A Technique to Adapt Course Presentation in Moodle

Ioannis Karagiannis, Maya Satratzemi

Department of Applied Informatics, University of Macedonia, Thessaloniki, Greece
giankara@gmail.com
maya@uom.edu.gr

Abstract: Learning styles play a crucial role in students' success in a course. This article presents how a course can differ among learners with different learning styles regarding the position of the learning objects in the particular course. The proposed technique was implemented in Moodle so as to be used either for an e-learning course or for blended learning. Although this technique is implemented in Moodle it can be easily integrated in any other Learning Management System as long as it is able to provide the same types of learning objects. Two evaluation studies of a Moodle course were conducted in the context of an introductory programming course in order to examine the effectiveness of the proposed technique and students' feedback on it. In both studies, two groups were formed, namely the experimental and the control group. The adaptation technique described in this paper was applied for the experimental group, while the control group had access to the standard version of Moodle. The studies were conducted during the winter semester of the 2015/16 and the 2016/2017 academic year, respectively. Both studies were conducted over the first six weeks of the course, up to the mid-term exam. On completion of the respective course sections but prior to the mid-term exam, all students had to answer a questionnaire evaluating the attended course. The questionnaire consisted of five-point Likert type questions evaluating the proposed adaptation technique, system usability and motivational appeal. The aim of our analysis was to investigate whether our adaptation technique helped students to improve their learning outcomes without increasing Moodle's complexity. Summarizing the findings of the study, we come to the conclusion that the implementation of the proposed technique into Moodle is positively evaluated by the experimental group, resulting in significantly higher grades on the mid-term exam comparatively to the control group.

Keywords: Learning Management System, learning styles, adaptivity, student modelling

1. Introduction

E-learning has become increasingly attractive during the last decade. Learning Management Systems (LMS) have been widely used to support teachers in creating, administering and managing online courses. Although these systems provide teachers with all the tools they need, their effectiveness is sometimes questioned.

A causal factor is that LMS typically do not consider the individual differences of learners and deliver the same set of educational resources to all, ignoring the fact that learners have different prior knowledge and learning styles. Selim (2007) identified instructor's teaching style as one of the eight critical success factors for acceptance of e-learning because the compatibility of teaching style and students' learning styles may affect learning. When mismatches exist, students become inattentive in class, do poorly on tests and get discouraged about the courses and themselves. Consequently, provision of same instructional conditions to all students can be pedagogically ineffective (Akbulut and Cardak, 2012).

The purpose of our paper is to present a technique to adapt the proposed sequence of resources within a Moodle course to students' different learning styles. The proposed technique is embedded in Moodle in order to evaluate its effectiveness but it can be integrated easily in any other LMS as long as it can provide the same types of learning objects. This approach aims to affect students' motivation and involvement and, consequently, their learning outcomes.

The remainder of the paper is organized as follows. The next section gives a short description of learning style theory. This is followed by a section where related work is presented. In section 4 a brief overview of our system is given. This is then followed by section 5 where the proposed technique is presented. After a section, where the evaluation study is presented, in the final section are the conclusions.

2. Learning styles

Students acquire and process information based on their learning styles (Felder and Silverman, 1988). There are many learning style definitions, but one widely accepted by theorists is the one given by Gregorc (1979).

Gregorc states that "A learning style is the composite of characteristic cognitive, affective, and psychological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment". Despite the variation in definitions, the fundamental idea behind learning styles is that each student has a specific learning style or preference, and he/she learns best when information is presented in this style (Akbulut and Cardak, 2012). Consequently, it is important for instructors to understand the differences in their students' learning styles, so that they can implement best practice strategies into their daily activities.

Many different theories and learning style models have been proposed. Coffield et al. (2004) identified 71 models of learning styles and categorised 13 of them as major models with respect to their theoretical importance in the field, their widespread use, and their influence on other learning style models. However, the Felder-Silverman Learning Style Model (FSLSM) (Felder and Silverman, 1988) is used far more than any other in AEHS, mainly because it describes learning styles in much more detail (Carver, Howard and Lane, 1999). There are four dimensions each with two scales: active/reflective, sensing/intuitive, verbal/visual and sequential/global, according to the way students process, perceive, receive and understand information. The resulting preferences are considered as tendencies, since even those learners with a strong preference for a particular learning style can at times act differently (Graf, 2007).

The Index of Learning Styles (ILS) was developed in order to assess FSLSM (Felder and Soloman, 1997). ILS is a 44-item questionnaire with 11 forced-choice questions about each of the four dimensions. Every learner has a personal preference for each dimension, which is expressed with a value of between +11 and −11 (including only odd values). This range comes from the 11 questions that are posed for each dimension. When answering a question, for instance, with an active preference, +1 is added to the value of the active/reflective dimension whereas an answer for a reflective preference decreases the value by 1.

3. Related work

Adaptive Educational Hypermedia Systems (AEHS) were used to personalize the educational resources. They can be defined as "hypermedia systems that build a model of the goals, preferences and knowledge of each individual user, and use this model throughout the interaction with the user, in order to adapt to the needs of that user" (Brusilovsky, 2001).

Student modelling can be either static or dynamic. Static student modelling refers to an approach where the user has to answer a special questionnaire at the beginning of the course to detect his/her learning style. In contrast, dynamic student modelling refers to an approach where the user model is frequently updated. Better results are achieved with the second approach, since it describes learners' current state rather than their specific state at the beginning of the course. Furthermore, the user model can be built with techniques that are based on the knowledge (Kazanidis and Satratzemi, 2009) or behaviour (Graf, 2007) of the learner.

The adaptation techniques that can be used are classified into two categories according to the type of adaptation provided: adaptive presentation and adaptive navigation support (Brusilovsky, 2001). Based on the above classification, researchers implement some of the adaptation techniques in the context of their learning system. The adaptation module considers the user model and applies the specific techniques to the educational resources.

Many AEHS have been developed to enhance learning process. Popescu, Badica and Moraret (2009) developed the WELSA system, which is an AEHS that adapts educational resources to users' learning styles ignoring learners' knowledge. WELSA implements dynamic student modelling to surpass the disadvantages of using a questionnaire such as the arbitrary responses that do not correspond to reality. WELSA implements the techniques of adaptation of modality and adaptive link annotation. Kazanidis and Satratzemi (2009) developed the Proper system which is a SCORM-based AEHS that adapts presentation and navigation according to a complex user model where learners' knowledge, educational objectives and learning style are represented. AMDPC (Yang, Hwang & Yang, 2013) is an AEHS that considers users' learning styles to adapt the presentation of the educational material and cognitive styles to adapt the system interface. The validity of the pilot study can be questioned though, since the two groups of students used actually a different system.

Other researchers attempted to exploit the advantages of LMS and combine them with those of AEHS, proposing the use of adaptation techniques in well known LMS such as Moodle. More specifically, Graf (2007) extended Moodle and tried to find patterns of user behaviour that give indications of learning style dimensions. Based on these assumptions, she extracted data representing relevant behaviour and applied two different approaches: one data driven and one literature based. The former used Bayesian Networks in order to build and train a model for automatic detection of learning styles, while the latter applied a simple rule-based method to calculate the learning style. Although the FSLSM was the learning style model used in this

case, its visual/verbal dimension was ignored in the development of educational resources resulting in incomplete personalization. Learners' knowledge was also ignored in student modelling. Regarding the adaptation techniques, Graf mainly used adaptive link sorting to adapt the proposed navigation to students' learning styles. Liyanage, Gunawardena & Hirakawa (2014) and Surjono (2014) proposed similar methods but they also ignored students' knowledge. Moreover, Surjono used static student modelling and proposed a method that increases a teacher's workload. Despotović-Zrakić et al. (2012) used the k-means algorithm in Moodle to cluster students and adapt the educational resources to these clusters. The proposed approach is not flexible since clusters cannot be automatically updated. The LearnFit system (Bachari, Abelwahed & Adnani, 2011) is an extension to Moodle that recommends resources to learners based on their learning styles. The user model is initialized according to the results obtained by the ILS and then updated by using the Bayesian model. Although the proposed approach was beneficial to students, it also depicted the limitation of actual application as it is quite complicated and time consuming for the instructor.

4. System architecture

After considering related works, it was decided to extend Moodle rather than develop a new AEHS in order to exploit the benefits of a very powerful LMS. The architecture of the proposed system is illustrated in Figure 1. The proposed system is different from the other systems presented in previous section since the user model is built with techniques that are based both on behaviour and knowledge of the learner. Moreover, the user model is dynamically updated to reflect students' current state regarding both behaviour and knowledge of the learner.

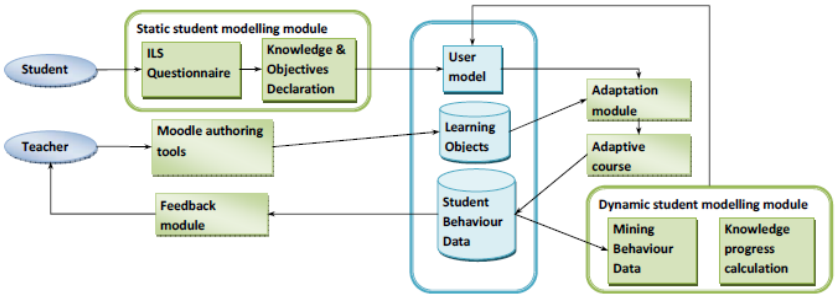

Figure 1: Architecture of the proposed system

As can be seen in Figure 1, static student modelling module requests that students respond to ILS and also declare their educational objectives at the beginning of the course. Thus, the system can adapt the course from the very beginning. To achieve dynamic updating, dynamic student modelling module applies a decision tree algorithm to users' behaviour data comprising the number of visits to each type of learning object, as well as their duration. Besides mining behaviour data, the dynamic student modelling module calculates knowledge progress as described in detail in our previous work (Karagiannis and Satratzemi, 2016).

5. Proposed technique

The purpose of our paper is to present a technique to adapt the proposed sequence of educational resources within a Moodle course to students' different learning styles. In order to match the diversity of learning styles, we decided to use seven different types of learning objects: outlines, content objects, videos, solved exercises, an open-ended question, quizzes, and conclusions. Outline presents an overview of the educational objectives of the current section. Content objects present the theory of the section. Videos explain basic concepts of theory and provide hints for problem solving. Solved exercises consist of a description of an exercise and its solution. Quizzes include multiple close-ended questions where each one of them demands prediction of program output or filling gaps in a program. Open-ended questions include a small piece of code and learner must predict its output and reason for this prediction. Finally, conclusions summarize the main points of current section's theory.

Each course consists of sections, each with a different theoretical concept, and its own learning objects. In turn, each section consists of: an outline, contents objects, videos, solved examples, one quiz, an open-ended question and a conclusion. The outline is the first learning object presented in the structure of a section. On the contrary, the conclusion is usually the last object in a section. Immediately after the outline, there is what we call the "area before content". The specific area includes one of the available learning objects and whose

aim is to stimulate the learner to become actively involved in this section. This in turn is followed by the content objects. Then there is the “area after content”, which consists of all the remaining objects of the current section. Taking into account the types of learning objects, course structure and learning style literature (Felder and Silverman, 1988), we decided that the “area before content” consists of one learning object among solved exercises, videos, open-ended questions and short quizzes. The next four adaptation features are related to the position of the solved exercises, quizzes, videos and open-ended questions and concern the “area after content”. Two more features concerning the specific area were also included. The first is the outlines, appearing not only at the beginning of a section but also between the content objects. The second feature is the conclusion appearing either right after the content objects or at the end of the section.

An adaptation matrix (Graf, 2007) is built to adapt the proposed sequence of educational resources to students’ different learning styles. The matrix is accessible from Moodle (Figure 2) to enhance flexibility of the proposed technique and consists of one row for each of the ten selected adaptation features and one column for each of the different values of each dimension of FSLSM, making a total of eight columns. The matrix cells are filled in as follows: 1 if the adaptation feature supports the specific learning style, -1 if the feature should be avoided in order to support the specific learning style and 0 if the feature has no effect on the learning style according to the literature.

Adaptation Feature	Active	Reflective	Sensing	Intuitive	Visual	Verbal	Sequential	Global
short_quiz_before	1	-1	-1	1	0	0	-1	0
example_before	-1	-1	-1	-1	0	1	-1	1
assignment_before	0	-1	1	1	0	0	-1	0
video_before	-1	-1	1	-1	1	-1	-1	0
outline	0	1	0	0	0	0	0	1
conclusion	0	1	0	0	0	0	0	1
example_after	-1	1	1	-1	0	0	1	1
quiz_after	1	-1	1	0	0	0	0	-1
video_after	-1	1	1	-1	1	-1	1	1
question_after	1	0	1	1	-1	1	0	-1

Figure 2: Adaptation matrix

For example, active learners prefer to do something active with the information. Therefore, quizzes and open-ended questions are recommended for them. In order to stimulate students’ interest, it is proposed that these learning objects be presented in “area before content”. Consequently, the respective matrix cells are filled in with 1 (Figure 2). In contrast, solved exercises and videos are not suitable for active learners and should be avoided for the “area before content”. They should rather be presented towards the end of the “area after content”. The outline and conclusion do not affect active learners and, therefore, the respective cells are filled in with 0. Taking the example of a student with a strong preference for the active learning style and a balanced preference for the other three dimensions of FSLSM, the proposed sequence of the educational resources is illustrated in Figure 3.

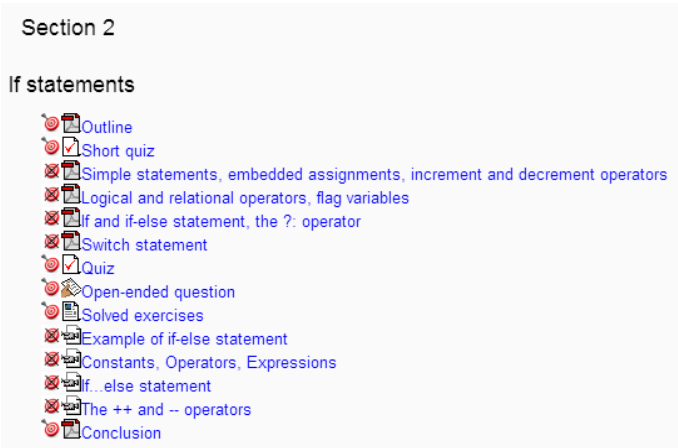

Figure 3: Proposed sequence of educational resources for an active learner

In contrast, because reflective learners prefer to think about the educational material first, learning objects should not be presented before the content. Learning objects, such as solved exercises and videos are best presented after the content, and quizzes should be placed at the end of this section. Since reflective learners need to think about the material, it is proposed that the outline should be presented both at the beginning and between the content objects, whereas the conclusion ought to appear directly after the content enabling them to contemplate it.

As regards sensing learners, all the selected learning objects are recommended for them in the "area after content" since all of their preferences seem to be compatible with all the material. Since sensing learners do not like complications or surprises, but prefer to first acquaint themselves with the procedures needed to solve each task, quizzes and examples should not be presented in the "area before content" as they may frustrate this learner type.

Intuitive learners, on the other hand, are innovative and like to be challenged. That is why it is expected that they would prefer quizzes and open-ended questions, which should be presented in the "area before content" in order to stimulate interest. Other learning objects, such as solved exercises and videos, which are neither creative nor challenging, can be presented towards the end of this section (Figure 4).

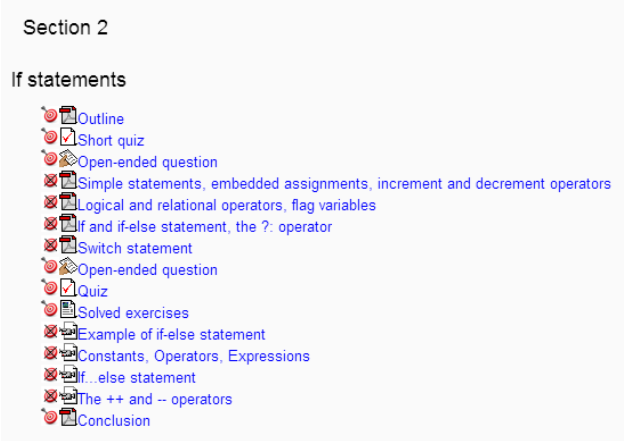

Figure 4: Proposed sequence of educational resources for an intuitive learner

Visual learners, who learn best from visual representations of the underlying concepts, would appreciate videos, which should be presented both before and after the content. The initial video in the "area before content" provides the stimulus for the student to become actively involved in the section. The other videos, along with solved exercises and open-ended questions can be placed in the "area after content".

Verbal learners learn best from text. Solved exercises, which are more suitable for this type and should be presented in both the area before and after content, are filled in with 1 in the matrix.

Sequential learners' preference is through logical steps of increasing complexity. This means that none of the learning objects should be presented in the "area before content". Thus, the four specific cells of the matrix are filled in with -1. On the other hand, solved exercises and videos would be more conducive right after the content and prior to quizzes and open-ended questions for this learner type.

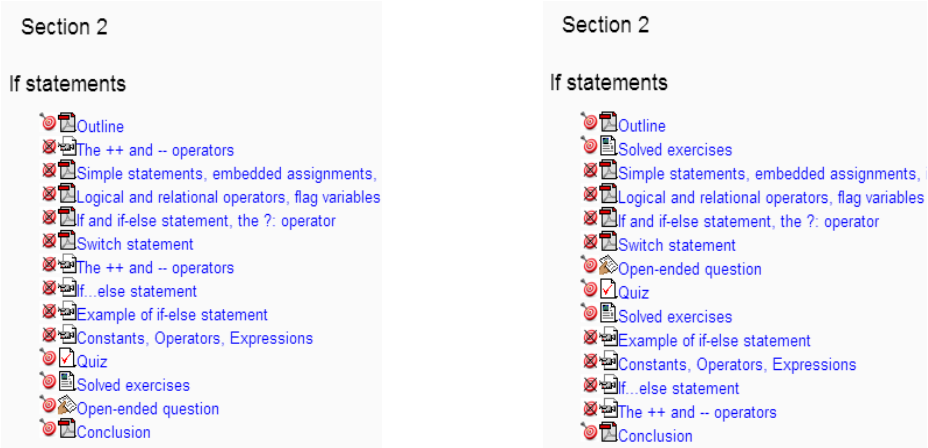

Figure 5: Proposed sequence of educational resources for a visual and a verbal learner

In contrast, the most important characteristic for global learners is to grasp the big picture prior to being involved in other activities. Therefore, in order to help learners better understand the material and get an overview of the entire picture, only solved exercises should be presented in the "area before content". Since

this learner type needs to gain a total understanding of the subject matter before they can master details, solved exercises and videos can also be presented in the "area after content" before any other learning objects. The outline ought to be presented both at the beginning of each section and between the content objects, whereas the conclusion ought to be presented directly after the content. Quizzes and open-ended questions should be presented towards the end of the "area after content" where the learner is likely to have acquired a fuller understanding of the educational material.

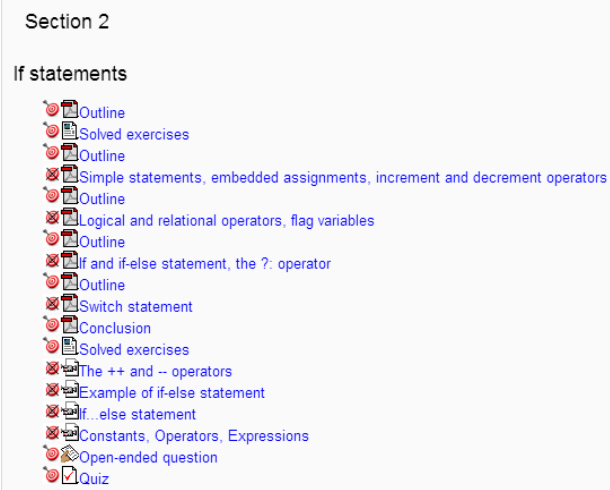

Figure 6: Proposed sequence of educational resources for a global learner

Based on the learning styles of the students, as obtained both from the questionnaire (LS_{ILS}) and the decision tree algorithm (LS_{AD}), we add up the respective values of the adaptation matrix for each of the adaptation features, by firstly considering LS_{ILS} and then the LS_{AD}, and the final ranking score is equal to their average. The "area before content" consists of the learning object, which has the highest ranking score from the solved exercises, videos, open-ended questions and short quizzes. Regarding the "area after content", all learning objects are ranked in descending order according to their score, which determines their positioning within the specific area.

6. Evaluation study

Two evaluation studies were conducted to assess the effectiveness of the proposed technique, during the winter semester of the 2015/16 and 2016/17 academic year in the context of the Procedural Programming introductory course, taught in our department. Course's total length is 13 weeks and it consists of a 2-hour weekly lecture and a 2-hour weekly laboratory where students practice and solve a problem. Both studies were conducted over the first six weeks of the course, up to the mid-term exam. During this time, five sections about the fundamental concepts of procedural programming are presented to students.

Two groups of students were formed, namely the experimental and the control group. More specifically, after students were informed of groups' differences, they expressed their preference for the group they wanted to be assigned to. In order to confirm the validity of the studies, we investigate the two groups' average grades in a similar course which is also taught in the first semester. None statistically significant difference was found and, thus, it can be assumed that the two groups were equally engaged in their studies and any differences in the study results were probably due to the proposed mechanism. Both groups attended the same lectures and laboratories whilst using two different courses in Moodle for studying. The educational resources were the same for both courses. The proposed technique described here was implemented for the experimental group, whereas, the standard version of Moodle was applied for the control group.

On completion of the 5 sections of Moodle's course but prior to the mid-term exam, students of both groups had to answer a questionnaire evaluating the course that they attended. The questionnaire consisted of five-point Likert type questions, ranging from 1 'strongly disagree' to 5 'strongly agree' and was divided into three subcategories in order to evaluate the usability, the motivational appeal and the adaptivity techniques applied by the system, respectively. Finally, 139 and 96 students participated in the two studies. They were equally assigned to each group. The aim of our analysis was to investigate whether our proposed technique helped students to improve their learning outcomes, learn easier and increase their motivation without increasing Moodle's complexity.

As can be seen from the results in Table 1 and Table 2, students rated the system usability highly overall for both studies. Slight differences exist between the mean values of the two groups for some questions. None of

these differences was statistically significant though. Consequently, the system usability is not affected by the implementation of the proposed adaptation technique, which was one of our main goals when designing the system.

Table 1: Student feedback on the usability of the system for the first study

Question	Experimental Group		Control Group	
	Mean	SD	Mean	SD
Pages loaded fast	3.9	0.896	3.9	0.831
Navigation was easy	4.2	0.858	4	0.806
Links were expressed definitely	4.3	0.851	4.3	0.839
System was user-friendly	4	0.904	4	0.856
System was considered adequate for novices	4.1	0.866	3.9	0.957
Easily familiarized myself with the system	4.4	0.868	4.4	0.787

Table 2: Student feedback on the usability of the system for the second study

Question	Experimental Group		Control Group	
	Mean	SD	Mean	SD
Pages loaded fast	4.3	0.739	4.1	0.872
Navigation was easy	4.2	0.869	4.3	0.742
Links were expressed definitely	4.5	0.757	4.2	0.915
System was user-friendly	3.9	0.957	3.9	0.958
System was considered adequate for novices	4.1	0.900	4.1	0.913
Easily familiarized myself with the system	4.4	0.957	4.3	0.857

The findings concerning the motivation appeal of the system for both studies are presented in Table 3 and Table 4. Regarding the first question on whether the system motivated students to study more, the experimental group of the first study gave a higher mean of 4.1 to the control group, whose mean was 3.6. This difference was statistically significant at the 95% confidence level ($U = 1679.5$, $p = 0.002$). A statistically significant difference was also found for the specific question regarding the second study where an average score of 4.4 and 4.1 was given by the experimental and the control group, respectively. The findings regarding the second question revealed that students found the proposed technique helpful in making learning easier. More specifically, experimental groups for both studies gave a higher mean to the respective control groups and that difference was also found to be statistically significant. All students were generally satisfied with the use of Moodle and the quality of the educational resources.

Table 3: Student feedback on the motivational appeal of the system for the first study

Question	Experimental Group		Control Group	
	Mean	SD	Mean	SD
System motivated me to study more	4.1	0.967	3.6	0.986
System helped me to learn easier	4.2	0.833	3.9	0.885
I'm generally satisfied from system usage	4.0	0.904	3.9	0.985
Quality of educational resources	4.1	0.622	4.1	0.574

Table 4: Student feedback on the motivational appeal of the system for the second study

Question	Experimental Group		Control Group	
	Mean	SD	Mean	SD
System motivated me to study more	4.4	0.777	4.1	0.958
System helped me to learn easier	4.4	0.618	4.1	0.813
I'm generally satisfied from system usage	4.1	0.852	4.0	0.760
Quality of educational resources	4.1	0.543	4.1	0.621

Students comprising the experimental group of each study were asked to answer to three more questions in order to evaluate the proposed adaptation technique (Table 5). The findings regarding the question on whether students found the proposed technique interesting and useful showed that the experimental group of the second study gave a higher mean comparatively to that of the first study. Regarding the second question, the findings are quite similar with those of the first question. Although the aforementioned findings indicate a positive attitude to the proposed technique, higher means were expected. This difference between the findings and the expected values may be due to the fact that they did not strictly follow the recommended sequence as can be seen from the means regarding the third question.

Table 5: Student feedback on the proposed adaptation technique

Question	First study		Second study	
	Mean	SD	Mean	SD
Is the functionality of the recommended navigation sequence interesting and useful?	3.2	1.199	3.51	1.079
Do you clearly believe that the recommended navigation sequence suits your learning style?	3.3	1.181	3.44	0.967
Did you strictly follow the recommended navigation sequence while studying?	3.1	1.333	3.38	1.319

The implementation of the proposed technique also improved students' grades on their mid-term exam. The results presented in Table 6 show that the experimental group of each study performed better comparatively to the equivalent control group. A two-tailed Mann-Whitney U test revealed that all differences were statistically significant since p-value was less than 0.05.

Table 6: Student performance

	Experimental Group		Control Group		utest	
	Mean	SD	Mean	SD	p	U
1st study	20.11	6.953	17.33	8.948	0.039	3572.5
2nd study	18.13	6.99	15.13	8.04	0.011	4399.5

7. Conclusions

The adaptation of educational material to suit students' learning styles is proven to be beneficial for them. Although many systems have been proposed to adapt the educational material, no proven recipes exist. Trying to contribute to research, we propose the integration of an adaptation technique in Moodle. The specific technique adapts the sequence of the educational material to students' learning styles and can be easily integrated in any other LMS as long as it can provide the same generic types of learning objects.

This paper describes the adaptation technique and presents two evaluation studies of the use of Moodle for blended learning. The results of the studies were quite positive since they show that the proposed technique helped the experimental group to learn easier and achieve higher grades on the mid-term exam comparatively to the control group, without added complexity to the system. These preliminary results may provide the basis for further research in the field of adaptive learning. Our future work will focus on the design and implementation of new and system independent adaptation techniques as well as on the inclusion of new types of learning objects.

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