Considering Learning Styles in Adaptive Web-based Education

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ABSTRACT

This paper shows a way of using some dimensions of learning styles of students in order to improve the efficiency of adaptive learning systems. Firstly, it reviews the literature and previous work related to the taxonomy of learning styles and its application to web-based education. Later, it introduces the Felder-Silverman learning style model and the procedure of extracting information about students' learning styles from the Felder-Soloman ILS questionnaire. Then, it presents a mechanism of application of these dimensions to content sequencing. The example used to explain the adaptation effects is taken from a course developed with TANGOW, Task-based Adaptive learNer Guidance On the Web.

Keywords: Adaptive hypermedia, web-based training, learning styles, adaptive content sequencing, user modeling.

1. INTRODUCTION

With the emergence of the WWW and the advances in instructional technologies it is growing the number of possibilities in the design and development of educational systems. The objective of these new resources is to manage an educational model centered in the students and their characteristics. Access to the education without geographical, economical or physical barriers is other important benefit.

Adaptive hypermedia is a way of tailoring the distance education course presentation to the needs of the user [1]. A user in an adaptive educational hypermedia system could see a presentation adjusted to his/her previous knowledge [2], age or language [3][4]. However, there are a few attempts to accommodate the characteristics of the course to the students' learning styles.

It is generally assented that learning styles are the preferences of students regarding to how they learn. Learning styles are sometimes addled with learning strategies. The main difference is that learning strategies can be learned and consciously addressed to different situations while learning styles are innate preferences of students as to how they prefer to go about the process of learning.

It is desirable that a Web-based instructional system includes information about the student learning style to optimally adapt the course structure to the individual characteristics of the student. By adapting course presentation to the individuals, students could learn more in less time because the materials fit in with their preferences. They can absorb the course content more rapidly and be more satisfied with how the material is presented.

2. PREVIOUS WORK

In past years, several authors have intended to manage a valid and stable classification of learning styles. Each classification has different categories depending on the author's field of research. Some of them are based on psychological, others in physical and sociological features.

Some endeavors have been made in order to adjust the course characteristics to the features of the user. None of them pay a special attention to content sequencing, in this regard, the proposal introduced in this paper is both fresh and divergent from previous work in this domain.

Learning Style Models

We try to resume the classifications which have been used over years and have impacted in teaching strategies.

The Myers-Briggs Type Indicator (MBTI): derived from the theory of psychologist Carl Jung classifies students as *extraverts* or *introverts*, *sensors* or *intuitors*, *thinkers* or *feelers*, and *judgers* or *perceivers* [5].

Kolb's Learning Style Model: classifies students depending on how they perceive and process information as *divergers* (concrete, reflective), *assimilators* (abstract, reflective), *convergers* (abstract, active), and *accommodators* (concrete, active) [6][7].

Herrmann Brain Dominance Instrument (HBDI): is based on four different task-specialized quadrants of the brain and students could be *Quadrant A* (left brain, cerebral), *Quadrant B* (left brain, limbic), *Quadrant C* (right brain, limbic), and *Quadrant D* (right brain, cerebral) [8].

Felder-Silverman Learning Style Model: categorizes an individual's preferred learning style along a sliding scale of five dimensions: *sensing-intuitive, visual-verbal, inductive-deductive, active-reflective* and *sequential-global* [9][10].

We have chosen the Felder-Silverman model among the existing learning style models because its ILS Questionnaire gives us the possibility of linking directly its results to automatic adaptive environments. Thanks to the distribution of the ILS Questionnaire in four different dimensions with two extremes we can build user models corresponding to each of these four dimensions.

Learning Styles in Web-based Education

Carver et al.: this research uses the Felder-Silverman Learning Style Model to build a relationship between learning styles and hypermedia components (slide shows, hypertext, digital library, media clips…) [11].

Arthur: in Arthur there are different student models based on auditory, visual, tactile or a combination of these styles. The system has instructors who make all the course concepts in each style and apply them randomly the first time that a student enters. This presentation style will continue or will change depending on the student's evaluation. [12].

The 4MAT Methodology: the 4MAT System Model [13] is based on the Kolb's classification and it states that a course must take a learner through a specific sequence:

- Connect
- Examine
- Image
- Inform
- Practice
- Extend
- Refine
- Perform

3. DESCRIPTION OF THE FELDER-SILVERMAN LEARNING STYLE MODEL

This model classifies students' preferred learning style on five spectrums. Though these options are active on a quotidian base, each individual could be grouped into a selected learning style in every dimension.

Sensing/Intuitive

Sensing learners: learning first concrete and practical information oriented toward facts and procedures is preferred by sensing learners.

Intuitive learners: intuitive learners prefer conceptual and innovative information oriented toward theories and meanings.

Visual/Verbal

Visual learners: visual learners obtain more data from visual representations as graphs, charts, pictures, and diagrams.

Verbal learners: verbal learners are more comfortable with verbal information as written texts or lectures.

Inductive/Deductive

Inductive learners: inductive learners like concluding principles and theories from specific cases by inference.

Deductive learners: deductive learners prefer deducing effects and uses from general axioms.

Active/Reflective

Active learners: learn by means of trying things out and doing something is preferred by active learners.

Reflective learners: reflective learners progress in their learning process through the thinking before doing things.

Sequential /Global

Sequential learners: sequential learners prefer courses organized step by step, very structured, allowing not many possibilities to the student.

Global learners: global learners prefer more flexible courses, less structured, to build a knowledge map from the exploration of the course.

The ILS questionnaire, Index of Learning Styles, was developed by Felder and Soloman based on the Felder-Silverman classification [14]. The ILS questionnaire's objective is to establish the dominant learning style of each student. ILS questionnaire is under construction and at present it is formed by 44 questions with two possible answers, *a* or *b*. These questions are separated into four groups, with eleven questions each. These groups correspond to four of the five categories in the

classification of Felder and Silverman. Authors do not take into account the inductive-deductive dimension for pedagogical reasons.

The results are explained in sections by Felder and Soloman [15]. If you get a score of 1 or 3 you have a mild preference but you are well balanced. Differently, if your score is 5 or 7, you have a moderate preference and you will learn more easily in teaching systems that favor that dimension. Finally, if you score 9 or 11, you could have difficulty learning in a system which does not support that preference.

4. ADAPTIVE SEQUENCING BASED ON LEARNING STYLES

In a Web based learning environment we try to attain an easiest and most effective learning process through adaptation of learning courses to individual learning styles. To minimize the time spent is a very important factor when we talk about Web-based learning. Most adaptive learning systems get the conscious student information from the students themselves. Nevertheless, students are not aware of their learning styles and we need a questionnaire to identify them.

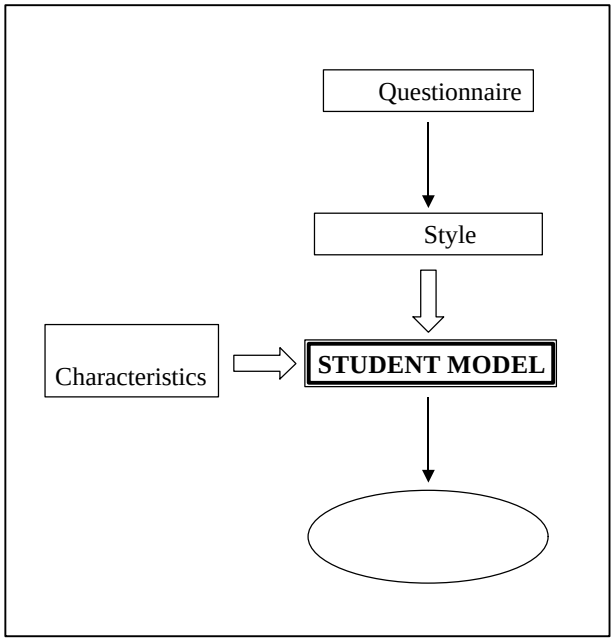

Figure 1. Processing information to obtain data for user modeling .

Adaptive web-based education needs four components: a user model, educational materials, a model of the content organization and relationships among the educational materials, and a strategy to select the order and type of these materials to achieve the optimal way of learning for each student [16]. We think that a user model should include learning styles as a key factor to decide the course content sequence and structure.

We propose an adaptation procedure for moderate and strong sensing-intuitive and sequential-global learners, as detected by means of the Felder-Soloman ILS questionnaire. In our approach, adaptation lies in presenting examples before expositions to sensing learners and quite the opposite to intuitive learners. In addition in presenting a fixed structure of content sequencing to sequential learners and a more flexible order to global learners.

As you can see in figure 1 the procedure is as follows: firstly the student fills out the questionnaire; then the score obtained points out the sensing-intuitive and the sequential-global preference of the student: mild, moderate or extreme; finally we use that preference to construct a student model, together with other student characteristics. The learning style data are used to adapt the exposition-exemplification sequencing in case of moderate and extreme sensing-intuitive learners and the content sequencing in case of moderate and extreme sequential-global learners.

5. A CASE STUDY

We have implemented the described adaptation procedure on TANGOW, Task-based Adaptive learNer Guidance On the Web [3][4]. TANGOW is a tool designed for building web-based courses. Structure and content are independent in TANGOW. Structure is defined in terms of teaching tasks and rules, and content is defined as a list of media elements associated to each task.

In TANGOW a course is described in terms of Teaching Tasks and Rules. Knowledge is represented by means of TTs that need to be achieved. TTs may be exposition tasks (E), practical or examples (e) and also can be atomic or compound. Rules say which tasks are part of other tasks and what the order of decomposition is:

- AND: all the subtasks following a fixed order
- ANY: all the subtasks in any order
- OR: at least one of the subtasks in any order
- XOR: just one of the subtasks

TANGOW provides adaptive guidance based on the student profile, the student actions and the teaching strategy.

In order to create a new course, the course designer has to define the tasks and rules corresponding to the course and classify the multimedia elements that will appear in the HTML pages generated.

Sequential/Global adaptation

Designers establish the default order, that is, the order of the tasks (AND, ANY, OR and XOR). Our approach is to dynamically modify this order according to the learning style. If the student obtains a score of 1 or 3, his/her preference to one or the other style is balanced and we apply the default order. On the contrary if the student scores 5 or more than 5, the order of the tasks will be in harmony with his/her learning preference.

We assume that sequential learners prefer courses more structured so for them the adaptation consists of changing the ANY rules in AND rules, and vice versa for global learners.

Sensing/Intuitive adaptation

Exposition TTs can have an example associated. Usually, designers establish exposition-exemplification as the default sequence. We apply the same scale of sequential/global to sensing/intuitive dimension and the students with a score in the ILS questionnaire greater than 5, will receive the order of exposition-exemplification in the preferred order.

We suppose that sensing learners prefer exemplification first, on the contrary that intuitive ones. We presume also, that a relationship between the two parts of these special nodes (exposition-exemplification) exists and that it is stronger and independent of any other possible sequencing.

In figure 2 we show the adaptive sequencing of a "course" formed by five Teaching Tasks. Taking into account these two dimensions sequential/global and sensing/intuitive, the possible course models are the combination of global with sensing and intuitive, and sequential with sensing and intuitive. So, from the learning style point of view, we can talk about GS (global-sensing), GI (global-intuitive), SS (sequential-sensing), and SI (sequential-intuitive) models of the course.

In these trees the root node is the whole course and it is a compound task. We can find other compound tasks and a special task (e-e task represented by a discontinue circle) in next level. Last level contains those two special tasks. Optional sequencing is represented with a line between nodes and a fixed order by means of an arrow.

As we can see in the figure, the order of the e-e nodes is always an arrow, so is always an AND. The difference between sensing and intuitive is that you can see either exemplification or exposition first, respectively. In the rest of the nodes the order is dependent upon the sequential/global (AND/ANY) dimension.

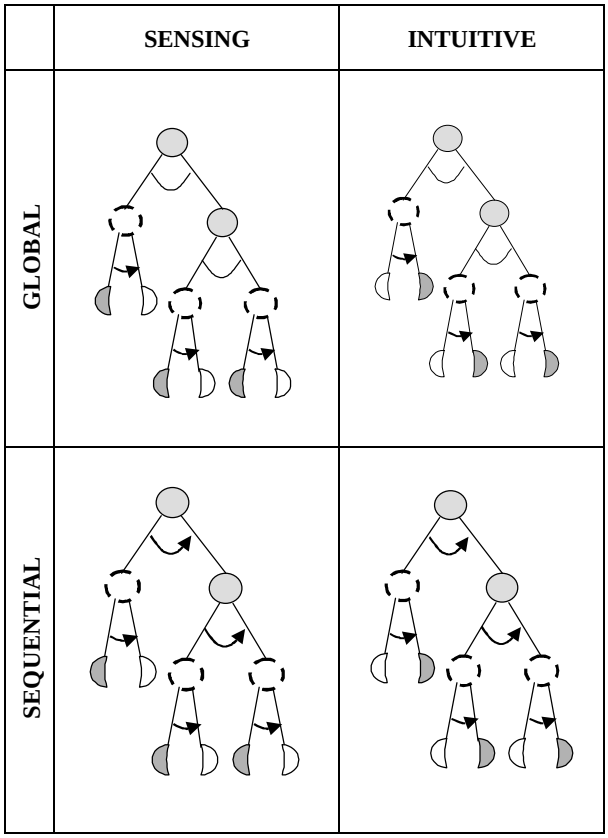

Figure 2. Adaptive sequencing based on sensing/intuitive and sequential/global dimensions. The discontinuous circles represent e-e tasks: the darker semicircles represent exemplification and the clearer ones represent example tasks.

6. CONCLUSIONS AND FUTURE WORK

This paper suggests the application of the results of the ILS questionnaire to automatically adapt some dimensions of the Felder-Silverman model to the course sequencing. We assume that a strong relationship between examples and their related theoretical expositions exists with independence of the conceptual representation. This relationship is more powerful than any other sequencing consideration, and can eventually be combined with other dimensions [17][18].

In addition to sequential-global and sensing-intuitive dimensions, at present our research examines the incorporation of other learning style dimensions, according to the ILS, to the general model. It involves the study of possible conflicts between adaptive actions based on different learning style dimensions and the

resolution of these conflicts by establishing a priority of some dimensions against others.

7. ACKNOWLEDGEMENTS

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