Chapter IX
Individual Differences in Adaptive Educational Hypermedia: The Effect of Cognitive Style and Visual Working Memory

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ABSTRACT

The purpose of this chapter is to experimentally explore the effect of individual differences in an adaptive educational hypermedia application. To that direction, the constructs of cognitive style (Cognitive Style Analysis) and visual working memory (visuo-spatial subsystem of Baddeley’s model) were employed as personalization parameters, thus rendering possible the provision of personalized learning environments according to users’ intrinsic characteristics. Two distinct experiments were conducted, with a total sample of 347 university students, seeking out to ground the hypothesis that matching the instructional style to learners’ preferences would increase their performance. Both experiments demonstrated that users in the personalized condition generally outperformed those that were instructed in a condition mismatched to their cognitive style or visual working memory ability.

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INTRODUCTION

Web-based educational applications have proliferated throughout the extensive development of the internet, in parallel with a significant research interest on this channel of instruction. Individual differences in e-learning constitute an interdisciplinary research area, and most approaches derive from the fields of Computer Science and/or Psychology, as a result of combined efforts to improve the effectiveness of web-based education.

In any case, it is a fact that web information resources are numerous, and the internet has become extremely vague (De Bra, Aroyo & Chepegin, 2004), making information processing very difficult for users. This has provided a good basis for the notion of personalization and for the development of adaptive hypermedia systems (Eklund & Sinclair, 2000; Brusilovsky & Nejdl, 2004), that take into account users’ (or learners’) individual characteristics, aiming to provide tailor-suited information.

The integration of human factors or traits in web-based education is also under the scope of many researchers, and in accordance to the aims of this paper we consider that this research is being carried out in two distinct ways: (a) computer scientists have developed systems that usually adapt on users’ learning or cognitive styles (Papanikolaou et al, 2002; Carver, Howard & Lane, 1999; Gilbert & Han, 2002) or respond to their current affective state (Picard, 1997), whereas (b) researchers mainly from the field of Psychology have examined the role of different cognitive traits in computer-mediated learning (De Stefano & Lefevre, 2007; Graff, 2003; Graff 2005, Bilda, 2007; Parkinson & Redmond, 2002; Federico, 2000; Workman, 2004). It is evident that the constructs of learning and cognitive styles have proven to be quite popular in this area, whilst the concept of the Working Memory (WM) has also gained some popularity in terms of examining interaction of WM span with different hypertext levels of complexity (De Stefano, 2007; Lee & Tender, 2003). Moreover, there have been efforts to build more complex models of human factors that may be proven useful in e-learning applications (Germanakos et al, 2007a; Lin, Kinshuk & Patel, 2003).

The main idea behind these approaches is to improve the effectiveness of web-based instruction by not ignoring individuals’ top-down processes (Eysenck & Keane, 2005), and to determine which factors (mainly cognitive) have a dominant role in web-based information processing. These efforts could be characterized as the first steps of introducing the notion of individual differences into web-based education, even if there are severe limitations imposed by the structure of the web.

On the basis of the aforementioned research directions in e-learning, we are in the process of developing and evaluating both a theoretical model of information processing in the web (Germanakos et al, 2007a), and a corresponding Adaptive Hypermedia system that implements our theoretical approach and assumptions (Germanakos et al, 2007b). Our experimental model is comprised of three dimensions: Cognitive Style, Cognitive Processing Efficiency and Emotional Processing. The first dimension is unitary, whereas Cognitive Processing Efficiency is comprised of (a) Working Memory Span (WMS) (Baddeley, 1992) and (b) speed and control of information processing (Demetriou, 1993). The emotional aspect of the model focuses on different aspects of anxiety (Cassady & Johnson, 2002; Cassady, 2004; Spielberger, 1983) and self-regulation.

Existing hypermedia systems mostly focus on a single cognitive construct, usually learning style, and both evaluation and assessment of the system in terms of benefit for the learners are often neglected or methodologically less elaborated. In our research we make efforts to theoretically introduce new concepts into web-based education and to experimentally assess the value of the proposed human factors. This process is continuous and revisions of the theoretical framework are