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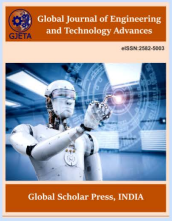

(REVIEW ARTICLE)

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A comparative study of characteristics and preferences to learner models in educational adaptive hypermedia systems

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Abstract

Educational adaptive hypermedia systems are online learning systems that aim to tailor the learning experience to the characteristics and needs of individual learners. These systems use a variety of techniques, including data analysis, machine learning, and dynamic adaptive user interface, to provide more effective and personalized learning for each learner.

The learner models in their systems are designed to help them better understand the learner and tailor their learning experience, to do this their models take into account the characteristics of the learner, such as their learning style, education level, prior knowledge and learning goals. Our work consists in making a comparative study of its models at the functional level and characteristics in the educational adaptive hypermedia systems in order to conclude the most effective learner model that can help to improve the academic results and to make online learning more accessible and effective for all learners, the results prove that the model based on learning styles allows a better adaptation in the educational adaptive hypermedia systems, its development will be devoted to the work of the next article.

Keywords: Adaptive educational hypermedia; Learner models; Preferences; Characteristics; Learning; Learning goal

1. Introduction

Educational adaptive hypermedia systems use a variety of learner models to personalize the learning experience for each learner. These models consider each learner's cognitive traits, online behaviors, motivation levels, and social interactions to provide personalized recommendations and feedback.

Our work consists of a comparative study of the different learner models in these systems. We refer to: the model based on learning styles, the model based on learner's characteristics, the model based on learner's knowledge, the model based on learner's prerequisites, the model based on learning objectives, each model with its usage environment and a detailed description.

In this paper, the comparison is mainly made on the characteristics and functionalities of each model in the educational adaptive hypermedia systems is the possibility of providing a hypermedia adaptation based on the learner's model. In the theoretical framework we propose a definition of the educational adaptive hypermedia systems and we are interested in explaining each model at the level of characteristics, technique, and use, the second part concerns the practical study that presents a comparative study of its models at the level of functionalities and characteristics in the educational adaptive hypermedia systems. The conclusion summarizes the content of the article and discusses the perspectives of research in the field of adaptive hypermedia.

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2. Theoretical study

Educational adaptive hypermedia systems are interactive online educational systems that use adaptive techniques to provide a personalized learning experience for each user. They are useful for learners who have special educational needs or who have difficulty learning in the traditional way. According to Brusilovsky (1996),[1] "By adaptive hypermedia systems we mean all hypertext and hypermedia systems that reflect certain characteristics of the user in the user model apply that model to tailor various visible aspects of the system to the user."

2.1. Problems and needs of adaptive hypermedia

Hypermedia offer an organization, a content, means of interaction and a unique presentation to all users, they do not have the same needs, the same knowledge, skills, interests, styles, etc...

So, they are not necessarily able to interact with the same hypermedia document where the need to adapt the document to the user. Adaptive hypermedia propose contents relevant to the user's needs and specifying his profile and preferences.

2.2. Objectives, characteristics and means

An adaptive hypermedia system has the following objectives

- Allow access to relevant information.
- Solve navigation problems.
- Improve the understanding of a complex document

2.3. Notion of adaptability

Research on how learners learn and the diversity of learners in a mass education system requires not only careful attention to differences among the student population, but also adapting instruction to individual needs. The goal of adaptability is to enable the learner to minimize the effort required to solve a problem and explore educational content by facilitating access to the information sought.

2.4. Types of hypermedia

Edmonds, (1981),[2], proposed an approach allowing to categorize the hypermedia, in three types of systems, according to their level of adaptability, [3,4]: The adapted systems in which the adaptation is the work of the designer himself. He implements them after a test phase. The user does not intervene to adapt the system but identifies himself beforehand through a user profile or a group of users defined beforehand. In such systems, the adaptation is not perceived since it cannot be specific to each individual. Adaptable systems are systems that can be modified upon explicit request of the user. The user enters his preferences via a dedicated interface, saves them in a model and restores them at his request. Adaptive systems implement behavior tracking mechanisms that exploit domain knowledge, knowledge about learners and knowledge about learning processes to offer personalized pedagogical approaches and content. The updating of the user model is done by the system itself, by observing the user's interactions with the system.

2.5. Adaptive hypermedia system model in education

An educational adaptive hypermedia system has adaptation rules, and means a learner model adapts the hypermedia based on a model and these rules. In other words, the system must meet criteria, it must be a hypertext or hypermedia system, it should have a learner model, and it should be able to adapt the hypermedia using this model, their diversity allows for a variety of choices in use and development, this comparative study is based on the different learner models, then we find:

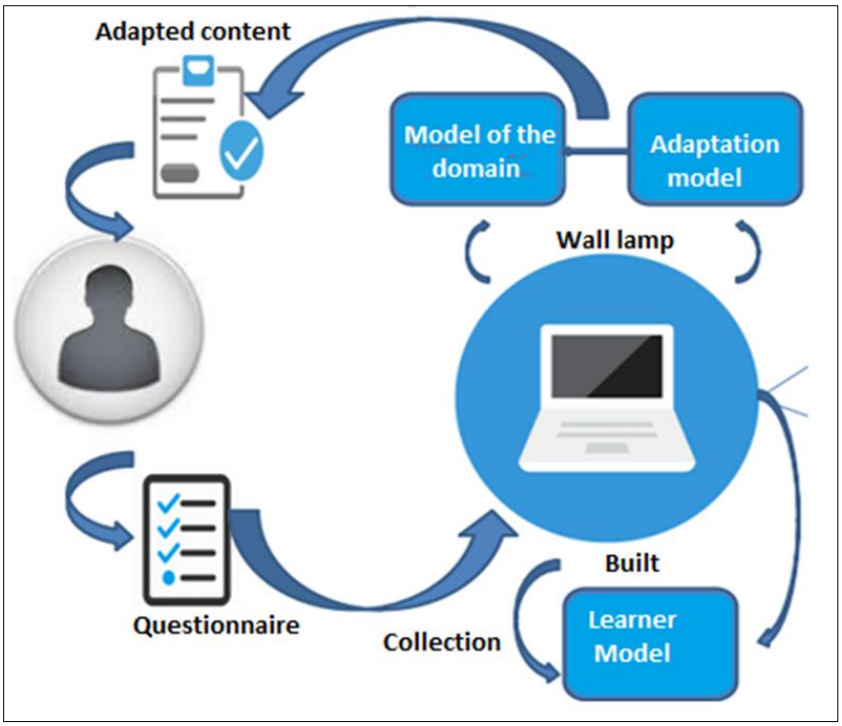

Figure 1 Adaptive hypermedia systems used in education, (Knutov et al., 2009), [5]

2.5.1. Learning Style Model

According to Grasha, A. F. and Riechman, S.W. (1975) [6], learning style models that focus on preferences for teaching and learning conditions presents a learning style-based model of learners that posits that learners have individual preferences for how information is presented and processed for different types of learning activities. SHAEs that use this model attempt to tailor the learning experience to the learner's preferences, this can improve their learning experience and performance.

2.5.2. Learner characteristics-based model

JEAN-DAUBIAS et al, (2009) [7]. The learner profile should characterize the learner's area of interest and any specific characteristics, the learner characteristics-based model should take into account the learner's characteristics, such as age, education level, gender, etc. An educational adaptive hypermedia system that uses this model attempts to adapt learning according to these characteristics, providing activities that are tailored to the learner's characteristics such as cognitive aspects, level of prior knowledge, information processing abilities, memory and attention. Socio-emotional characteristics such as motivation, self-esteem, anxiety and commitment can also be taken into account.

2.5.3. Learner knowledge-based model

The learner profiles from the research are solely about their knowledge (RUEDA et al. 2006) [8]. The learner knowledge model focuses on understanding how the learner processes and assimilates information. SEHAs that use this model attempt to tailor learning based on how the learner processes information, by providing activities that are tailored to the learner's preferred processing mode. The use of technology can also facilitate the implementation of this approach, particularly through the use of adaptive learning systems.

2.5.4. Learner prerequisite-based model

CARCHIOLO et al (2007) [9], proposed an adaptable architecture to support e-learning. Learner profiles are mainly used to describe prior knowledge and preferences in order to generate personalized learning paths. SEHAs that use this model attempt to adapt their learning based on the learner's prior knowledge, providing activities that are tailored to the learner's level of knowledge. It is an approach that focuses on the learner's prior knowledge and skills, based on the principle that in order to effectively learn new concepts, the learner must first master the basic concepts that are necessary to understand those new concepts. Adaptive educational systems can use algorithms to analyze learner performance and identify prerequisites that need to be reinforced before moving on to more advanced concepts.

2.5.5. Learning goal-based model

BULL et al (2003) [10], talks about the target knowledge to be acquired or the instructional goals to be achieved. This model focuses on the learner's learning objectives. SHAEs that use this model attempt to tailor learning to the learner's learning goals by providing activities that are tailored to the learner's specific objectives. This approach considers that in order to learn effectively, it is important to have clear and precise learning objectives that guide the learner in his or her learning, and activities and assessments must be designed to help learners achieve these objectives.

2.6. Adaptive hypermedia systems in education

Adaptive hypermedia is hypermedia that automatically change according to the user and that adapt their links, contents and presentations to the needs of the learners. These systems aim to reduce the cognitive load on the user on the one hand and the dimensions of the navigation space on the other.

According to Brusilovsky, adaptive hypermedia systems can be classified into six application areas: educational hypermedia, online information systems, online help systems, information retrieval systems, institutional hypermedia and personalized view systems.

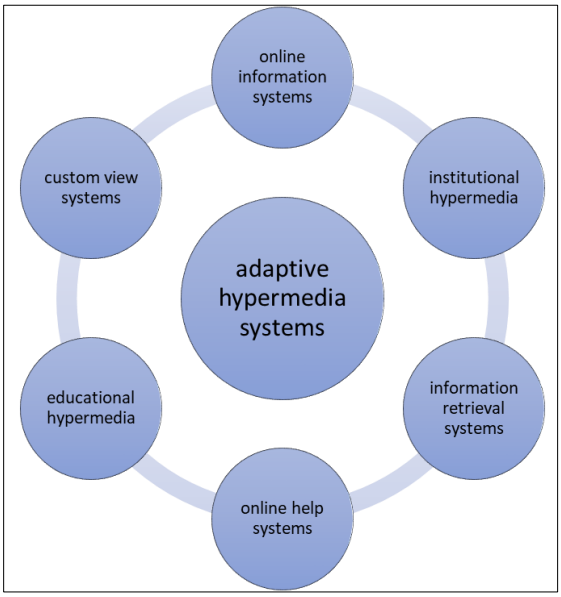

Figure 2 Application Domain of adaptive hypermedia

Table 1 Examples of adaptive hypermedia systems classified according to their belonging to the application domains (Brusilovsky, 1996) [11]

Type of hypermedia	Example
Educational hypermedia	ELM-ART, TANGOW, METADYNE, STI, C-BOOK, HYPERGAP, Anatom-Tutor,Metadoc, AHAM, AVANTI, ONU Modèle canonique, C-Book, <Clibbon>, ISISTutor, ITEM/PG, HyperTutor, Land Use Tutor, Manuel Excel, SHIVA, SYPROS, ELM-PE, Hypadapter, HYPERCASE.

We are mainly interested in educational hypermedia, which is the main field of application of adaptive hypermedia. These systems make it possible to integrate teaching with hypermedia. The objective is to provide learners with theoretical knowledge, illustrations, explanations, case studies, simulations, etc. (Fischer, 2001) [12]. Many educational hypermedia applications have been developed. Among the educational systems, classified in the table above are:

3. Practical part

Adaptive hypermedia provides a considerable help in the learning process since they define an order in the learning of concepts, leading to personalized and precise paths through the educational resources offered. They provide the necessary data for the other modules in order to adapt the teaching to the learner. (Zhou et al., 1999) [13].

Our work in this article consists in presenting a comparative study, the focus will then be on the study of the main functionalities of the learning model. We will divide these features into six categories of model based on: (learning styles, learner characteristics, learner knowledge, learner prerequisites, learning objectives), and we will present a study in 10 different hypermedia ( ), to conclude on which features they are based. Then, we will focus on this functionality to develop a learner model in educational adaptive hypermedia systems which will be the work of the next article.

3.1. Categories of learner models in SHAE

Today's SHAEs increasingly emphasize system intelligence. One of the most important factors in assessing the quality and usability of the system is the level of responsiveness to the learner's needs. We are interested in its model categories based on learning styles, learner characteristics, learner knowledge, learner prerequisites, learning objectives, which are well detailed in the theoretical part.

3.2. Existing Educational Adaptive Hypermedia Systems

In this study to understand the main functionalities of educational adaptive hypermedia systems, we have chosen 11 SHAEs from different fields of intervention. We will compare each of them based on the characteristics and preference of each model, we find :

- **ELM-ART** which is intended for learning programming in the LISP language (Brusilovsky, 2001) [14]. The adaptation techniques used in this system are direct guidance and link annotation. It uses different techniques for initializing and updating its learning model: overlay model, complex machine learning methods and Bayesian networks to represent the episodic learning model (Weber et al., 2001) [15], This system also incorporated a learner/user model that contains the knowledge that a learner has about different concepts. The level of knowledge of each concept is modified according to the user's actions. Learning goals can be defined for each learner.
- **TANGOW** The TANGOW (Task-based Adaptive learNer Guidance On the WWW) system (Carro et al., 1999) [16]. It is a tool for developing courses on the Internet. This system facilitates the construction of adaptive learning environments on the Web and guides students during their learning, based on student profiles and the history of previous actions. Courses are structured by means of Teaching Tasks and rules, which are stored in a database. In TANGOW a student process is started for each student connected to the system. Each student process consists of two main modules: a task manager that guides the students in their learning, and a page generator that produces HTML pages. The student process also maintains information about the actions performed by the student. This information is used by TANGOW to tailor course content to the student's learning progress. TANGOW also has information on student profiles, which is used to select, at runtime, the content of each HTML page to be presented.
- **METADYNE**, is a dynamic adaptive hypermedia for teaching, it is based on four main components: the model of the domain, the model of the user, a base of multimedia documents and a generator of the course, Improving the adaptability of a hypermedia whose goal is to provide an online course adapted to the knowledge as well as to the preferences of the user, and by taking into account the profile of the learner and his learning style, (Delestre, 2004) [17],
- **ITS** According to Murray, (1999) [18], ITS are computer-based instructional systems that have content in the form of a knowledge base (which specifies what is to be taught), instructional strategies (which specify how to teach that content) as well as knowledge about the learner's level in the content, in order to dynamically adapt their instruction.
- **C-BOOK** is a system that implements an adaptive presentation. Its role is to adapt the content of a hypermedia page to the learner's goals, level of knowledge and other information stored in his or her learner profile; the pages are not static but are generated or assembled in an adaptive manner. (Kay and Kummerfeld, 1994) [19].The following systems use this technique: C-Book an adaptive course on Hypertext [Calvi and De Bra, 97], Medtec [Eliot et al., 97], ELM-ART [Brusilovsky et al., 96], AST [Specht et al., 97] and InterBook [Brusilovsky and Schwarz, 97].
- **HYPERGAP**, Balla, A., et al (2003) [20], a dynamic adaptive hypermedia and generator of pedagogical activities. The advantage of this hybrid system lies in two important points: the first is the creation and dynamic adaptation of the structure of the document according to the characteristics provided by the learner and his profile and the second is the exploitation of the pedagogical activities and tasks in the general learning framework.
- **Anatom-Tutor** (Ian H. Beaumont, 1994) [21] is a learning system for human anatomy. It is specifically oriented towards pedagogy. It consists of an access mode to the knowledge base, which allows the user to obtain cards for each concept of the anatomy course. This access mode is not, in any way, personalized. It also has a hypertext

mode that allows the elements of the domain to be presented differently depending on the user. Finally, it has a question mode, which allows the student to be questioned and to check his level.

- **MetaDoc**, (Craig Boyle and Antonio O. Encarnacion,1994) [22], is an adaptive hypermedia system that relies on the "Stretch text" method, combined with a user profile, to provide text that is tailored to the user. The user can then request to modify this level by adding or removing information. The user's level of knowledge of the concept addressed in the document is then updated.
- **AHAM,** (Paul De Bra, Geert-Jan Houben, and Hongjing Wu, 1999) [23] (Adaptive Hypermedia Application Model) is a model for the creation of adaptive hypermedia, based on the Dexter Hypermedia Reference Model, with an emphasis on the representation of user knowledge, preferences, goals, and browsing history through tables
- **AVANTI** is a system designed for learners/users with different needs. It combines in the data collection and initialization stage stereotypes of the learner model and the overlay method to create initial hypotheses and maintain user knowledge. (Anouar Tadlaoui et al., 2016) [24]
- **ONU Modèle canonique** : consist in using a representation called stereotype of the needs, characteristics, cognitive functioning, reasoning mode, etc. of all users (Koch, 2000) [25]

3.3. A comparative study

This comparative study is considered to be a tool to assist in choices and decision making, by collecting, analyzing and comparing different models of SHAEs, It is only a mechanism to identify issues and challenges and allow to choose the system equivalent to the preferred model, which gives a general view is dominant on the most popular adaptive hypermedia systems in education, the following table illustrates the results find

Table 2 Comparison between adaptive hypermedia systems classified according to their belonging to the educational domain according to the six models

SHAE	Characteristics ofthe learner	Knowledge of the learner	The learner's prerequisites	Profile and Learning Styles	Learning objectives
ELM-ART	+	++	+	++++	+
TANGOW	+++	++	+++	++++	+
METADYNE	+++	+++	+	+++	+
STI	++	++++	+++	++	++
C-BOOK	++	+++	++	+++	+++
HYPERGAP	++++	++++	++	++++	++
Anatom-Tutor	+++	+++	++	+++	++
MetaDoc	++	+++	++	+++	+
AHAM	++	+++	++	+++	++
AVANTI	++	+++	++	+++	++
ONUModèle canonique	+++	++	+	++	+

The indices used in the table: (++++ Very good, +++ Good, ++ Average, + Poor)

3.4. Interpretation of results

Different types of adaptive hypermedia systems are characterized by establishing relationships with learners to manifest themselves in hyperspace. These devices allow learners to be guided in their learning and teachers to better structure the instructional material. In this way, learners are still fully guided and can navigate freely, and teachers can better organize their knowledge for presentation to learners. While these systems have made significant progress, some problems remain. Changing links seems easy, but changing content is just the beginning. Hiding or commenting on links is easy, but replacing parts of a page or changing the structure is difficult. From the results of this study, it can be assumed that hypermedia can better meet the needs of learners, fill gaps in a more targeted way, adapt working methods and speed of assimilation. The choice was made on the profile/style of a student which is mainly used to describe his knowledge and preferences in order to generate a personalized learning path, the profile/style can adapt

the learning not only to the learners' knowledge but also to their characteristics and preferences, this study will be conducted in the next article on the influence of styles on adaptive hypermedia in order to validate their necessity in online teaching as an adaptation criterion.

4. Conclusion

The goal of any learning process is to improve, enhance and facilitate an education; and all research in setting objectives. Adaptive hypermedia systems can be added to a knowledge domain including information about its users. An adaptive system can provide different sets of information at different levels of abstraction. Also it can provide processing based on characteristics such as the user's age, language, geographical location or whether the learner is a novice or an expert. Such a system attempts to tailor its response to the needs of the learner. The system can be adapted in different ways: The system is accessible to a learner profile or group, from the beginning. The system requires that an adaptation phase be addressed during its design phase (adapted system). The system can allow the learner to change his or her behavior to adapt (adaptable system). The system can adapt its behavior to the learners during the runtime phase by maintaining a user model from a sample of learner behavior patterns (runtime adaptability or adaptive system).

In this article, we have defined adaptativity, its different types, and adaptive systems to move on to a particular case of these systems, namely adaptive hypermedia, which attempts to remedy the comparisons with the utility of models based on : educational hypermedia, online information systems, online help systems, information retrieval systems, institutional hypermedia and personalized view systems, to conclude that the learner profile or style is a factor that plays a primary role in the construction of adaptive hypermedia systems.

Learner profiles are very important objects that can contribute to the success of educational learning systems. These profiles must be able to contain different types of information about the learner, in order to take into account, the different facets of his/her learning. Therefore, it is necessary to have models that allow representing all learner profiles, but it is also interesting that these models specify the place of the different facets of the profiles in order to subsequently provide the relevant information to personalize learning.

Compliance with ethical standards

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Disclosure of conflict of interest

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version. Additionally, there are no conflicts of interest in connection with this paper, and the material described is not under publication or consideration for publication elsewhere.

References

[1] Brusilovsky,1996, User Modeling and User Adapted Interaction, v 6, n 2-3, pp 87-129 (Special issue on adaptive hypertext and hypermedia),

[2] Edmonds E. A., Adaptive Man-Computer Interfaces, in Computing skills in the user interface, Coobs M.J & Alty J.L Eds., Computer and People series, Academic Press, 1981.

[3] Benadi S. A., "Structuring of data and services for distance learning", National Institute of Applied Sciences of Lyon, France, 2004

[4] Derouich A., "Design and production of an adaptive hypermedia dedicated to distance education", 2011.

[5] Knutev,E ,P.De Bra and M.Pechenzky, 2009. AH12 Years later a comprehensive survey of Adaptative Hypermedia methods and Multimedia 15(1)Taylor and Francis ,UK,

[6] Grasha,A. F. etRiechman, S.W.(1975) Student learning styles questionnaire. Cincinnati, OH : University of Cincinnati, Faculty Resource Center,

[7] Jean-Daubias, S., Eyssautier-Bavay, C., Lefevre, M., “Models and tools to enable computer reuse of heterogeneous learner profiles”. STICEF, vol 16, 2009. ISSN 1764-7223

[8] Rueda, U., Larrañaga, M., Arruarte, A., Elorriaga, J.A., “DynMap+: A Concept Mapping Approach to Visualize Group Student Models”, In First European Conference on Tec hnology Enhanced Learning, EC-TEL'06, W. Nejdl & K. Tochtermann (Eds), p. 383-397, Cret, Greece, 2006.

[9] Carchiolo V., Longheu Al., Malgeri Michele., Mangioni G., “An Architecture to Support Adaptive E-Learning”, International Journal of Computer Science and Network Security, Vol.7, No.1, 2007.

[10] Bull, S., McEvoy, A.T., Reid, E., “Learner Models to Promote Reflection in Combined Desktop PC / Mobile Intelligent Learning Environments”, workshop "Learner Modelling for Reflection", In AIED'03, Aleven V., Hoppe U., Kay J., Mizoguchi R., Yacef K. (Eds), p. 199-208, Sydney, Australia, 2003.

[11] P. Brusilovsky, Methods and Techniques of Adaptive Hypermedia. In Modeling and User-Adapted Interaction (UMUAI 96), vol.6,, 1996. pp. 87-129

[12] G. Fischer, „User Modeling in Human–Computer Interaction“, User Modeling and User-Adapted Interaction, 11(1 – 2), 65 – 86, 2001.

[13] Zhou, Y., & Evens, M. W. (1999). A practical student model in an intelligent tutoring system. In Tools with Artificial Intelligence. Proceedings. 11th IEEE International Conference on (pp. 13-18). IEEE, 1999.

[14] P. Brusilovsky (2001). Adaptive Hypermedia. User Modeling and User- Adapted Interaction, vol. 11, pp. 87-110,

[15] Weber, G., & Brusilovsky, P. ELM-ART: An adaptive versatile system for Web-based instruction. International Journal of Artificial Intelligence in Education, 12, 351–384.2001.

[16] Carro, R. M., Pulido E. and Rodr|¨gues P.: TANGOW: Task-based Adaptive learner Guidance on the WWW. Proceedings of Second Workshop on Adaptive Systems and User Modeling on the WorldWideWeb, Toronto and Banff, Canada. Computer Science Report 99-07, Eindhoven University of Technology, pp. 49-57 , 1999.

[17] Delestre Nicolas PSI Laboratory INSA de Rouen, BP08, Place Emile Blondel, 76131 Mont Saint Aignan Cedex NicolasDelestre @ insa-rouen.fr Benadi S. A., "Structuring of data and services for distance learning", National Institute of Applied Sciences from Lyons, France, 2004

[18] Murray, T. Authoring Intelligent Tutoring Systems, An Analysis of the State of the Art. International Journal of AI and Education, Vol. 10, no. 1, pp. 98-129,1999.

[19] Kay, J., Kummerfeld, R.J. (1994). An Individualised Course for the C Programming Language. Proceedings of Second International WWW Conference, Chicago, IL, October 17-20. Internet.URL : http://www.ncsa.uiuc.edu/SDG/IT94/Proceedings/Educ/kummerfeld/kummerfeld.html.

[20] Balla, A., et al. HYPERGAP: A dynamic educational hypermedia generating educational activities. Digital Document, 7(1), 39–57. 2003 .https://doi.org/10.3166/dn.7.1-2,

[21] Ian H. Beaumont. User modelling in the interactive anatomy tutoring system anatom-tutor. User Model. User-Adapt. Interact,1994., 4(1) :21–45,

[22] Craig Boyle and Antonio O. Encarnacion. Metadoc : An adaptive hypertext reading system. User Model. User-Adapt. Interact., 4(1) :1–19, 1994

[23] Paul De Bra, Geert-Jan Houben, and Hongjing Wu. AHAM : A dexter-based reference model for adaptive hypermedia. In UK Conference on Hypertext, 1999. pages 147–156,

[24] Anouar Tadlaoui, M. Management of a learner model in an adaptive educational system based on Bayesian networks. Academic Press, 2016.

[25] Koch N., Software Engineering for Adaptive Hypermedia Systems Reference Model, Modeling Techniques and development process. Doctoral thesis, Mathematics and Computer Science, Ludwig-Maximilian's University, Munich, 2000.