

Incorporating Learning Styles in Adaptive Educational Systems

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Abstract: - This paper investigates the accommodation of learning styles in Adaptive Educational System. Particularly we outline some of the most well-known learning styles theories and models, as well as some criteria for selecting among them. Based on this approach, we outline some personalised learning sub-systems of adaptive educational systems which are utilising learning styles. The adaptive educational system is being developed in our project based on the above approach is also described.

Key-Words: - Adaptive Educational Systems, Learning Styles, Personalised Learning, Web-based Knowledge

1 Introduction

Adaptive Educational Systems (AESs) [1] possess the ability to make intelligent decisions about the interactions that take place during learning, aiming to support learners without being directive. Typically, Adaptive Educational Systems reflect several learner characteristics to the 'learner model', and apply this model to adapt various visible aspects of the system to individual learners [2]. An important issue in designing Adaptive Educational Systems is the sharing of control between the system and the learner, as many researchers acknowledge that learners benefit from learner control opportunities [3] [4]. However, the development of web-based Adaptive Educational Systems in which learners are individually supported in accomplishing their personal learning goals (adaptive dimension of an AES) and at the same time they are allowed to control when, what and how to learn (adaptable dimension of an AES), requires a deep understanding of the learning and instructional processes. To this end, it is important to consider adaptation within the framework of modern learning theories and models, and thoroughly enhance learner control opportunities over the instructional process [5]. Although several instructional approaches have been used in Adaptive Educational Systems that reflect specific learning/instructional theories, the use of constructivist theories as a base for the development of Adaptive Educational Systems is very limited [6]. Constructivist theories acknowledge the importance of learner control over the learning process and assume that knowledge is individually constructed and socially constructed by learners based on their interpretations of experiences of the world. Constructivist learning environments engage

learners in meaning making (knowledge construction) having as a focus a problem, a question, or a project, and surround it with various types of support [7]. The main characteristic of constructivist learning environments is that a specific problem drives the learning, rather than acting as an example of the concepts of the subject matter. The learning environment (and general the AES) has to accommodate the personal learning style of each learner.

The sub-system of an Adaptive Educational System that has the capability to automatically and continuously *adapt* to the changing attributes of the "learning context" is defined as Personalised Learning System.

Personalised Learning systems can be quite diversified according to their adaptation logics, depending on the requirements of the specific learning context [8]. For example, Personalised Learning determinants can include learners' characteristics, which can, in turn, include learner's background, expertise, prior knowledge, skills, requirements, preferences, etc.

This paper addresses the incorporation of learning styles in the adaptation logic of Personalised Learning systems. That is, the definition of new Personalised Learning determinants, constituents and rules which are based on, and reflect specific learning styles theories and models. The next section provides a short overview of the most well-known learning styles theories and models, as well as some criteria for selecting among them when developing a Personalised Learning system. Finally, the paper outlines some existing Personalised Learning systems which utilise learning styles research, with emphasis on the Personalised Learning system

which is being developed in our Adaptive Educational System.

2 Learning Styles Research: A Brief Overview

There is no single way to describe learning styles, as a number of definitions appear in the literature. Learning styles can be generally described as “an individual’s preferred approach to organising and presenting information” [9]; “the way in which learners perceive, process, store and recall attempts of learning” [10]; “distinctive behaviours which serve as indicators of how a person learns from, and adapts to his/her environment, and provide clues as to how a person’s mind operates” [11]; “a gestalt combining internal and external operations derived from the individual’s neurobiology, personality and development, and reflected in learner behaviour” [12].

Existing learning styles models can be presented through an onion metaphor (proposed in [13]), consisting of three basic layers which categorise learners in terms of instructional preferences (outermost layer), information processing (middle layer) and personality (innermost layer). Social interaction, a fourth layer placed between Curry’s two outer layers, was proposed in [14].

The most well-known and used learning styles theories and models are:

1. Kolb Learning Style Inventory proposed for Divergers (concrete, reflective), Assimilators (abstract, reflective), Covergers (abstract/active) and Accommodators (concrete/active) [15], [16].
2. Dunn and Dunn – Learning Style Assessment Instrument proposed for Environmental, Emotional, Sociological, Physical factors [17], [18].
3. Felder-Silverman – Index of Learning Styles proposed for Sensing-intuitive, Visual-verbal, Indicative-deductive, Active-reflective, Sequential-global [19], [20].
4. Riding – Cognitive Style Analysis proposed for Wholists-Analytics, Verbalisers-Imagers [21], [22].
5. Honey and Mumford – Learning Styles proposed for Theorist, Activist, Reflector, Pragmatist [23].
6. Gregoric – Mind Styles and Gregoric Style Delineator proposed for Abstract Sequential, Abstract Random, Concrete Sequential, Concrete Random [11]; [24].
7. McCarthy – 4 Mat System proposed for Innovative, Analytic, Common sense, Dynamic [25], [26].
8. Gardner – Multiple Intelligence Inventory proposed for Linguistic, Logical-mathematical, Musical, Bodily-kinesthetic, Spatial, Interpersonal, Intrapersonal [27], [28].
9. Grasha- Riechmann – Student Learning Style Scale proposed for Competitive-Collaborative, Avoidant-Participant, Dependent – Independent [29], [30].
10. Hermann – Brain Dominance Model proposed for Quadrant A (left brain, cerebral), Quadrant B (left brain, limbic), Quadrant C (right brain, limbic), Quadrant D (right brain, cerebral) [31], [32].
11. Mayers-Briggs – Type Indicator proposed for Extroversion, Introversion, Sensing, Intuition, Thinking, Feeling, Judgement, Perception [33], [34].

3 Selection Criteria for Different Learning Style Models in Personalised Learning Systems

Given the variety of learning styles theories and models that are available in the related literature, we need to define a set of selection criteria for selecting the most appropriate learning style model to be accommodated in a specific Personalised Learning sub-system of an Adaptive Educational System. The most important criteria are the theoretical and empirical *justification* of the model. In addition, the learning style model should be *suitable* for the specific learning context. So, if all learners of a specific learning context are “experts” in the domain, then it might not be reasonable to select a learning style model which categorises learners according to their expertise in the domain. Similarly, if all the educational material that is available for a specific case is in textual form, then it is not reasonable to select a model which differentiates content according to its medium.

A set of additional important selection criteria are briefly summarised below.

1. Measurability. We need to be able to “measure” whether learners belong to the categories defined by each model. Although it is reasonable from a theoretical point of view, models differentiate learners according to their emotions, since emotions can affect learning, it may not be reasonable to select such models for an Adaptive Educational System, since it may be difficult to measure learners’ emotions. Felder and Silberman model [19], [20], for

instance, is supported by the Felder and Solomon questionnaire, which easily determines how a learner is categorised according to the dimensions proposed by the model. The lack of such an assessment instrument (questionnaire) can be a reason for *not* selecting one model.

2. *Time effectiveness.* The assessment instrument related to each learning style model needs to include a reasonable number of questions in order to be time effective. If an assessment instrument consists of 200 questions, then the instrument may not be time effective. The user may not be willing to dedicate his/her time in order to complete a large questionnaire before starting using the system.

3. *Descriptiveness and Prescriptiveness.* The model should describe not only how learners are categorised, but also how instruction should be adapted for each learner category. This means that apart from the *descriptive* information (learners are categorised into “active” and “reflective”) the model should provide *prescriptive* guidelines, which can lead to specific rules for designing instruction and adaptation (what types of educational content should be selected for active and reflective learners).

4. *Cost.* The cost of a learning style model along with its assessment instrument is a parameter that system designers may need to consider. Some assessment instruments are only available for use after payment, while others are available to be used free-of-charge. The designers need to consider the cost of the model and its assessment instrument. Then, the availability of the test in relation to the number of users needs to be considered.

4 Some Examples of Accommodating Learning Styles Research in PL Systems

Learning styles research has formed the basis for the development of a number of Personalised Learning systems. TrainingPlace.com is a notable example of a commercial PL system which is based on learning styles research. The system is based on Learning Orientation Theory, which categorises learners as transforming, performing, conforming and resistant. Based on this categorisation, the system presents different “learning experiences” to each learner. The system selects “loosely structured environments that promote challenging goals, discovery and self-managed learning” for transforming learners, and “semi-complex, semi-structured, coaching environments that stimulate personal value and provide creative interaction” for performing learners [35].

SMILE, a web-based knowledge support system aiming at promoting intelligent support for dealing with open-ended problem situations, utilises a learner profile which takes into consideration the learner’s learning style, following Honey and Munford’s categorisation [36]. The 3DE European Project (www.3deproject.com) categorises learners into activists, reflectors, theorists and pragmatists, in order to create courses customized to their needs.

Our Adaptive Educational System that is under development aims to deliver an adaptive learning environment for personalised learning. In this context, the aim of the system is to facilitate the development of adaptive educational content which can be easily interchanged and re-used across different e-learning applications and services. In particular, our system is working on the *knowledge packaging format* (an extension of the existing IMS Content Packaging Specification [37]), for the description, in a common format, of knowledge packages (collections of learning objects), together with the rules which determine which learning objects should be selected for different learner profiles. As a result, our e-learning system (or any system compliant with the knowledge packaging format), can import a knowledge package (a collection of learning objects described through the knowledge packaging format), interpret the rules included in it, and present different knowledge routes to each individual learner, according to his/her profile, thus facilitating personalised learning.

Our proposed Adaptive Educational System includes an authoring environment for describing adaptive educational content through the knowledge packaging format. Through this authoring environment, the user (learning material author, tutors, publisher) can define the Personalised Learning logic (determinants, constituents and rules) which drive the personalisation of the knowledge package.

In order to assist the developer of knowledge packages, the IMS Learner Information Profile Specification [38] proposed some elements for describing learner profiles. The designer can easily select which of these determinants are suitable for the specific learning context, and include them in a new knowledge package. Similarly, the IEEE Learning Objects Meta-Data Specification [39] proposed elements for describing learning objects characteristics; as well as a set of Personalised Learning rules, which select different Personalised Learning constituents (learning objects characteristics) for different Personalised Learning determinants (learner characteristics).

Parts of the Personalised Learning logics, based on

specific learning styles models, are built-in in the system for assisting the user to easily accommodate these learning styles models into the development of adaptive educational e-content. So, if the user selects to accommodate a specific learning style model which categorises the learners as visual/verbal; the learner profile which is created by the system for each learner, will include an element for representing whether each individual learner is visual/verbal; similarly, the educational meta-data file which describes each learning object will include a specific element for representing whether the learning object is visual or verbal.

4 Conclusion

This paper has investigated the accommodation of learning styles research in Personalised Learning systems. It has briefly reviewed the most well-known learning styles theories and models, as well as some criteria for selecting among them when developing a Personalised Learning system. The paper has also outlined some Personalised Learning systems which utilise this line of research for delivering personalised learning, with emphasis on the Personalised Learning system which is being developed in our Adaptive Educational System.

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