Adaptive Educational Resources Framework for eLearning using Rule-Based System

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Abstract. The implementation of Information and Communication Technology (ICT) in education sector has been carrying a great potential possibility to provide students an environments to their needs and preferences. There currently numerous education industry that are working with standard, traditional or non-adaptive e-learning. There are no fixed learning resources, processes and strategies for students, so adaptive framework is really needed. In addition, educational content adapted for some students may not be appropriate for the others. In this paper, an adaptive framework is proposed. This proposed framework developed using rule-based system to orchestrate the interaction with the student and deliver customized resources that are available through e-learning repositories. Moreover, this proposed framework could be accessed by student with visual disabilities by equipping with customized user interfaces.

Keywords: E-learning, educational resources, adaptive framework, student model.

1 Introduction

The rapid advancement of Information and Communication Technology (ICT) has dramatically increased technology use in teaching and learning processes. This has led to educational institutions giving a twist to the formulation of their academic programs and curricula, including new tools, courses and pedagogical aids based on virtual education platforms. All this has generated the need to start studying the different ways of learning of students and develop strategies that allow adapting educational processes.

Virtual education is an increasingly popular trend in the different educational institutions, because it allows reaching a greater number of people with the same resources, as well as serving the public that has limitations to attend a physical institution [1, 2]. Through the virtual education platforms, complementary courses

and even complete training actions are offered, such as professional careers [3]. This makes the number and type of interactions between these platforms and students increasingly growing and varied.

Adapti education platform is an important research topic. It works according to the needs and particular preferences of the students. In order to carry out this, several type of activities are required to identify some characteristics and to establish a specific profile for each student [4, 5, 6].

A student model is needed to know the specific characteristics of each user in order to perform processes related to personalization, such as the delivery of adapted content or the recommendation of those that cover a large part of their needs [7]. The student information gathering is required prior the construction of a user profile. There are several susceptible components to adaptation in an education system: the interfaces with the student, the course plan, educational strategies, selection of educational resources, information filtering and the process evaluative, among oth s.

In this paper, we propose a platform oriented to the adapted delivery of digital education resources according to the characteristics captured in the student profile, supporting the search process and recovery of this material. The platform also performs changes in some of the interface settings for offer greater accessibility to the user. The platform performs the adaptation process based on a system of rules that crosses the characteristics of the model of the student with the metadata of the educational resources that are stored in repositories and that result from a search made by the user.

The rest of the paper is organized as follows: In section 2 presents the theoretical framewo and literature study. In section 3 the design works related to the proposal, which is detailed in the section 4. Finally, section 5 presents conclusions and future work.

2 Literature Study

2.1 Adaptive Framework

One of the great possibilities output of the collaboration between ICT and education is to offer a customized environments for students that appropriate to their needs and preferences. It's known as adaptive, due to its ability to automatically respond to these conditions [7, 8].

In an adaptive system, a strategy of adaptation that consists of establishing "What to Adapt" specifying the components to be delivered in a personalized, "When to Adapt" that corresponds to the moment which will trigger the adaptation, "Why Adapt" that is relates to the objectives of the adaptation process and "How Adapt "that are recognized as rules of adaptability [9].

A particular case of adaptive systems are the recommendation systems that offer suggestions of items, objects, products or services that are useful for a user, making

predictions of their tastes or needs [10]. This type of systems have main feature like the ability to work with users of individual way, identifying their preferences and elements potentially relevant, for which profiles are required to structure this information [11].

One of the main applications of the recommendation systems is in search engines of different types, where the results of a search are filtered to select those that contain information close to the identified conditions for each user [12]. In the modeling of a recommendation system defines the elements that intervene, such as the characteristics that will be captured from the user, the recommendation strategies that will be used and the detail of the items that will be recommended.

2.2 Student Model

The main objective of user in a system is to have access to services and contents that meet their needs. Therefore, the user profile is understood as the modeling with the required information to identify each user of independently and offer an experience more in line with its characteristics [13]. This modeling is fundamental and it requires an adequate structure for its analysis, recovery and use [14].

Student Models are geared towards capturing, storing and updating relevant information related to both the characteristics of the student and with some elements of the educational process. It seeks to define distinctive and most relevant characteristics of each user in the teaching and learning process for systems in which they want to make some kind of personalization or adaptation [15].

One of the main advantage of the student model is the ability to deliver search results different for each user according to their characteristics, needs and preferences. Specifically for the case of repositories of educational material, it is expected to deliver resources that present elements that support the requirements of the student and can enrich the educational process [16].

2.3 Digital Resources

Digital Educational Resources are distinguished from other resources because of their predisposition to reuse in multiple contexts, in addition to their availability in different environments [1]. They are recognized as digital entities that their main characteristics are reusability, adaptability, accessibility and scalability, what it offers advantages over other types of educational resources. In addition they are accompanied by metadata that describe them and allow your identification, to facilitate your search, recovery and use [15] Educational resources are stored in repositories that allow their management and effectiveness in searches and recovery [3, 4].

Millions of these resources are stored and managed through repositories that must follow a series of standards in order to increase its effectiveness and interoperability, guaranteeing access by students and teachers around the world.

2.4 Recommendation Systems

A recommendation system a complement to a smart mentoring system, whose main objective is to increase interaction of the student and the teacher, through the recommendation of learning objects to the teacher according to the topics that he dictates and according to the profiles of the students who receive the course [16]. Although his contribution focuses on creation of efficient and adapted virtual courses, characteristics of the objective profile of this work as are special education needs.

Klašnja-Milićević in [17] developed a recommendation system for a programming tutoring module called PROTUS. Its main objective is to deliver and build programming courses that are tailored to the student's learning. In this system, they are taken into account various factors such as: student's educational level, learning style and navigation logs, with the purpose of identify individual characteristics of each student to deliver adapted content to it. To make this process of recommendation, students are first classified in different clusters according to their learning style, followed by the interactions that the student has analyzed. Finally, each student is presented with a list of recommendations ordered according to the qualifications frequent, provided by the Protus system and expected that the delivered results have a high level of acceptance by students.

Salehi and others present a hybrid system of recommendation for educational materials using genetic algorithms, perform two recommendation processes, the first of them deals with the explicit characteristics represented in a preference matrix the interests of the student. The second recommendation is with implied pesos to educational resources that are considered as chromosomes in the genetic algorithm to optimize them according to the historical values. This recommendation is generated by the nearest neighbor [18].

Peissner and Edlin-White (2013) propose a design of patterns based on the implementation approach of adaptive user interfaces for people with special needs. In this work, they are based on development of adaptive interfaces and not punctually in the delivery of adapted educational materials [19]. They present a recommendation system based on roads for accessibility. They give resources to people with special needs. Uses the concepts of computing ubiquitous, it also focuses on finding similarities between paths, context information and user profiles for recommend accessible resources.

A large number of systems work has been carried out adaptive in education, however they have not yet been filled expectations due to problems such as the lack of generic personalization schemes [9, 20, 21] and difficulties in the capture and update of the student profile [22], in addition when it comes to educational resources it is necessary to have metadata that allows you to clearly distinguish your characteristics, in order to make a personalized selection [23, 24]. In this research, we present a platform that delivers adapted educational resources to the needs and preferences of users.

3 System Design

Within the repositories there is a great variety of educational programs resources, which have different characteristics indicated by their metadata. The metadata can be defined in different standards, for this proposal we use the IEEE-LOM standard extending some metadata to handle accessibility data, using information of the different categories.

The searchers of these resources, usually perform searches only the keywords, obviating a large number of attributes. This leads to are not considered user characteristics as can be, his learning style that has a close relationship with the way in which the student prefers the educational contents sought, supporting their teaching - learning process.

Other characteristics such as educational level, some cultural conditions and certain special needs of education are not commonly taken into account when deliver the resulting educational resources in a search. However, this could improve the experience of users when finding material that best suits their terms.

Taking into account the previous approach, it is proposed a technological platform that allows us to adapt the search and recovery of digital educational resources in accordance with specific characteristics of the users, in addition to some features associated with the interface.

One of the main elements in an adaptive system is the student model, where the characteristics that will allow to establish difference between each user and offer an answer according to these dissimilarities. For this proposal, we work with the student model presented in Fig. 1.

Based on the review carried out on some models of users in educational systems and previous work, Three main components are defined: data personal, psychopedagogical characteristics and Education Specials Needs (NEED). The capture of these characteristics will support the adaptation process, recognizing specific conditions of students and delivering educational resources according to them.

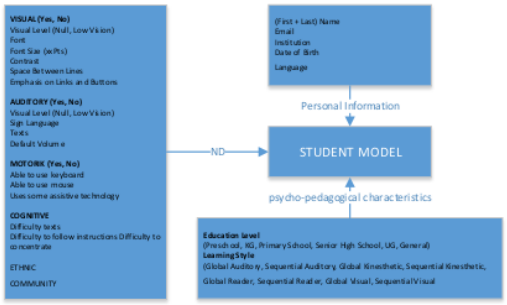

Fig. 1. Proposed Student Model

The process of capturing the student's profile is done through a registration system in which the user is made a series of questions divided into two tests. The first test is oriented to identify if the student presents some type of visual, auditory, motor or cognitive disability. The test also asks about related aspects to the form as the student interacts with the platform, what preferences for its visualization and control. If it requires some kind of support or if the contents must comply with some special conditions. It also allows to establish if belongs to an ethnic community, ie community indigenous, which has different culture, language and customs and to which we can deliver developed resources in our own language according to these unique aspects of their culture.

In the second test, the learning style is identified predominant in the user, where the models are combined Visual Auditory Read/Write Kinesthetics (VARK) and Felder-Silverman Learning Style Model (FSLSM) making a total of 24 questions [25]. FSLSM test takes only the sequential-global dichotomy, related to how to process and understand the information.

During this registration process, the personal data of the student, language and educational level in which it is located, that according to the established in Indonesia it could be: preschool, basic primary, basic secondary, middle and higher. The category is also established General for cases where the student is not in a formal educational process.

The platform allows searching and recovery of adapted educational resources to the special needs of education and psychopedagogical characteristics of the user. In the Fig. 2 presents the general scheme of the process of adaptation.
With the definition and capture of the student model and using the digital educational resources stored in distributed repositories, the platform performs the delivery of adapted resources in response to a search by the user.

As previously commented, the platform also makes adaptations of some aspects of the interface, such as contrast levels, font size and type, and line spacing. This is done especially for the case where the established user has a visual disability and requires of these modifications for a better interaction.

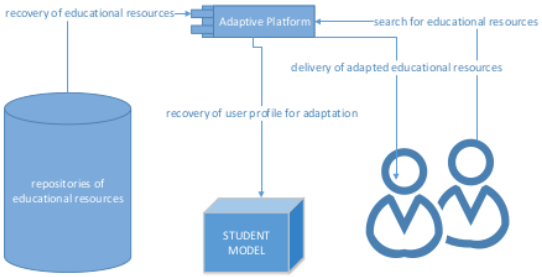

Fig. 2. General Scheme of Adaptation Process

The adaptation of the educational contents is done to from a series of rules, which evaluate characteristics of the student's profile in front of the metadata provided by the repositories.

First, the educational resources that are selected are selected meet the criteria of Language and Level of Schooling executing the following rule:

```
Yes (language == General.Language Λ SchoolLevel == Educational.context)
```

Then it is verified if the student answered yes in any of special needs and the rules are executed for NEED, but the rules for learning style are executed.

Below is an example of the rules for NEED:

```
If [(NEED (visual) Λ Visual (Nullvision)] then
{For each OA to do
val = 0
[If HasAuditoryAlternative (f) then val + = 0.7] Λ [Yes (InteractivityLevel (very low) v
InteractivityLevel (low) v InteractivityLevel (medium))
then val + = 0.1] Λ
[If (Format (audio) v Format (video)) then val + =
0.1]
}
```

Below is an example of the rules for learning styles:

```
If [Learning Style (Auditory-Global)] then
{For each OA select
[If Educational.LearningResourceType (audio) V Educational.LearningResourceType (video)] Λ [Yes Educational.InteractivityLevel (medium)
V Educational.InteractivityLevel (low)]
V [Educational.InteractivityType (Expositive)
V Educational.InteractivityType (Mixed)]
}
```

Once the rules corresponding to the profile of each user, you get a filtered list of resources education that adapt to their characteristics, which will allow improve the student experience and facilitate the process of identification of the educational material that supports your process learning.

The platform is developed in the languages of PHP, JavaScript and HTML programming which allow have a good performance of both the server responses to when conducting searches, such as when generating interaction fast on the client side when executing the adaptation process in the interface. There is a database manager PostgreSQL, for the persistence of user data.

4 Discussion and Analysis

A prototype of the adaptive platform was implemented using the PHP programming languages and JavaScript. In total, 25 adaptation rules were implemented that cross the elements of the student's profile with the metadata that are stored in digital educational resource repositories.

The tests were also implemented to capture the characteristics of the students. In Fig. 3 it can be observe one of the interfaces used for this process.

Fig. 3. Test to identify NEED

As a case of particular study, a simulated student that corresponds to the characteristics that

They are presented below:

- Name: Student 1
- Language: Indonesia
- Educational Level: Basic Primary
- Learning Style: Visual-Global
- Visual NEED: No
- Auditory NEED: No
- NEED Drive: No
- Cognitive NEED: No
- Ethnic NEEDs: Yes
  - o Ethnic Community: Java

A search was made with the keyword "culture", first as a generic user who has not registered to the platform, that is, one that has not been captured profile. In Fig. 4 the delivered results list is presented.

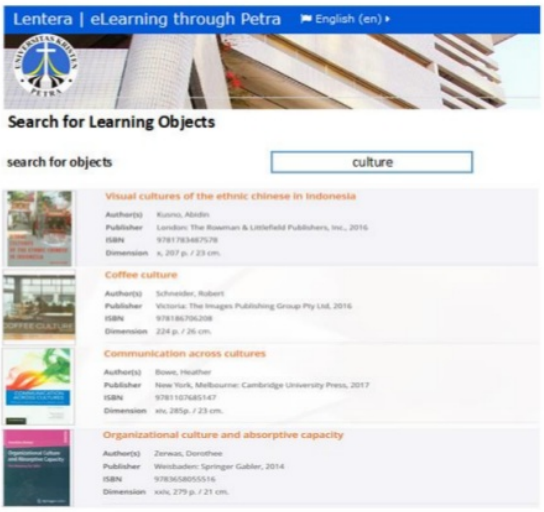

Fig. 4. Results for Geenric User

For the case of the student named as "Student 1 "whose profile indicates that it is part of an ethnic community, specifically the Indonesia-Java, the process of adaptation and in response to the search "culture" only one educational resource is delivered that meets the conditions required by this student. This can be Observe in Fig. 5.

As can be seen in Fig. 4 and 5, the results delivered to each user are different, that is, they were adapted to the specific characteristics of your profile.

This adaptation allows the student to be able to concentrate on consulting resources that are more in line with their conditions, avoiding waste of time and possible demotivation when faced with long lists of search results that contain material that does not support properly their educational process.

Fig. 5. Results adapted to the User

To evaluate the proposed framework, the consistency reliability of the system was calculated using Cronbach's. in this testing process, we used Cronbach's $\alpha \geq .70$, because it is categorized to be high in internal consistency [26].

TABLE 1. EVALUATION FRAMEWORK

Parameters	Cronbach's α
Learning Satisfaction	.924
Learning Interface	
- Easy to Use	.871
- User-friendly	
Learning Content	
- Up-to-date content	
- Contents fits your needs	.895
- Provides useful content	
Personalization	
- learn the needed content	
- choose what you want to learn	.923
- control your learning progress	

From Table 1, it can be seen that the learning satisfaction from proposed framework is 0.924 (Cronbach's α=.924).

5 Conclusion

The search for educational resources was implemented by considering the student profile, allows the individual characteristics are recognized, what is expected to be translated into a recovery more in line with the needs. It can come to be reflected in a greater effectiveness in the educational process.

The presented application showed that it is possible to take advantage of the metadata of educational resources, to make the process of adaptation according to the data captured in the profile of the student.

The IEEE-LOM standard was used, and we carried out the extension of some metadata to consider the characteristics of accessibility. This adaptation model can be used under other standards as long as modifications are made to the rules of adaptation for the proper selection of metadata.

It is expected to carry out a greater process of validation of the adaptation rules, considering more of users with different profiles.

As future work, the inclusion of a functionality that allows to show texts and links in the platform in Indonesian Sign Language, in order to adapt these characteristics to students who they require it. Likewise, a functionality that allow audio playback under the same conditions previous.

References

1. Nganji, J.: Towards Learner-constructed e-learning Environments for Effective Personal Learning Experiences. Behaviour & Information Technology, vol. 37:7, pp. 647-657 (2018)
2. Santoso, L.W., Yulia: ITIL Service Management Model for elearning. Journal of Advanced Research in Dynamical and Control Systems, vol. 11, no. 6, pp. 190-197 (2019)
3. McGreal, R.: A Typology of Learning Object Repositories. İn: Handbook on Information Technologies for Education and Training, pp. 5 – 28 (2008)
4. Murray, M., Pérez, J.: Informing and Performing: A study Comparing Adaptive Learning to Traditional Learning. Informing Science: the International Journal of an Emerging Transdiscipline, vol. 18, pp. 111-125 (2015)
5. Santoso, L.W., Yulia: The Analysis of Student Performance using Data Mining. Advances in Intelligent Systems and Computing (2019)
6. Santoso, L.W.: Early Warning system for Academic using Data Mining. Proceedings - 2018 4th International Conference on Advances in Computing, Communication and Automation, ICACCA (2018)
7. Somyürek, S.: Student Modeling: Recognizing the Individual needs of Users in e-learning Environments. International Journal of Human Sciences [Online], vol 6, no. 2 (2009)
8. Spector, J.M.: Emerging Educational Technologies and Research Directions The 2011 Horizon Report. Educ. Technol. Soc., vol. 16, no. 2, pp. 21–30 (2013)
9. Zhang, J., Ghorbani, A.: GUMSAWS: A Generic User Modeling Server for Adaptive Web Systems. Fifth Annual Conference on Communication Networks and Services Research (CNSR 2007),117-124, 14-17 May 2006, Fredericton, New Brunswick, Canada, IEEE Computer Society.
10. Tintarev, N., Masthoff, J.: Recommender Systems Handbook, vol. 54. (2011)
11. Frias-Martinez, E., Magoulas, G., Chen, S., Macredie, R.: Modeling Human Behavior in User-Adaptive Systems: Recent Advances using Soft Computing Technique. Expert Systems with Applications, vol. 29, no. 2 (2005)
12. Isinkayea, F., Folajimi, Y., Ojokohc, B.: Recommendation Systems: Principles, Methods and Evaluation. Egyptian Informatics Journal, vol. 16, Issue 3, pp. 261-273, November 2015 (2015)
13. Amato, G., Straccia, U.: User Profile Modeling and Applications to Digital Libraries. Eur. Conf. Digit. Libr., pp. 184–197 (1999)
14. Esichaikul, V., Lamnoi, S., Bechter, C.: Student Modelling in Adaptive E-Learning Systems. Knowledge Management & E-Learning: An International Journal, vol 3, no 3, pp. 342-355 (2011)
15. Dekson, D., Suresh, E.: Adaptive e-Learning Techniques in the Development of Teaching Electronic Portfolio – A Survey. International Journal of Engineering Science and Technology, vol. 2, no. 9, pp. 4175-4181 (2010)
16. Dall'Acqua, L.: A Model for an Adaptive e-Learning Environment. proceedings of the World Congress on Engineering and Computer Science (WCEES), vol. 1 (2009)
17. Klašnja-Milićević, A., Vesin, B., Ivanović, M., Budimac, Z.: E-learning Personalization Based on Hybrid Recommendation Strategy and Learning Style Identification. Comput. Educ., vol. 56, no. 3, pp. 885–899, Apr. 2011 (2011)
18. Salehi, M., Pourzaferani, M., Razavi, S.: Hybrid Attribute based Recommender System for Learning Material using Genetic Algorithm and a multidimensional information model. Egypt. Informatics J., vol. 14, no. 1, pp. 67–78, Jan. 2013 (2013)
19. Peissner, M., Edlin-White, R.: User Control in Adaptive User Interfaces for Accessibility. Lect. Notes Comput. Sci., vol. 8117, pp. 623–640 (2013)

20. Aroyo, L., Dolog, P., Houben, G., Kravcik, M., Naeve, A., Nilsson, M., Wild, F.: Interoperability in Personalized Adaptive Learning. Educational Technology & Society, vol. 9, no. 2, pp. 4-18 (2006)
21. Kravcik, M., Angelova, G., Ceri, S., Cristea, A., Damjanović, V.: Requirements and Solutions for Personalized Adaptive Learning. Research report of the ProLearn Networkof Excellence (IST 507310), Deliverable 1.1. (2005)
22. Zervas, P., Sergis, S., Sampson, D., Fyskilis, S.: Towards Competence-based Learning Design Driven Remote and Virtual labs Recommendations for Science Teachers. Technol. Knowl. Learn., vol. 19 (2015)
23. Nacheva-Skopalik, L., Green, S.: Adaptable Personal Eassessment. Int. J. Web-Based Learn. Teach. Technol., vol. 7, no. 4, pp. 29–39, Jan. 2012 (2012)
24. Gonzalez, C., Burguillo, J., Llamas, M.: A Qualitative Comparison of Techniques for Student Modeling in Intelligent Tutoring Systems. Proceedings. Front. Educ. 36th Annu. Conf. San Diego, pp. 13–18 (2006)
25. Ciloglugil, B.: Adaptivity based on Felder-Silverman Learning Styles Model in E-Learning Systems. 4th International Symposium on Innovative Technologies in Engineering and Science (ISITES 2016), pp. 1523-1532 (2016)
26. Nunnally, J.: Psychometric Theory, NY: McGraw-Hill. (1978)

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