THE MECHANISMS OF ADAPTING THE PEDAGOGICAL CONTENT TO THE LEARNER'S PROFILE IN A DYNAMIC CEHL ENVIRONMENT

Fayçal MESSAOUDI

Laboratory of Research in Entrepreneurship and Management of Organizations
National School of Business and Management
Sidi Mohamed Ben Abdellah Fès University, Morocco

Adil KORCHI

Laboratory of Signals, Systems and Components
Faculty of Science and Technology,
University Sidi Mohamed Ben Abdellah, Fez, Morocco

Lahcen OUGHDIR

LIMAO, Department of Mathematics, Physics and Informatics
Polydisciplinary Faculty of Taza
Sidi Mohamed Ben Abdellah Fès University, Morocco

ABSTRACT

Building quality educational resources with new technologies requires offering learners and teachers a simple computing environment that would be adapted and would allow it to use its pedagogy in respondent contents of learner's needs, in terms of adaptability, portability monitoring and evaluation.

In this article, the focal point is reminding the architecture of our Dynamic Adaptive Hypermedia (DAH) system, we shall focus on these different elements namely, the model domain, the student's model, teaching model, the courses' generator, and the multimedia database. Then, we will detail the steps of the proposed approach to the development of educational content through this (DAH) system, dedicated to both teachers and learners. The purpose is to come up with a mechanism that can adapt the course to the learner's profile, in a Computing Environment For Human Learning (CEHL).

In this article, we are putting much importance on the various information stored in the models of our system, which would be useful to dynamically generate structured and comprehensive educational content according to cognitive status and the learner's style. The aim is to try hard and to look for pedagogical contents, dealing with concepts of a particular field of knowledge that is adapted to a particular learner. In other words, we want to develop a generic model of interactive multimedia

educational content and a learner model based on the integration of skills and knowledge.

Key words: CEHL, Dynamic Adaptive Hypermedia, Model domain, Learning style, Workflow.

Cite this Article: Fayçal MESSAOUDI, Adil KORCHI, Lahcen OUGHDIR, The Mechanisms of Adapting the Pedagogical Content to the Learner's Profile in a Dynamic CEHL Environment, *International Journal of Computer Engineering and Technology* 10(3), 2019, pp. 119-133.

<http://iaeme.com/Home/issue/IJCET?Volume=10&Issue=3>

1. INTRODUCTION

In recent years, hypermedia has opened a new line of research in the field of E-learning, which currently occupies a prominent place in scientific research. This is thanks to the increased needs of training and continuous choices of the democratization of information and communication technologies. In fact, the concept of learning gradually becomes primordial in many contexts such as educational, academic, personal, professional, or continuous training (formal or informal).

In addition, even the amount of information available are also increasing sharply, and instead of the learner exploiting this huge flow of information, he finds himself lost in front of a bifurcated hyperspace. Moreover, even if the learner is not lost, he exploits very poorly or badly the richness of the available information. It is, therefore, clear that it is necessary to adapt the educational content according to the profile of the learner before starting the learning activity. This profile represents the learner's model in our system, which is time-evolving, interoperable and machine-readable. However, the integration of New Information and Communication Technologies (NICT) in an educational system is materialized by the use of digital multimedia teaching resources that must be created according to well-defined standards that would allow their use according to pedagogical methods.

The research work done on the learner's modeling, places him at the center of learning. Their weaknesses lay in the fact that they do not personalize the learning according to the style of the learner. Therefore, and for a better adaptability of the educational contents to the learners, we are interested in the use of a very fine granularity approach of the pedagogical objects, which would be more efficient since it provides to the system of learning information personalizing it and making it appropriate to the characteristics and preferences of the learner.

Taking into account that cognitive models therefore become insufficient, we must add other models containing cognitive, behavioral and psychological information (know-how, intentions, emotions) to make the system accessible to a more and more heterogeneous population. For this, it is necessary to make a triple-personalization's adaptation of the training (context, skills and prerequisites). This operation allows targeted long-term learning (continuing education) in a variety of contexts.

In this article, we will discuss the detailed conceptual study of our learning system, using the Unified Modeling Language (UML), and the proposed methodological choice for the development and scripting of simple and user-friendly educational content adapted to the needs expressed by the actors concerned. Namely the author who is the content developer, the teacher who plays the role of the tutor and the evaluator, the learner who exploits the educational contents and finally the administrator who manages the platform.

Our article is organized in three parts: The first presents briefly the architecture of our "SmartKnowledge" environment. The second one focuses on the process of creation of educational contents, it shows the notion of granularity, reusability and adaptability as well as

the relation between these three notions. The third materializes our designing vision with the modes and adaptation mechanisms used in our dynamic adaptive hypermedia, using class diagrams implementing our granular approach. Finally, we conclude with perspectives related to our work.

2. METHODOLOGY AND PURPOSE

We propose to develop a dynamic adaptive hypermedia dedicated to the online training system, which is able to provide opportunities to adapt the training to the characteristics and needs of learners. For this purpose, we suggest a learner-centered approach. In other words, we have to observe our system from the perspective of the learner, then we must place it as the major actor of the learning process to have the opportunity to manage knowledge by itself.

We would have understood that each learner has a unique learning style and a unique way to organize his concepts and information. This is known in pedagogy and psychology as learning styles. Thereby, the teaching cannot be perceived in the same way by all learners.

In so doing, we take the approach by attitudes and skills that allow the combination of power and knowledge. In this frame, we have developed a cognitive model that suits the learner, which is based on the integration of learner's skills and productions; it is built on measures of learning.

Moreover, all information about the learner's model will help maintain a deep knowledge of each learner and will define the characteristics that can measure their performance and their motivation, and identify their level of knowledge, their goals, their interests, their learning style, their strategies and their psychological problems. It will also track their progress and provide adapted administrative and cognitive tutoring.

The creation of this model could be done in different ways. For this model, we have chosen the method of recovery (Overlay), where the state of knowledge of the learner is represented as a subset of the model's knowledge [1]. We have also chosen the Felder-Silverman model to learn about their learning style.

That said, we are interested in the study of learners' profiling process using the measure of learning style. This measure is based on the index of learning styles (ILS) established by Felder and Silverman. The FelderSilverman questionnaire contains 44 questions. For each question, the learner must choose an answer between 'a' and 'b'. The 44 questions are divided into four groups of 11 questions for each. Each group of questions defines a dimension of the learner's cognitive model which is composed of four dimensions: Sensory dimension, Progression dimension, Sequential Thinking dimension, Reasoning dimension.

A questionnaire was uploaded online, addressed to 452 students of the National School of Commerce and Management of Fez (ENCGF). The results were transferred to the data base of our system.

The primary objective of this study is to measure the learning style of each student then reveal the most popular style which will be assigned to all newly registered students that have not taken the questionnaire. After analyzing the results, we found that the target group consisted of multiple and different learning styles.

According to the questionnaire, the learner must answer the 44 questions, in which each dimension has 11 questions and two different values. We can deduce 16 possible learning styles in our study, so we have retained the following table:

Table 1 Different learning styles identified

STYLE	DIM 1	DIM 2	DIM 3	DIM 4
Style 1	Active	Inductive	Verbal	Sequential
Style 2	Active	Inductive	Verbal	Global
Style 3	Active	Inductive	Visual	Sequential
Style 4	Active	Inductive	Visual	Global
Style 5	Active	Deductive	Verbal	Sequential
Style 6	Active	Deductive	Verbal	Global
Style 7	Active	Deductive	Visual	Sequential
Style 8	Active	Deductive	Visual	Global
Style 9	Reasoning	Inductive	Verbal	Sequential
Style 10	Reasoning	Inductive	Verbal	Global
Style 11	Reasoning	Inductive	Visual	Sequential
Style 12	Reasoning	Inductive	Visual	Global
Style 13	Reasoning	Deductive	Verbal	Sequential
Style 14	Reasoning	Deductive	Verbal	Global
Style 15	Reasoning	Deductive	Visual	Sequential
Style 16	Reasoning	Deductive	Visual	Global

We notice from the figure above, that the style 1 is the most popular one among learners. This result reflects the focus of our study, as we have mentioned above. This style will be assigned by default to new learners who do not wish to take the FelderSilverman questionnaire. Style 1 is composed of four dimensions.

Figure 1 Division of learners in each learning style

3. PROPOSED ARCHITECTURE OF DYNAMIC ADAPTIVE HYPERMEDIA HAD

According to [2], an adaptive hypermedia system must meet three criteria: it must be a system hypertext or hypermedia; it must have a template of the user; and must be able to adapt hypermedia using this model. Besides this definition, to design the overall architecture of the system, to improve the quality of adaptation, and to take into account new data instantly, we oriented dynamic adaptive hypermedia. The proposed dynamic aspect's results in the generation, customization and composition of educational content according to the characteristics of learners taking into account their learning style and cognitive status.

The Mechanisms of Adapting the Pedagogical Content to the Learner's Profile in a Dynamic CEHL Environment

Figure 2 below shows the overall architecture of our environment "SmartKnowledge" which generally approximates the standard architecture of dynamic adaptive hypermedia.

Figure 2. The architecture of our system « SmartKnowledge »

It is based on five main models; they are presented as follows:

The domain model: aims at determining the relevant concepts and relationships and provides an overall structure of the learning area. It has been created to help in using a database of knowledge in relation to the field of teaching [3].

The learner's model: it allows taking into account the different declarative and behavioral information to the learner, such as the information about his knowledge (level), his competencies, his profile (personal lines), his purpose, preferences, attitudes, and information on learning styles, according to the Felder-Silverman's model. This information allows the system to choose the most suitable course concepts to the learner and to dynamically design the layout and organization of educational content [4]. It uses two types of data: the first indicates the level of learner's knowledge and the second backs up preferences.

The multimedia database: this resource contains basic concepts and documents to be presented to the learner, using the domain model. It enables offering fragments necessary for the learner during a learning activity. These fragments represent the concept of granularity and reusability of learning objects, which is characterized by a set of attributes. [5]. We distinguish three types: the cognitive type, the cognitive level, and the physical type.

The pedagogical model: states how to model the teaching strategies used by teachers during the presentation of learning content to learners. It also stores the parameters used to present the cognitive status of each learner [6]. to allow the system to present the concepts in different ways so as to find the best possible presentation and thus, empower the learner who needs to have feedback [7].

Courses generator: this is the most important element in our system because it relates different parts and various models of system. It also allows creating a virtual hypermedia. That is to say, the pages and the links will be constructed dynamically with the fragments [8]. This generator uses two filters: the first serum would be applied on fragments to select what is corresponding during the request; the second would be applied to select the fragments corresponding to the learning style of the learner. This is done in order to retain fragments' accordance to the style of learning and cognitive status of the learner.

4. PROCESS OF DEVELOPING EDUCATIONAL CONTENT IN OUR ENVIRONMENT HAD

As any resource, an educational resource has a life cycle that extends from its structure to its spread. Indeed, an educational resource should be structured, scripted, mediated, indexed, validated and distributed. The overview of the proposed architecture for the domain model is illustrated in the following figure:

Figure 3. The cyclic life of the pedagogical object

In what follows, we will develop this life cycle and spread these modules.

4.1. Structuring

The first educational content development step is the structuring of dividing knowledge in basic units of fine-grained to basic educational objectives. Then, these units can be combined in several ways to construct different learning paths and adapt them to cognitive status, learning styles, needs and preferences of learners and allow them to progress at their own pace. This granularisation will fully prioritize pedagogical content; reuse the way of teaching grains easier in other learning situations, and to pool resources between teachers. Thus, our learning object consists of a set of elements that can be defined as follows:

- **Pedagogical Model:** It is the upper granularity of educational content structure, which can be associated to metadata for describing content.
- **Division:** is the most encompassing content. It may contain learning or assessment type of activities as it may also contain other divisions. A division must have at least a grain that is open by default.
- **Grain content:** It is a set of paragraphs, which compose a semantic unit. If the grain is long, it can be subdivided into recursive parts.
- **Part:** it is a set of teaching blocks with a common educational target. The use of parts is suitable for prioritized content over two the levels.
- **Pedagogical Blocks:** If the grain is short, it will consist of directly teaching blocks. Each block will be materialized in media.
- **Pedagogical activity:** is a set of activities in which the learner interacts for a fixed term with educational content. It can be a learning activity or an evaluation one.

4.2. The scenarisation

The structuring step, as cited above, is to cut the content in teaching units. Each of these units will be then scenarised. This script is the second step in the process of realization of educational content available online. The pedagogical scenario gives a better understanding of the hierarchical structure of educational content, and by the determination of scheduling concepts, must address the learner in the learning process. It involves planning all educational activities such as learning activity or the activity of the evaluation in time and space for a given population taking into account the learners' characteristics (level, skills). [9].

Links between concepts can be different types. In our design, we chose to use the three most important links; they are as follows:

- **Link prerequisites:** the transition to the next concept requires the acquisition of the concept.
- **Conditional link:** in addition to the prerequisite condition, the teacher- scriptwriter can determine other conditions of passage between the concepts. For example, time spent, score achieved, etc.
- **Default link:** the previous concept just needs to be seen to move to the current notion. The diagram below shows the different elements needed to have a better educational content scenario.

Figure 4. The scenario of pedagogical content

It allows making a clear correspondence between the parts and elements of the content. The diagram below, Figure 5 explains this well in general correspondence:

Figure 5. The structure and the scenario of the pedagogical object

4.3. Mediatization

The media model is responsible for the actions associated with the selected media objects. At this level, it is to implement the educational content and its representation by the association of media resources to educational concepts and the determination of their presentation by the expression of the displayed rules. This will facilitate the learning situation, the interaction between the learner and content and the collaboration as well.

4.4. Indexing

It is very essential to index the educational resources involving "metadata" to facilitate their handling, optimize research and promote reuse, sharing and dissemination.

Step 2: The learner finds himself facing two distinct choices: either to fill in the Felder-Silverman's questionnaire and move to the fourth step; otherwise, the current generator moves to the third stage.

Step 3: If the student exceeds the survey, the system must assign a learning style default that we have already defined and move on to the fifth phase.

Step 4: the overall responses from the learner concerning the questionnaire will allow our system to measure and define the degree of preference for each dimension of Felder-Silverman's model.

Step 5: This step is to measure the adaptation content parameters according to the preference's degrees.

Step 6: When the learner specifies his goal and tells the system the course he wants to follow, the course generator will recuperate the concept to be learned, the knowledge's level of the learner on this concept, the page's structure and the hypertext links to the chosen concept. This is according to the measurement results of the adaptation parameters.

Figure 7 summarizes the adjustment mechanism according to the learning style of learners:

Figure 7. The contents' adaptability mechanisms according to the learning style

5.2. The adaptation mechanisms according to the learner's cognitive state

Our system allows monitoring, supervising the learner and registering of all his traces in his hypermedia's navigation and sitting for the pre-tests and post-tests relating to each learning objective. So, the adaptation mechanism content can be summarized in four steps according to the cognitive status:

Step 1: When a learner already signs up or chooses a course for the first time, the system is responsible to emit a survey; but this time, the type of knowledge. The result of this survey will allow the system to initialize the sub-model knowledge of the learner by giving him a

level (Beginner, Intermediate or Expert). If the student exceeds this pre-test, the system will present the default content structure.

Step 2: This step allows generating a structured pedagogical content. This generation focuses on three main points: the relationship between the objectives and concepts stored in the domain model; the new cognitive state of the learner for each unit learning; and teaching rules stored in the pedagogical model.

Step 3: The system always gives the learner the opportunity to update his cognitive state through a post-test for each concept studied and after each training session.

Step 4: The system generates a new course's structure for the learner depending on his last cognitive state. This is based on the domain model and the interaction of the learners with the system.

Figure 8 below regroups the steps the generator course can execute for adapting the pedagogical content in relation to the cognitive state of the learner:

Figure 8. The contents' adaptability mechanisms according to the cognitive state

The adaptation mechanisms described earlier can be summarized in four steps to represent the teaching strategy used by the system and based on constructivist theory of Jean Piaget cognitive skills (Piaget, 1967).

Discovery phase: it aims at refreshing the memory of the learner's knowledge and his requests throughout the pretest and the direct contact with the new experience represented in the different concepts of educational content, which pushes the learner to raise questions and find their answers.

Interpretation phase: it corresponds to the need to clarify and explain the concept chosen by the learner and present it according to his cognitive status and learning style; it comes after having benefited from his previous skills.

The expansion phase: the learner discovers the importance of concentrating on a concept to use and apply it later to learn other notions.

The evaluation Phase: Provides a structure of adaptive content according to the cognitive state of the learner; this is based on the post-test and the impact of his interaction with the system.[10]

5.3. Navigation's Adaptive techniques

The target of adapting navigation is to help the learner move in the hyperspace. Several techniques have been developed to introduce to the learner a more or less simplified organization, which fits his profile. We use annotation and direct guidance techniques in our system. [11].

- **Annotation:** This technique helps enrich the links with some forms of comments. These annotations can appear in textual or graphic forms; they use various icons, colors or tooltips that help educate the learner about the current state of the nodes behind the annotated links.
- **Direct guidance:** the idea is to show the learner the best next node to direct him to his targets and other parameters represented in his model.

6. DETAILED CONCEPTUAL STUDY

After studying the various needs and pedagogical aspects and following the analysis of the different elements and styles of our system defined earlier, we will now turn to the detailed design study using UML.

6.1. Learning Object Package

According to the creative process proposed above, the first phase of the development process involves the structuring of learning objects. Then, the screenwriting and the mediatizing stages can be done simultaneously. Figure 9 below illustrates the various components of the domain model. It puts the focus on designing an authoring environment for authors for the development of educational content dedicated to students and can be adapted to various learning situations. [12].

Figure 9. Package Class Diagram (pedagogical Object)

6.2. Workflow Package of Validation

The pedagogical content must follow a validation circuit, which allows the members of the validation committee to provide their views on the subject content. As stated below, figure 10 shows the different components of the Package Workflow.

Figure 10. Package Class Diagram (validation workflow)

7. CONCLUSION

The Dynamic Adaptive Hypermedia System differs from a classical computer system architecture including the user model (learner's model). The domain model is a pedagogical one. In this article, we presented our dynamic adaptive hypermedia system based on the Index of Learning Style (measurement of the learning style), which is able to determine the preferences of the learner's level, goals and habits. We presented also its complete architecture based on the overall architecture of the dynamic adaptive hypermedia.

Our goal is to improve firstly acquisition techniques, not only for adaptation to the bottom, but also to a better understanding of what the learner has. On the other hand, we aim at adapting the content of the documents to his knowledge. To this end, we have put a great importance on the adaptation mechanism according to the profile and cognitive status of learners. However, to guarantee the production and the structuring of teaching content, we have proposed a scalable, reusable structure, which allows generating lessons adapted to the learning style and cognitive status of learners.

We can summarize our research perspectives as follows:

- We want to achieve broad experimentation in real learning situations seeking deeper impacts of the use of our environment.
- The establishment of a full educational curriculum based on the face-and complemented by an adaptive current distance using our system. This will enable learners to improve their knowledge.
- Improving the speed's system, the computer's security, the response's time, as well as interfaces, design and communication features...etc.
- The adaptation of the system to visually impaired students will be the research topic in the domain of dynamic adaptive hypermedia.

REFERENCES

- [1] Piombo, C. Modélisation probabiliste du style d'apprentissage et application à l'adaptation de contenus pédagogiques indexés par une ontologie. *Thesis, Toulouse University*. 2007, pp. 329.
- [2] Brusilovsky, P. Methods and Techniques of Adaptive Hypermedia, User Modeling and User-Adapted Interaction. *Kluwer academic publishers*, 1996, 6(3), pp. 87–129.
- [3] Derouich, A. Karim, M. Marjane, D. and Messaoudi, F. Design of an Adaptive Distance-Learning Hypermedia Based on Learner Modeling: Application for a course in Electrical Engineering. *Journal of Theoretical and Applied Information Technology*, 2013, 53(2), pp. 171–179.
- [4] Korchi, A. Amrani, N. E. Jeghal, A. Oughdir, L. and Messaoudi, F. A Modeling learner approach in a Computing Environment for Human Learning based on Ontology. *International Journal of Computer Engineering & Technology*, 2015, 6(9), pp. 21–31.
- [5] Paquette, G. Marino, O. Learning Objects, Collaborative Learning Designs and Knowledge Representation. *Technology, Instruction, Cognition and Learning, Old City Publishing, Inc*, 2007, Vol. 3, pp. 85–108.

- [6] Brusilovsky, P. Schwarz, E. and Weber, G. A Tool for Developing Adaptive Electronic Textbooks on WWW, *Proceedings of the WebNet'96 Conference*, 1996b, San Francisco pp. 64–69.
- [7] Deletstre, N. METADYNE un hypermédia adaptatif dynamique pour l'enseignement. *Thèse de l'université de Rouen (France)*, 2000, pp. 53–72.
- [8] Messaoudi, F. Moussaoui, M. Bouchboua, A. and Ouremchi, R. Modeling and Object-Oriented Design of Adaptive Hypermedia in Distance Learning. *International Journal of Computer Science Issues*, 2013, 10(2), No 1, pp. 249–253.
- [9] Emin, V. Pernin, J.P. and Guéraud, V. Scénarisation pédagogique dirigée par les intentions. *Revue Sciences et Technologies de l'Information et de la Communication pour l'Éducation et la Formation*, 2011, (Numéro spécial : TICE).
- [10] Korchi, A. Amrani, N. and Oughdir, L. Modeling and Implementing Ontology for Managing Learners' Profiles. *Int. J. Adv. Comput. Sci. Appl*, 2017, vol. 8, no 8, pp. 144–152.
- [11] Zeidan, B. Dasgupta, S. Wörgötter, F. and Manoonpong, P. Adaptive Landmark-Based Navigation System Using Learning Techniques. In A. P. del Pobil. *13th International Conference on Simulation of Adaptive Behavior*, 2014, Vol. 8575, pp. 121–131. Springer.
- [12] Bouchboua, A. Ouremchi, R. Messaoudi, F. and Ghazi, M. Generation of pedagogical content based on the learning style of learners in a dynamic adaptive hypermedia environment. *International Journal of Advanced Studies in Computer Science and Engineering*, 2014, 3(7), pp.18–24.