Scientific Journal of Faculty of Education, Misurata University-Libya, Vol. 9, No. 21, mar. 2023
Published online in March
المجلة العلمية لكلية التربية، جامعة مصراتة، ليبيا، السنة التاسعة، المجلد التاسع، العدد الحادي والعشرون، مارس 2023
Issn :2710- 4141
تاريخ الاستلام 2023/01/18 تاريخ النشر 2023/03/01

Adaptive educational systems in terms of its impact on students' performance and engagement: A review study

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Abstract:

Research into computing-based education has indicated that students have different needs and abilities which is known as a Learning Style. It also recommends considering these differences because that will increase the efficiency and effectiveness of the educational process. The adaptive educational system aims to consider the individual differences between students by providing them with the content and teaching methods that match their learning styles. This paper, by reviewing 10 previous studies related to adaptive educational systems, aims to investigate deeply the impact of using such systems on the performance and engagement of students. The results of this research offer clear insights into achievements and challenges in the field.

Keywords: Adaptive educational system- student participation- individual difference- learning styles

أنظمة التعليم المتكيفة من حيث تأثيرها على أداء الطلاب ومشاركتهم: دراسة مراجعة

الزين مفتاح الزين
جامعة مصراتة

الملخص:

أشارت الأبحاث في التعليم القائم على الحوسبة إلى أن الطلاب لديهم احتياجات وقدرات مختلفة تُعرف باسم أسلوب التعلم. كما توصي هذه الأبحاث بالنظر في هذه الاختلافات لأن ذلك سيزيد من كفاءة وفعالية العملية التعليمية.

يهدف النظام التعليمي التكيفي إلى مراعاة الفروق الفردية بين الطلاب من خلال تزويدهم بالمحتوى وطرق التدريس التي تتناسب مع أساليب التعلم الخاصة بهم. هذه الورقة ومن خلال مراجعة 10 دراسات سابقة

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تتعلق بالأنظمة التعليمية التكيفية، تهدف إلى التحقيق وبعمق في تأثير استخدام مثل هذه الأنظمة على أداء ومشاركة الطلاب. كما تقدم نتائج هذا البحث رؤى واضحة حول الإنجازات والتحديات في هذا المجال.
الكلمات المفتاحية: النظام التعليمي التكيفي– مشاركة الطلاب– الفروق الفردية– أساليب التعلم.

1 Introduction

1.1 Learning style

Research on education has revealed that students tend to gain more knowledge from educational content that matches their preference, for example, learners with a visual style mostly get more knowledge from the content that depends on the visual material or information, whereas the same content will be less useful for learners with a verbal style because they prefer lessons that are represented using audio and text. Moreover, some learners tend to learn more through thinking and reflecting on things, whereas others prefer to do these things by themselves to understand them. These patterns that students prefer to learn are called Learning Style (LS) (Alshammari 2016, Alzain, Clark et al. 2016).

Within the scope of adaptive educational systems, in 2015 Özyurt carried out a review study in which 69 studies published between 2005 and 2014 were analyzed. Özyurt revealed that 48 studies out of 69 (69.6 %) relied on instruments of learning style to detect student preferences in order to achieve the adaptation process (Özyurt, Özyurt 2015).

1.2 Adaptive Education Systems

As mentioned above, learners usually have different needs, preferences, aims, experiences and backgrounds. Although this disparity, the traditional educational systems usually provide the same resources and teaching strategies for all students (Brusilovsky 2001). Therefore, to bridge this gap and consider the individual differences among learners, adaptive systems

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have been harnessed. These systems have been defined by Feighas as "technological component of joint human–machine systems that can change their behavior to meet the changing needs of their users, often without explicit instructions from their users" (Feigh, Dorneich et al. 2012).

1.3 Research question

What is the impact of using an Adaptive Education System on the engagement and performance of students?

To answer this question and know to what extent the use of an adaptive education system could positively affect the performance and engagement of students this paper examines a number of experimental studies related to using an adaptive education system based on learning styles published in refereed conferences and journals from 2000 to 2019.

2 Search method

In this paper, different articles on the impact of the use of adaptive educational systems were collected from three scientific search engines: Scopus, Google Scholar and Science Direct. These articles were then reviewed, analyzed, synthesized, and investigated. The results are shown in the next section.

3 Results

3.1 Adaptive Educational Systems Architecture

By reviewing the literature, it was clear that all the systems followed a very similar development process where it is integrated one or more of the learning style instruments to detect the preferences of learners and then, the system achieves the adaptation process to match these preferences with the

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educational content and teaching strategies. The next figure explains the mechanism of adaptive educational systems.

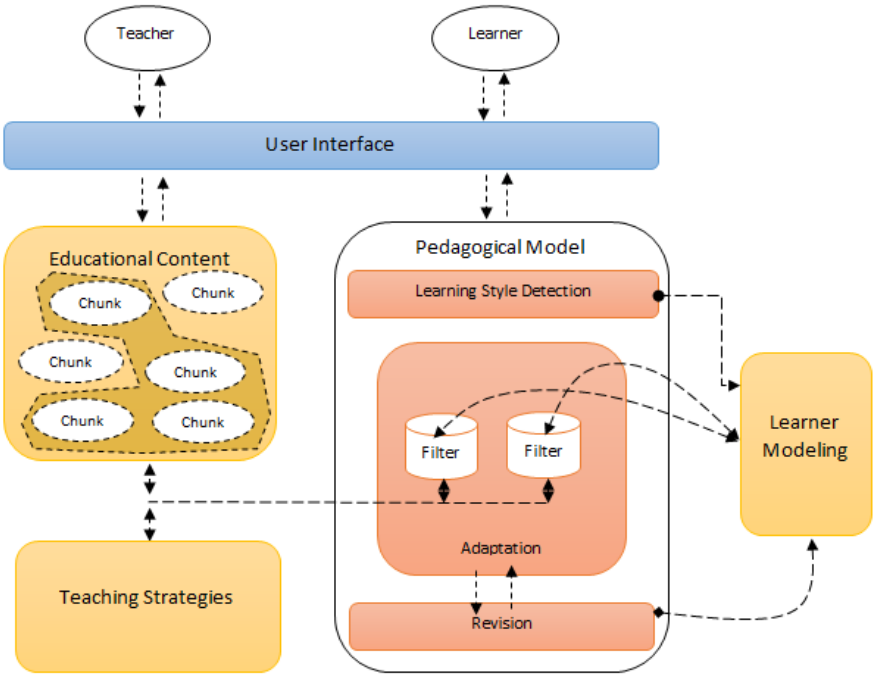

Table 1: Architecture of adaptive educational systems

3.2 Previous Studies

This section will investigate 10 of the previous adaptive educational systems, which have attempted to consider the individual differences among students.

3.2.1 TANGOW System

TANGOW stands for (Task-based Adaptive learNer Guidance On the Web) which is a web-based educational tool that aims to the enhance learning and teaching process by considering the preferred learning styles of students (Paredes, Rodriguez 2004). The developers of TANGOW think that the instruments of learning style could be partly inadequate to determine the learning preferences for reasons related to poor design. Therefore, they think

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the preferences of each student should be updated by considering the student's background, actions, language and age. To achieve the adaptation process first TANGOW used (the Index of Learning Style questionnaire (ILS) to collect information about student preferences and later, other implications such as background, age, language and student interaction were considered to update learners' profiles. Accordingly, the TANGOW system provides adaptive guidance for learners. Although this study flowed was very clear and strict in terms of methodology, it does not provide any empirical or statistical evidence about the efficiencies and effectiveness of this adaptation mechanism (E. Brown 2007).

3.2.2 AHA! System

AHA stands for (Adaptive Hypermedia Architecture) which is an adaptive educational system (Zakaria 2004). The developer of AHA grants more privileges to the instructors in terms of selecting which learning style model and instrument should be applied in the systems. For that reason, generic adaptive language (LAG-XLS) was developed, (LAG-XLS) allows 3 different learning style models of adaptive behavior, namely ordering information by type, creating different navigation and item selection. Some pre-defined adaptation strategies were also provided for the preferences of Active-Reflective, Global-AnalyticVerbalizer-Imager, and Dependent-Field Independent. Moreover, the system allows the instructors to reuse a pre-defined teaching strategy or build their own new strategy. To evaluate this system, 34 students from business information systems and computer science schools participated in an empirical experiment, they were asked to fill out the index of Learning Style questionnaire (ILS). Subsequently, the LAG-XLS generic adaptive language. The results of preferences detection of the two

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instruments were compared. As a result, a significant difference was detected between the results of the two instruments.

Although the results indicated that the participants realized the basic concepts of learning styles, they faced many problems when they were asked to build their own instructional strategies (Al-Jojo 2012).

3.2.3 iWeaver System

iWeaver is a research project aiming to accommodate individual differences in an adaptive e-learning system to teach the java programming language (Wolf 2003). This system employed the Dunn-Dunn learning style model to achieve this goal, it also depends on a number of learning tools. To detect the learning preferences, the participants first filled out the Building Excellence Inventory, and then a student model was built using these references for each student. Moreover, in each session, the student model is compared with the educational content model to match the learning content and some recommendations are provided for students.

Although iWeaver system was evaluated by 63 students in a 3-day workshop, this workshop have not succeed to provide any empirical evidence about the impact of the using iWeaver on the engagement and performance of participants (Al-Jojo 2012).

3.2.4 3DE System

Design, Development and Delivery - Electronic Environment for Educational Multimedia (3DE) is a research project in education funded by European Union (EU) and conducted by researchers from France, Italy, Spain and Finland. The idea behind this system is to provide a number of teachers for each student instead of one teacher for a number of students as what happens

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in traditional classrooms, to achieve this idea a personalized learning environment was built, whereas this environment offers several teachers and materials and students can choose the most suitable content and teacher.

Honey and Mumford learning style model was used to detect the learning preferences of learners and classify them into four different groups, which are: Reflectors, Activists, Theorists, and Pragmatists, moreover, some other characteristics such as learning goals, previous knowledge, and competence skills were considered. To evaluate this system, empirical research was conducted with 160 participants from (Italy, Spain, France and Finland), the results revealed that the learners who learnt in a matching way scored significantly higher than the others who learnt in a mismatched way (Alghamdi 2010).

3.2.5 ILASH System

"Incorporating Learning Strategies into Hypermedia", is an adaptive educational system called the ILASH system, which tries to incorporate hypermedia into learning strategies. This system used Physics courseware, which belongs to students of GCSE level. the content of this courseware was adapted by Fullick in 2001 (Bajraktarevic, Hall et al. 2003a). In this research, only one dimension out of four in the Felder- Silverman learning style model was used to detect learner preferences and based on these preferences, the system could present the most suitable instructional content (Bajraktarevic, Hall et al. 2003b). In order to evaluate the ILASH, empirical research with 22 students was conducted. The students have been taught in a matched style and then, they have been taught in a mismatched style. Finally, statistical analysis has been conducted. The results showed that the participants who

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were taught in the matched style achieved higher than others (Bajraktarevic et al. 2003b, Bajraktarevic et al. 2003a, Al-Jojo 2012)

3.2.6 EDUEC System

EDUEC is an intelligent adaptive education system that aims to enhance student performance and engagement by providing instructional content that fits student preferences. The Multiple Intelligence Developmental Assessment Scales inventory was used to detect the preferences. For each student, the EDUEC generates a static profile to keep the results of the MIDAS inventory, and a dynamic one to save student details such as student feedback, history of navigation and time spent on each lesson. EDUEC provides two different ways of content presentation, which extend from presenting the least preferred content to presenting the most preferred content. Moreover, for each lesson, the system provides four different instructional content and material. Therefore, based on the learner profile and presentation strategy the system determines which content is the best to present first (Kelly, Tangney 2004, Kelly, Tangney 2005). Two empirical studies with 117 participants were conducted to evaluate this system, and the results revealed that the participants who have a low level of activity get more from the resources that mismatch their preferences (Alghamdi 2010, Al-Jojo 2012).

3.2.7 INSPIRE System

The Intelligent System for Personalized Instruction in a Remote Environment or INSPIRE is an adaptive education system designed to provide different levels of adaptation, which extend from the entire user-control level to the entire system-control level. INSPIRE allows the learners to navigate and

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select learning goals, which in turn are used to generate the content. in this system, the preferred learning style of students is calculated by using the Honey and Mumford questionnaire in the first login on the system (Magoulas, Papanikolaou et al. 2003). After that, the user has privileges to edit his/her preferred learning style (Papanikolaou, Grigoriadou et al. 2003). To evaluate this system 23 students participated in empirical research, and the results reported that, the most of the participants appreciated the adaptation process of this system (Al-Jojo 2012), Alghamdi reported that this system (INSPIRE) does not succeed to provide different types of educational content for different types of learners.

3.2.8 CS383 System

CS383 is the first adaptive educational system, which used the Index of Learning Style (ILS) instrument to find out the preferred learning style of learners in terms of 3 dimensions: visual-verbal, sensing-intuitive and sequential-global (Al-Jojo 2012). This system also provides different comprehensive educational materials including instructional movies, audio files, slideshows, hypertext, lesson objectives and a digital library. These materials are evaluated on a percentage scale, this evaluation, in turn, is compared with the preferred learning style of the learners to find out the materials that match the students (Carver Jr, Howard et al. 1999). The developer depended on informal information to assess the functionality of the system where the data were collected from the participants over two years and the findings were positive (Alghamdi 2010, Al-Jojo 2012).

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3.2.9 Arthur System

the traditional education system which usually provides only one teacher for each classroom. On the contrary, the Arthur system aims to provide many teachers for each learner in each classroom. Developers of Arthur think that this aim can be achieved by preparing materials for each subject and then being taught by many teachers in different teaching strategies. Four different learning and teaching styles were considered in the content preparation, which are: auditory-text, visual-interactive, auditory-lecture, and text-only presentation. In the first login to the system, for each student, Arthur randomly assigns one lesson to the student. And at the end of each lesson, the student needs to answer a multiple-choice-quiz to evaluate his/her performance, if the learner scores 80% or more, the learner will be nominated to go forward to the next lesson, which is typically prepared in the same learning style and provided by the same teaching method. In contrast, if the learner gets 20 % or less, the system will assume this strategy does not fit the learner, Accordingly, Arthur will select another learning and teaching style for the learner. The Arthur system was evaluated using two empirical experiments although some experts criticized the accuracy of the functionality of assigning the first lesson, the findings revealed that Arthur succeeded to achieve a significant impact on the performance of students and learning outcomes, (Alghamdi 2010).

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3.3 Summary of Research Studies

Table 1: summary of previous studies

No	System	Learning style model	Learning style instrument	Evaluation procedures
1	TANGOW	Felder- Silverman model	Index of learning style questionnaire (ILS) - updating the student profiles	No formal experimental research has been conducted (informal evaluation)
2	AHA!	Determined by the teacher	LAG-XLS generic adaptive language. Students can update his/her profile	An empirical study with 34 students was conducted
3	iWeaver	Dunn and Dunn model	Building Excellence Inventory	A workshop with 63 students was conducted
4	3DE	Honey and Mumford learning style model	Honey and Mumford questionnaire (students have privileges to decide whether follow his/her preferred learning style or try another alternative)	A cross-cultural empirical study was conducted and 40 participants from each country (Italy, France, Spain, Finland) have participated
5	ILASH	Felder- Silverman model	Index of learning style questionnaire (ILS)	An empirical study with 22 students was conducted
6	EDUEC	Gardner's Theory of Multiple Intelligence	MIDAS Multiple intelligence inventory	2 empirical studies with (117 students) were conducted
7	INSPIRE	Honey and Mumford learning style model	Honey and Mumford questionnaire.	empirical study with 23 sample size was conducted
8	CS383	Felder and Silverman model	Index of learning style instrument (ILS)	No formal experimental study has been conducted (informal evaluation)
9	Arthur	Different learning style models	Determine by the system (No psychometric instrument)	An empirical study with 89 participants was conducted

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4 conclusion

In general, it is clear that researchers completely agree that the learning style is one of the most important strategies that should be considered and employed to model students. On the other hand, although some studies don't succeed to provide statistical evidence about the impact of using an adaptive education system, the results of most previous studies revealed that using adaptive education systems in education has a positive impact on student performance and engagement

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