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Learning styles and cognitive traits – Their relationship and its benefits in web-based educational systems

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ABSTRACT

Different learners have different needs; they differ, for example, in their learning goals, their prior knowledge, their learning styles, and their cognitive abilities. Adaptive web-based educational systems aim to cater individual learners by customizing courses to suit their needs. In this paper, we investigate the benefits of incorporating learning styles and cognitive traits in web-based educational systems. Adaptivity aspects based on cognitive traits and learning styles enrich each other, enabling systems to provide learners with courses which fit their needs more accurately. Furthermore, consideration of learning styles and cognitive traits can contribute to more accurate student modelling. In this paper, the relationship between learning styles, in particular the Felder–Silverman learning style model (FSLSM), and working memory capacity, a cognitive trait, is investigated. For adaptive educational systems that consider either only learning styles or only cognitive traits, the additional information can be used to provide more holistic adaptivity. For systems that already incorporate both learning styles and cognitive traits, the relationship can be used to improve the detection process of both by including the additional information of learning style into the detection process of cognitive traits and vice versa. This leads to a more reliable student model.

1. Introduction

Different learners have different knowledge about the domain, aim at different goals, have different learning styles, and also have different cognitive abilities. In traditional education, teaching in a way that the needs of all students are met is difficult, especially in classes with a high number of students. In web-based educational systems, lots of research works have been conducted in the area of adaptive instruction (Brusilovsky, 1996). Adaptive systems have been developed which aim at providing courses that fit the needs of learners.

Adaptivity can be provided in different ways. Adaptation techniques can be distinguished between adaptive presentation support and adaptive navigation support (Brusilovsky, 1996). Adaptive presentation includes adaptation features based on content such as adaptive multimedia presentation and adaptive text presentation, whereas adaptive navigation is based on links and includes features such as direct guidance as well as adaptive sorting, hiding and annotating of links. Furthermore, adaptivity can be provided based on different characteristics of learners such as their prior knowledge, motivation, learning styles, and cognitive traits.

This paper focuses on the consideration of learning styles and cognitive traits in adaptive web-based educational systems. Several educational theories and studies agree that learners learn easier when their learning styles match with the teaching style (e.g., Bajraktarevic, Hall, & Fullick, 2003; Felder & Silverman, 1988; Graf, Lan, Liu, & Kinshuk, 2009; Hayes & Allinson, 1996). Felder and Silverman (1988) pointed out that learners with a strong preference for a specific learning style have difficulty in learning when this learning style is not supported by the teaching environment. Such mismatches lead to poor student performance. Based on these arguments, adaptive systems such as AHA! (Stash, Cristea, & de Bra, 2006), CS383 (Carver, Howard, & Lane, 1999), IDEAL (Shang, Shi, & Chen, 2001), MAS-PLANG (Peña, Marzo, & de la Rosa, 2004), TANGOW (Paredes & Rodríguez, 2004), as well as an add-on for the learning management system Moodle (Graf & Kinshuk, 2007) has been developed, which provide courses that match the learning style of learners.

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Like learning styles, cognitive traits influence the learning process. Research on working memory (Anderson, 1983; Byrne, 1996; Case, 1995; Huai, 2000; Salthouse & Babcock, 1991; Scandura, 1973) showed the fact that the speed of learning, the memorisation of learned concepts, effectiveness of skill acquisition, and many other learning abilities are all affected by the capacity of working memory. Providing content that exceeds the cognitive abilities of a student affects the learning progress in a negative way and leads to poor student performance.

For learning styles and cognitive traits, different kinds of adaptivity can be provided. A system that incorporates only learning styles provides different adaptive features than a system that incorporates adaptivity for cognitive traits. Combining adaptivity for both learning styles and cognitive traits allows a system to provide better adaptivity than a system that provides adaptivity for only one of them.

However, a requirement for providing adaptivity in web-based educational systems is to know the characteristics of learners. Therefore, student models are essential to any adaptive educational system (Brusilovsky, 1994). Student models contain information about the learners. For example, they can include demographic data, domain competence, learning goals, learning style, and/or cognitive traits. Student modelling is the process of building and updating the student model. Brusilovsky (1996) distinguished between two different ways of student modelling: collaborative and automatic. In the former, the learners are asked to provide explicitly information for building and updating the student model. For instance, the learners can provide data such as answering explicitly whether a page was relevant for their learning goals, filling out questionnaires in order to identify their learning styles or performing tasks to detect their cognitive traits. In the automatic student modelling approach, the process of building and updating the student model is done automatically based on the actions of the learners when they are using the learning system. A challenge of this approach is to get enough reliable information to build a robust student model. As a solution, the use of additional sources can help to get more information about the learners (Brusilovsky, 1996).

In this paper, focus is placed on the Felder–Silverman learning style model (FSLSM) (Felder & Silverman, 1988), and working memory capacity (WMC), a cognitive trait included in the Cognitive Trait Model (CTM) (Kinshuk & Lin, 2003; Lin & Kinshuk, 2005). Both models are introduced in Section 2. The aim of the paper is to demonstrate the benefits of incorporating both, learning styles and cognitive traits, in adaptive web-based educational systems. On one hand, considering learning styles and cognitive traits allows suiting courses more accurately to the students' characteristics by providing adaptivity based on learning styles as well as cognitive traits. Furthermore, by incorporating learning styles and cognitive traits in an adaptive educational system, more information about the learner is available which can be used to improve student modelling. In order to use this information as an additional source in the detection process of learners' characteristics, investigations about the relationship between FSLSM and WMC were conducted and are presented in Section 3. First, existing studies were investigated and indirect relationships could be derived. Afterwards, an experiment was performed where the direct relationship between FSLSM and WMC was analysed. Discussion about the benefits from the identified relationship for improving student modelling and therefore adaptivity is provided. Section 4 concludes the paper.

2. Learning style model and Cognitive Trait Model

In this section, the Felder–Silverman learning styles model and the Cognitive Trait Model are introduced in order to provide background information for current investigations. Description about the two models is provided and student modelling and adaptivity issues are discussed.

2.1. 1 Felder–Silverman learning style model

Several learning style theories exist in literature, for example, the learning style model by Kolb (1984), Honey and Mumford (1982), Dunn and Dunn (1974), Pask (1976), and Felder and Silverman (1988). While most learning style models classify learners as belonging to a few groups, the Felder–Silverman learning style model (FSLSM) describes the learning style of a learner in more detail, distinguishing between preferences on four dimensions and therefore enabling adaptive learning systems to provide courses which are better tailored to the learners' preferences. Moreover, FSLSM is based on tendencies, indicating that learners with a high preference for a certain behaviour can act sometimes differently, enabling the learning style model to considers exceptional behaviour. Another important reason for selecting the FSLSM for this research work was that it is widely used in adaptive educational systems focusing on learning styles, which therefore makes this research widely applicable.

2.1.1. Description of the Felder–Silverman learning style model

FSLSM characterises each learner according to four dimensions: sensing/intuitive, active/reflective, visual/verbal, and sequential/global.

Learners who prefer a sensing learning style like to learn facts and concrete learning material. They tend to be more patient with details and also more practical than intuitive learners and like to relate the learned material to the real world. Intuitive learners prefer to learn abstract learning material, such as theories and their underlying meanings. They like to discover possibilities and relationships and tend to be more innovative and creative than sensing learners. Therefore, they tend to score better in open-ended tests than in tests with a single answer to a problem.

The active/reflective dimension distinguishes between an active and a reflective way of processing information. Active learners learn best by working actively with the learning material, by applying the material, and by trying things out. Furthermore, they tend to be more interested in communication with others and prefer to learn by working in groups where they can discuss about the learned material. In contrast, reflective learners prefer to think about and reflect on the material. Regarding communication, they prefer to work alone.

The visual/verbal dimension differentiates learners who remember best what they have seen, such as pictures, diagrams and flow-charts, and learners who get more out of textual representation, regardless whether they are written or spoken.

In the fourth dimension, the learners are characterized according to their understanding. Sequential learners learn in small incremental steps and therefore have a linear learning progress. They tend to follow logical stepwise paths in finding solutions. In contrast, global learners use a holistic thinking process and learn in large leaps. They tend to absorb learning material almost randomly without seeing connections but after they have learned enough material they suddenly get the whole picture. Then they are able to solve complex problems and put things together in novel ways but they have difficulties in explaining how they did it.

Each learner has a personal preference for each dimension. These preferences are expressed by values between +11 to −11 per dimension. Using the active/reflective dimension as an example, the value +11 means that a learner has a strong preference for active learning, whereas the value −11 states that a learner has a strong preference for reflective learning.