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Influence of Prior Knowledge and Cognitive Styles in Adaptive Hypermedia Learning Systems

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Abstract: Most Adaptive Hypermedia Learning Systems (AHLSs) tailor presentation content and navigational support based on prior knowledge or cognitive styles of students separately. There is, however, a need to explore how the two individual difference characteristics could be combined in adaptive hypermedia learning systems in order to maximize learning and comprehension of educational materials. To this end, the study presented in this paper developed two adaptive hypermedia learning systems, one tailored to students' prior knowledge, with the other tailored to their cognitive styles, with emphasis on Pask's Holist-Serialist dimension. Findings indicate that, in general, adapting to either prior knowledge or cognitive styles improves learning performance.

Keywords: Cognitive Styles, Prior Knowledge, Learning Performance, Adaptive Educational Hypermedia, Holist-Serialist, e-learning

1. Introduction

In the past decade, a growing body of research has examined the influence of prior knowledge in (adaptive) hypermedia learning systems (AHLSs). Such research has suggested that different levels of prior knowledge suited to different types of content structure (Calisir and Gurel, 2003) and different navigation tools (McDonald and Stevenson, 1998b). It demonstrates that prior knowledge can determine how well learners acquire information from hypermedia and can influence their learning patterns in a hypermedia system (Alexander et al., 1994, Last et al, 2001).

Several dimensions of cognitive styles have been studied in the past century, including Holist-Serialist (Pask, 1976), Wholist-Analytical (Riding, 1991), Verbaliser-Imager (Betts, 1909), and Field Dependence-Field Independence (Witkin et al., 1977). Among them, Field Dependence/Independence (FD/FI) has emerged as the most widely studied, Pask's Holist-Serialist has a conceptual link with FD/FI (Chen and Macredie, 2004). Similar to FD learners, Holists process information in relatively global ways in that they tend to build an overall picture of the subject area. Conversely, Serialists take a similar learning pattern of FI learners, tending to maintain a local focus, concentrating on one thing at a time, and on building up procedural understanding step by step.

In Chen (2000) it was shown that Holists and Serialists have very different preferences, as do Novices and Experts. Thus, it is necessary to develop AHLSs, where one matches with the preferences of Holists and Serialists, and the other those of Novices and

Experts. To this end, the focus of the research described in this paper is a comparative analysis to see which of two AHLSs improves learner performance more.

2. Experimental Design

2.1 Participants

104 participants from a UK University took part in this experiment. 60 students participated in the prior knowledge version while 44 participated in the cognitive styles version experiment respectively. The age group of the participants ranged between 18 and 30. Participants were chosen from such diverse disciplines and different levels of courses so that the bias of a particular type of domain knowledge or course could be reduced.

2.2 Instruments

An AHLS was prototyped, containing material on introduction to XML. The content was designed to cater for the needs of both novice and expert learners. The content was on the same topics, however, experts were provided with material that was more advanced while novices were provided with less advanced material which was accompanied by additional explanations. Tables 1 and 2 provide the main differences between the two interfaces.

Table 1: The differences between novices' and experts' interfaces

Adaptive Hypermedia	Novice Interface	Expert Interface
Link hiding	Hidden links	Rich links
Adaptive layout	Hierarchical Map	Alphabetic Index
Additional support	Advisements	No advisements
Annotated Links	Traffic light metaphor	No annotations

Table 2: The differences between Holist and Serialist interfaces

Adaptive Hypermedia	Holist Interface	Serialist Interface
Guidance	No guidance	Next/ Previous Buttons
Link hiding	Rich links	Disabled links
Adaptive layout	Hierarchical Map	Alphabetic Index

2.3 Experimental Procedures

In order to determine whether or not the AHLS adapting to prior knowledge (i.e. PAHLS) was better, with respect to learning performance, than the AHLS adapting cognitive styles (i.e. CAHLS), a between-subjects design was used. The same content was used for both systems without incurring the practice and fatigue effects in the experiment. Furthermore, each participant went through the same procedures in order to minimize bias. A pre- and post-test was administered in order to ascertain learning performance.

3. Results

T-test analysis indicates that there was no significant difference in learning performance between users of prior knowledge adaptive hypermedia learning system and those that used the cognitive styles adaptive hypermedia learning system, t (46) = -1.256, p = .215. That is, the average performance (gain score) of students using the prior knowledge adaptive system

(M = 30.15, SD = 19.396) was not significantly different from that of students using the cognitive styles adaptive system (M = 36.64, SD = 15.735).

The t-test results also indicated that there was no significant difference in post-test score between user of prior knowledge adaptive hypermedia learning system and those that used the cognitive styles adaptive hypermedia learning system, t (46) = 1.191, p = .240. That is, the average performance score of prior knowledge (M = 72.65, SD = 12.096) was not significantly different from that of cognitive style (M = 68.64, SD = 11.074).

Multiple comparisons were done to determine the relationships between the group means were performed using Bonferroni post-hoc tests (Table 3). Results show that, with respect to post-test scores, there were no significant differences between prior knowledge groups and the cognitive styles groups. However, the results show that both the Holists and Serialists gained more than the experts in the prior knowledge groups.

Table 3: Bonferroni post-hoc tests for multiple comparisons of styles

		Novice/Holist	**Novice/Serialist**	**Expert/Holist**	**Expert/Serialist**
Post-Test	Mean Diff *(Std Error)*	1.200 *(4.538)*	7.133 *(4.783)*	1.485 *(4.891)*	7.418 *(5.119)*
	Sig.	***1.000***	***.858***	***1.000***	***.927***
Gain Score	Mean Diff *(Std Error)*	6.050 (*5.693)*	4.833 (*6.001)*	-22.265 (*6.136*)	-23.482 (*6.423*)
	Sig	***1.000***	***1.000***	***.004***	***.004***

The implication therefore is that there should be a way of adapting to both prior knowledge and cognitive styles in a single adaptive hypermedia system in order to maximize on line educational learning – and this forms the focus of our future efforts.

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