A Framework for Adapting Instruction to Cognitive Learning Styles

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Abstract
This paper presents the main components of an adaptive tutoring system based on cognitive learning styles. A Bayesian network is used to model the student learning style. An original domain model based on Bloom taxonomy is adopted. An instruction adaptation module matches the student style to the domain model based on pedagogical rules that can be modified.

1 Introduction
Many experimental studies in differential psychology have shown that individual differences play an important role in learning and instruction [8, Error! Reference source not found.]. Learners acquire and process instructional information in different ways; they achieve learning at different pace in different learning contexts [4]. These results suggest that matching instruction to learning style allows the student to retain information longer and apply it more effectively. Recently, some researchers have started looking at incorporating individual styles into the design of tutoring systems [2, 9, 10]. Most of these studies rely on self reported questionnaire to assess learning styles. This paper presents a different approach to take into consideration cognitive learning styles. Both instructional design and material sequencing are dependent on the student style. A Bayesian network is used to model cognitive styles. The learning material is designed by taking into consideration not only the individual differences, but also the target level of cognitive skills [1].

2 Cognitive learning styles
A review of the abundant research in individual differences shows no consensus on the nature of cognitive style and the way to use it in instruction. Nevertheless, most of these studies suggest that the cognitive style has a significant effect on student learning [11]. They also consider feasible and desirable to adapt instruction to individual styles. In accordance with these suggestions, we assume that the learning style is the preferred way a student acquires and processes instructional information.

In addition, we assume that such style depends on the complexity of the task. Given these assumptions, we have adopted the cognitive learning style model proposed by Felder and Silverman [Error! Reference source not found.]. This model classifies students according to four dimensions: sensing/intuitive, visual/verbal, active/reflective, sequential/global. An assessment instrument has been proposed for this model in the form of a forty-four item questionnaire. Our aim is to develop a teaching/learning system that implements the principle of adapting instruction to individual styles. The remainder of this paper explains the components and functions of this system.

3 Content model
Most existing learning support systems use materials that have a content-oriented structure. The proposed system uses materials that feature an original objective-oriented structure. By objective, we mean the level of cognitive skill targeted by the material or activity. These objectives comply with the Bloom taxonomy [1]. A course material consists of a tree-like structure of objectives that resembles a work-breakdown-structure. Every leaf-objective is described by its level, and has a set of resources corresponding to all possible learning style dimensions. These resources have the same objective; but each material uses a different mode of presentation or a different pedagogical activity.

4 Student model
Student models typically are used for cognitive diagnosis and to represent behavioural and conceptual knowledge of the student. Despite this common purpose, the content of student models vary considerably. Most of them focus on student knowledge and skills, although some researchers argued that individual features must also be dealt with [12]. A number of research works have been made on the use of Bayesian network in student modelling [5, 7, 3]. They all use their models to analyse the state of student knowledge and to predict future actions.

The proposed system divides the student model into two components: the knowledge model, and the psychological model. The first represents acquired knowledge. It shows...
the state of knowledge the student has reached and different other parameters related to their performance and progress. The second represents the individual psychological environment. It captures the personal psychological characteristics of the student. These characteristics include motivational, emotional, intellectual, memory, and cognitive style aspects. The knowledge model is used to sequence the learning material. In practice, this model allows to progress through the content tree. The psychological model is used to adapt the nature and the presentation of the learning activities. It allows the selection and combination of the appropriate resources for the current learning objective. This paper deals only with the cognitive style model. A Bayesian belief network is used for modelling the cognitive style. The structure of the network is simple. It consists of three layers. The first layer contains a single node that takes one of the six levels of complexity of the task as defined in Bloom taxonomy. The second layer consists of cognitive style indicators (CSI) measured from the student interaction. They represent the behaviour and achievement of the student using different modes of presentation and different nature of activities. The achievement of the student is measured for each CSI. Four different states (insufficient, average, good, excellent) are used. The third layer contains the four dimensions of the Felder-Silverman learning style.

In order to complete the Bayesian network, we need to assign conditional probabilities to each node, respecting the dependence model. An empirical study has been designed for this purpose. An experimental computer-based course has been designed. Volunteer students take this course. During the experiment we measure behaviour of students using the CSI indicators. The same students answer the Felder-Soloman questionnaire to determine their style. Statistics from both sources allow the creation of the conditional probability tables. The initial Bayesian network will be used to predict new students’ style; but continue to be refined by integrating behaviours of new students. This reinforcement process makes the model evolve continuously and become more accurate. Given the student profile determined by the Bayesian network, an adaptation module selects the most appropriate resources and combines them for delivery. This selection and combination obeys to pedagogical rules derived from pedagogical research.

5 Conclusion

This paper presented a framework for using cognitive learning style to adapt the nature and the mode of presentation of instructional material to students. An empirical study using the Felder-Silverman index of learning style (ILS) and an experimental course is the basis for developing an initial Bayesian network that models the cognitive learning style. A reinforcement process is used to continuously refine the model. Future work will concentrate on refining pedagogical rules of adaptation and on wide scale evaluation of the system.

REFERENCES


