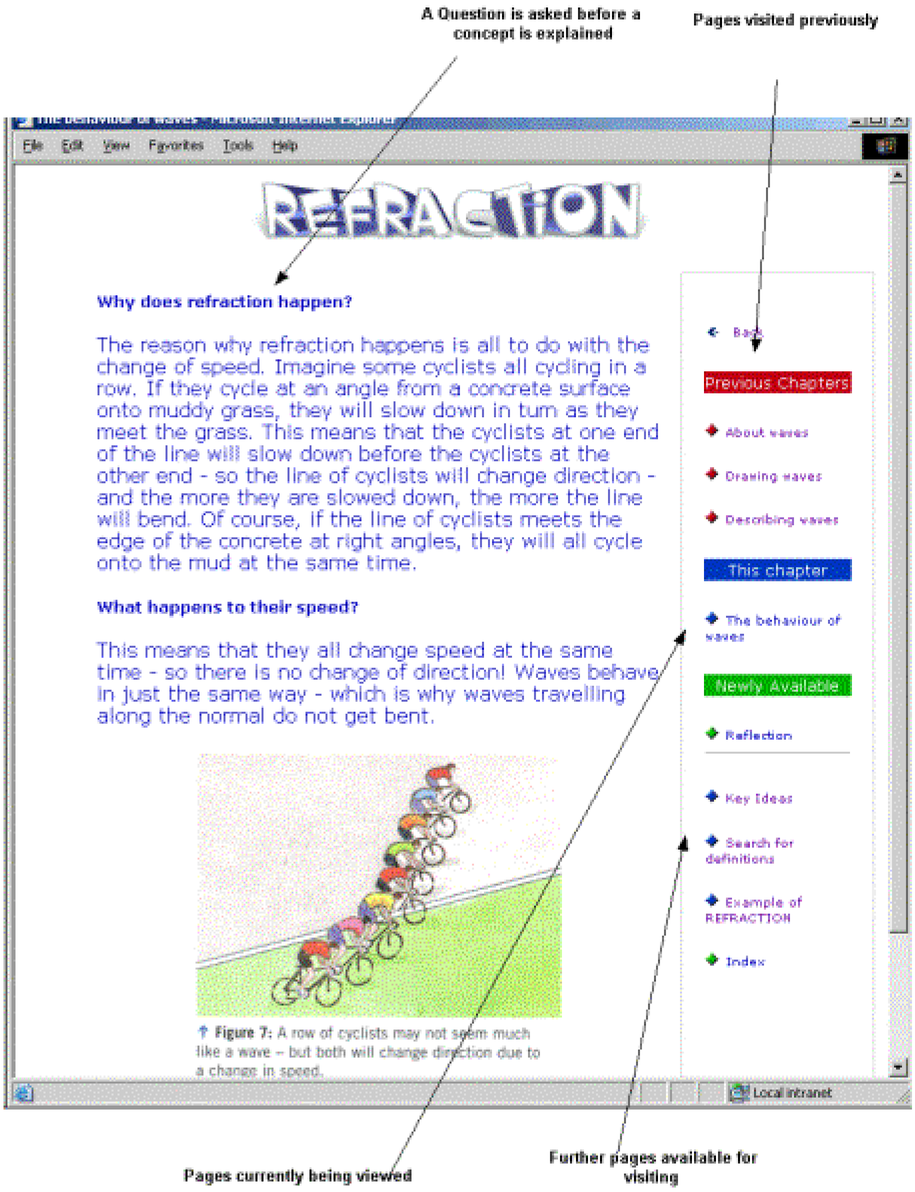

Fig. 2. Adaptive sidebar layout

(1) Adaptive session

In this first, adaptive part of the system the students log in and start browsing. The students are not able to see all the pages at first (See Figure 1). The links that the system provides become available as the student learns more. The students start browsing pages that embed "summarising" strategy elements (S_type page layout). At the end of a lesson the student is asked to summarise it ("summarising" strategy check) and the student fails to provide a correct answer, then a different learning strategy ("questioning" strategy) is provided (the Q_type page layout). At the end of that lesson, when a strategy check point is reached, and if the student fails to answer, then the students can continue to browse the lesson, but the links to the pages they can browse are restricted until a concept is mastered. The post-test is presented after the students have completed 75% of studying.

(2) Non-adaptive session

This is the second part of the system where students re-log in. This version of hypermedia courseware offers students unrestricted navigation throughout the lessons. The students can apply whatever learning strategy they wish. Summaries of key points are provided in the non–adaptive side bar (See Figure 3). The student's comprehension is tested after each lesson, but no clues are given if they provided an incorrect answer. At the end of the chapter they take another post-test. The student's behaviour is monitored and the history of links is logged. Questions asked at the end of adaptive and non-adaptive parts of the system follow Bloom's taxonomy of educational objectives on knowledge, comprehension and synthesis of information. The questions were created so that the students were asked to demonstrate that they fulfil these conditions by being asked to demonstrate these cognitive levels by having to define, match and classify information, as well as to describe and explain concepts in their own words.

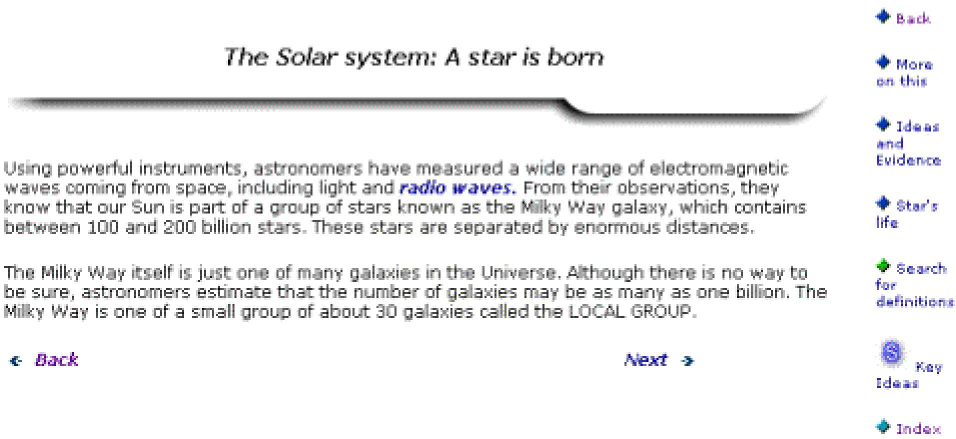

Fig. 3. Non adaptive layout

4. Technologies used in the experiment

For this study the following technologies were used: The PHP scripting language, MySQL, a relational database engine, Apache web server, HTML, XML (Extensible Markup language) and XSL (Extensible stylesheet language) technologies. PHP is a server side scripting language that can be embedded in html documents. This provides an easy way to incorporate dynamic content within what was previously a static document. Also, PHP is well suited for reading information from web forms and maintaining sessions between pages. This is important in order to keep the name of the currently authenticated student, their browsing actions and history in the student model. Sessions are used to maintain student-specific information. XML and XSL allow content to be separated from the presentation, where XML is used to store the content and XSL is used to present pages with different layouts.

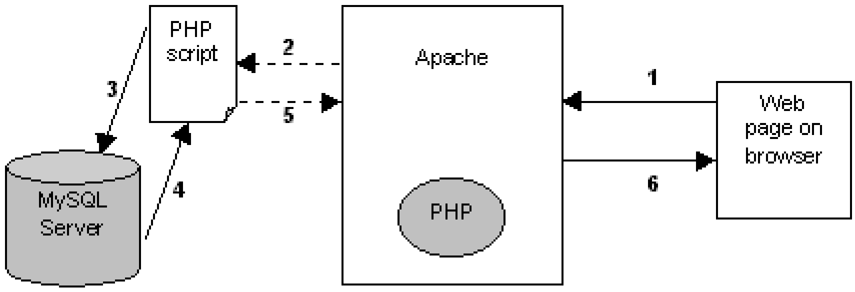

Fig. 4. Architecture of the system

Figure 4 shows the system architecture. A student requests a particular page from the Web server by means of a Web browser (1). In response to this request the Web server calls a PHP script (2), which is executed by the PHP preprocessor (3), pulling data from the database (4). The results are processed by the rest of the PHP script (5) and turned into HTML, which is returned to the student's browser (6). The current implementation of the system is as shown above, using Apache server. The student model is stored in a MySQL database. The courseware is stored in XML files. The students need to use a browser capable of parsing XML and XSL. No specific client side software needs to be installed on the client's PC.

5. Conclusion and future work

A review of the literature indicated that there is a paucity of investigations concerning the application of learning strategies in the field of adaptive educational hypermedia. In this study an adaptive hypermedia system has been created that provides the adaptation of learning strategies. This is achieved by applying adaptive presentation and navigational support. The aim of the study is to prove that by using adaptive features in hypermedia based educational systems, students' learning outcomes and comprehension can be enhanced. The system adaptively scaffolds students and allows them to apply effective learning strategies. In terms of specific learning strategies, the study hopes to find significant improvement in a student's achievement following an adaptive lesson. The use of the aforementioned strategies may provide students with the tools to enhance their success in hypermedia based studying. The system is currently being evaluated.

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[1] GCSE denotes General Certificate of Secondary Education in the UK

[2] According to Bloom's cognitive domain taxonomy 'knowledge' is defined as an ability to acquire, to identify, to recognize knowledge of facts, specifics and abstractions and to recall previously learned information. 'Comprehension' implies the ability for translation, interpretation, extrapolation of meaning of information and understanding of the facts. 'Synthesis' is defined as an ability to discriminate, distinguish, reintegrate and organise the information and the relationships into a meaningful whole.

[3] See Brusilovsky (1996) for the definition of the techniques.