Adaptive Instruction in Adaptive Educational Hypermedia Systems

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Abstract: - In this paper we focus on adaptive instruction and especially on the educational perspective that should underlie the development of web-based Adaptive Educational Hypermedia (AEH) systems used for Internet-based distance education. A design rational and guidelines are proposed for adaptive instruction in the context of AEH systems, which unify several processes that formulate system's adaptation such as structuring the domain knowledge, developing the content, planning individualised instruction and support, assessment, and learner control opportunities. The main aim of this approach is to incorporate a variety of pedagogical models and learning theories in order to accommodate the diversity needs and perspectives of learners and teachers. Paradigms of the way these guidelines have been implemented mainly in AEH systems, are provided.

Key-Words: - Adaptive Educational Hypermedia Systems, adaptive instruction, instructional design, instructional strategies, learning style.

1 Introduction

The Internet offers distance education an opportunity to augment the traditional methods, content and strategies of teaching and learning. In this learning context, web-based learning environments can serve as centrally available systems that allow a user to learn transcending typical time and space barriers. The challenge posed for the education and the computer science communities is the exploitation of the innovative characteristics of the Internet for the development of web-based learning environments, flexible enough to accommodate learners' individual differences in a distance learning setting and provide learners control over instruction in a way that enhances learning. For pedagogical reasons, the effective design of flexible learning environments within the technologically rich medium of Internet demands understanding of: (i) the learning and instructional processes under the specific conditions of Internet-based distance education, (ii) the diversity of the audience which consists of learners with different backgrounds,

preferences, goals, knowledge level, etc. and (iii) the unique characteristics of the medium which encourage the development of learner-centered environments. Otherwise, course design may become technology driven rather than allowing technology to serve as a resource in support of learners needs [8].

Towards these directions there has been current research into the area of adaptive instruction [4], where the primary principle is that learners will be able to achieve their learning goals more efficiently, when pedagogical procedures accommodate their individual differences. In the area of adaptive instruction, Adaptive Educational Hypermedia (AEH) systems [2] emerged as an alternative to the traditional "onesize-fits-all" approach in the delivery of courseware. AEH systems possess the ability to make intelligent decisions about the interactions that take place during learning and aim to support learners without being directive. To this end, AEH systems build a model of the goals, preferences and knowledge of each individual learner and use this model throughout the interaction for adapting the content and the navigation to the needs of the particular learner [1].

The idea of developing web-based learning environments, in which learners are individually supported to accomplish their personal learning goals, demands a cohesive instructional background to integrate system's functionalities that lead to the adaptation enhancing its educational potential. To this end, in this paper we focus on adaptive instruction and especially on the educational perspective that should underlie the development of web-based AEH systems used for Internet-based distance education. A design rational and guidelines are proposed for adaptive instruction in the context of AEH systems with the aim to accommodate a variety of pedagogical models and learning theories and enable the system (or the learner) to select the most appropriate approach following the individual characteristics of the current learner and context. Paradigms of the way these guidelines have been implemented AEH systems, are also provided.

2 The Proposed Design Rational for Adaptive Instruction

The proposed design rational aims to provide a picture of how the content, assessment and instruction work together to build purposeful lessons that accommodate learners' individual differences and provide learner control opportunities. To this end, we propose a set of guidelines for designing adaptive instruction in the context of AEH systems that unify several processes underlying system's adaptation such as structuring the domain knowledge, developing the content, planning individualised instruction and support, assessment, and learner control opportunities. The proposed design rational addresses the following issues: (a) *Instructional strategies* (b) *Content* (c) *Assessment* (d) *Individualized support* (e) *Learner control opportunities*.

Instructional strategies. A variety of methods of instruction are supported which are based on different pedagogical models/learning theories. Adaptive instruction aims to: (*i*) individually support learners to accomplish their goals in a way that matches their style of learning and knowledge level, and (*ii*) become system independent by enabling them to manipulate and accommodate instructional approaches to their own needs and preferences.

Guidelines: (*i*) Define a set of instructional strategies, which differ in the amount of structure, learner control and support provided to learners. (*ii*) Provide learners the option to select an instructional strategy. For each one provide a brief overview of the main idea and the different functionalities of the strategy in order to support learners select the most appropriate for them. (*iii*) Design each instructional strategy so that to provide: (a) individualized content following learner's profile (b) individualized support following learner's profile (c) multiple assessment opportunities (d) meaningful tasks and activities in which learners undertake an active role (e) collaboration opportunities. (*iv*) Propose the most appropriate strategy for learners with specific profiles, e.g. the initial acquisition phase is better served by classical instructional design techniques while complex and constructivist environments serve advanced knowledge learners better.

Implementation Example. As different cases of instructional strategies can be considered those starting *from* a highly *constructive* approach, in which learners are basically on their own to figure out where and how to acquire the knowledge, skills and attitudes, *to* a more *prescriptive* approach, in which structure and guidance are provided to help the learners acquire the knowledge, skills and attitudes accommodating their individual differences.

Cases of *constructive* approaches. In KBS-Hyperbook [5] learners are able to work on projects and the system supports them by providing appropriate material and guidance. Project results are used to represent and to assess learners' knowledge. In SCI-WISE [9] learners undertake collaborative research projects and a community of

software agents, such as a Planner, a Collaborator, and an Assessor, support them providing strategic advice and guidance.

Content. The main topics of the curriculum are presented as learning goals enabling learners to select the one they prefer or need to study. Learning goals are building elements of the content as well as of learners' interaction with the content. The educational content of each learning goal includes all the concepts important to the curriculum for the particular learning goal (declarative and procedural knowledge) and comprise of multiple independent modules, which can be re-used by different instructional strategies.

Guidelines: (*i*) Define a set of *learning goals*, which are fundamental topics of the domain that can be recognized and selected even by a novice learner independently of his/her previous selections. (*ii*) Provide learners the option to select the learning goal to study according to their needs and preferences. For each goal provide relevant learning outcomes, information about its fundamental concepts, and a brief overview to support learners to select the one to study. (*iii*) For each learning goal build a *conceptual structure* based on design principles extrapolated from instructional theory. This structure should include all the necessary concepts comprising the goal and their interrelations (such as prerequisites, related). (*iv*) Develop *educational material* for each domain concept that supports learning/achievement of specific skills/performance levels. Develop multiple knowledge modules of different types of educational resources and authentic and meaningful tasks that cover a variety of learning/cognitive styles. (*v*) The modularity of the content allows the use of its different components - concepts, knowledge modules - by different instructional strategies for a variety of learners' profiles.

Assessment. Multiple assessment opportunities are provided that aim to support learners identify their own progress and provide the system with the necessary information about learners' level of performance in order to be able to adapt accordingly.

Guidelines: (i) Provide self-assessment opportunities in the educational content through a plurality of assessment tasks that actively engage learners and stimulate them to assess and record their own progress and study accordingly (formative assessment). (ii) Provide formal assessment aligned with the content provided in order to assess retention of learning following specific criteria given in terms of objectives and competences which state what learners must achieve (summative assessment - criterion-referenced assessment). (iii) Provide feedback to learners' answers in order to support the learning process, provoke reflection on and articulation of what was learned.

Individualized support is provided aiming to advice and not direct learners. The amount of support and guidance provided is mainly dependent on learner's characteristics such as knowledge level, learning style, preferences.

Guidelines: (*i*) Support learners in undertaking control over the learning process and the adaptation. Provide learners with information about the different functionalities of the system that lead to the adaptation and of the influence of their actions on the system's functions. (*ii*) Support learners in accomplishing their tasks by providing individualized content, support, and navigation advice. Learners should be allowed to decide on their next steps and not restricted to follow system's suggestions.

Implementation Example. In several AEH systems such as ELP-ART, AES-CS, the externalization of the learner model is used as a means of communication between the learner and the system. In these systems the learner model is open to the learners providing information about the system adaptation, the instructional decisions of the system, and the opportunities they are provided to intervene in the instructional process. Moreover, different adaptation technologies such as adaptive presentation, adaptive navigation support, curriculum sequencing, are used to provide individualized content, support, navigation advice following learners' knowledge level, progress, and learning style.

Learner control opportunities. Learners undertake an active role in the learning process and are allowed to take varying levels of initiative. Learners are informed about the internal workings of the system and they are provided with opportunities to control the learning process and undertake control over the system. As system adaptation is mainly based on the learner model, an open learner model is a fundamental part of learner control [6].

Guidelines. Provide learners with the options to: (a) decide what to learn; (b) decide how to learn; (c) decide when to learn; (d) control the adaptation; (e) control the amount of control.

Implementation Example. In SCI-WISE learners select their learning peer / teacher / companion (how to learn). Cases of systems where learners select "When to learn" can be considered Ecolab [7] and I-Help [3]. In both systems learners ask for support when they need to and in Ecolab, an expert learner assists a novice one to complete an activity, whilst I-Help supports the interaction of a network of peers

that help each other out.

3 Adaptive Web-based Instructional Systems

Adaptive Web-Based Instructional Systems (WBIS) are currently a highly active research field. They have started appearing as commercial applications. AWBIS are called upon to solve certain problems that originate from the traditional web-based instructional systems and are summarized as following:

- In instructional Systems that are not adaptive, the learners are lost during navigation through the hypermedia content and do not know where they have come from, where they are and where they can lead themselves.
- Cognitive overload. Too much effort is spent by the learner to comprehend the hypermedia structure, on the expense of the learning process. For example the learner tries too hard to comprehend the functions of the graphical user interface, instead of focusing on the learning content.
- They are either too restrictive, effecting in the loss of the user's flexibility and freedom, or too relaxed, resulting in chaotic structures.
- The variety of learning styles and learners' different performance causes it impractical and ineffective to treat all the learners in the same way. Instead, each learner should be treated in a personalized way, according to his/her performance, preferences and learning style.
- In cases where the learning process takes place without any teacher supervision (e.g. in distance learning), the learner must be fully supported and assisted by the instructional system.

AWBIS are characterized by certain attributes and functions that solve the above problems. To begin with, AWBIS by adapting their content and links, leverage the complexity of the hypermedia structure, restraining the navigation and making it easier for the novice users to better orientate and avoid getting lost. On the other hand, they give expert users enough freedom and flexibility in their navigation, so that they won't feel constrained. Furthermore, they assist the novice users to focus on the content of the learning material instead of trying to comprehend the user interface. Finally they guide users with content and link adaptation and help them individually, according to their needs and preferences.

4 Conclusion

The development of web-based learning environments that accommodate learners' individual differences is the real challenge for distance education taking into account the diversity of its audience as well as the issue that an instructional approach that benefits one category of learners may create obstacles for other categories. A critical issue in the development of such systems is the pedagogical background underlying the adaptation.

The design rational presented in this paper focuses on the educational perspective of Adaptive Educational Hypermedia Systems with the aim to support the development of learning environments built on sound pedagogic principles and rich enough to accommodate a diversity of instructional/learning approaches. From the technological perspective, the proposed guidelines provide the educational basis for modeling the domain knowledge of the system, the learner model (although in this paper this aspect of the framework has not been covered) and system's adaptation. In particular, modeling the domain is a critical issue in the area of personalized web-based instruction, as it should support courseware reusability. One of the major goals of courseware re-use is to support the generation of personalized courses enabling the production of several versions of the same course targeted to different audiences, from the same rich set of learning objects. Consequently, the decomposition of the content based on pedagogical principles enhances the educational perspective of its re-use under a variety of instructional situations and learners' profiles.

References:

[1] Brusilovsky, P., Methods and Techniques of Adaptive Hypermedia, *User Modeling and User-Adapted Interaction,* 6 (2/3), 87-129. 1996.

[2] Brusilovsky, P., Adaptive Hypermedia, *User Modeling and User-Adapted Interaction,* 11 (1/2), 111-127, 2001.

[3] Bull, S. & McCalla, G., Modelling cognitive style in a peer help network, *Instructional Science,* 30, 497–528, 2002.

[4] Federico, P.-A., Hypermedia environments and adaptive instruction, *Computers in Human Behavior*, 15, 653-692, 1999.

[5] Henze, N., Naceur, K., Nejdl, W. & Wolpers, M., Adaptive Hyperbooks for constructivist teaching, *Kunstliche Intelligenz,*26-31, 1999.

[6] Kay, J., Learner control, *User Modeling and User-Adapted Interaction,* 11(1/2), 111-127, 2001.

[7] Luckin, R. & Du Boulay, B., Ecolab: The Development and Evaluation of a Vygotskian Design Framework, *International Journal of Artificial Intelligence in Education*, 10, 198-220, 1999.

[8] Trapp, A., Hammond, N. & Bray, D., Internet and the support of psychology education, *Behavior Research Methods, Instruments, & Computers*, 28, 174 –176, 1996.

[9] White, B.Y., Shimoda, T.A. & Frederiksen, J.R., Enabling students to construct theories of collaborative inquiry and reflective learning: Computer support for metacognitive development, *International Journal of Artificial Intelligence in Education*, 10,151-182, 1999.