Journal of Basrah Researches (Sciences) **50**(2), 1 (2024)
DOI: https://doi.org/10.56714/bjrs.50.2.1

Effectiveness of Artificial Intelligence in Mathematics Teaching by Protus 2.1

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ARTICLE INFO

Received 23 January 2024
Revised 5 November 2024
Accepted 15 November 2024
Published 31 December 2024

Keywords:

Artificial Intelligence, Mathematics Education, Learning Styles, Protus.

Citation: H. M. AL- Alhalafi et al., J. Basrah Res. (Sci.) **50**(2), 1(2024).
DOI: https://doi.org/10.56714/bjrs.50.2.1

ABSTRACT

The use of Artificial Intelligence (AI) in the field of mathematics education as a novel tool has introduced new capabilities in the learning and teaching processes. This technology not only assists teachers and students in enhancing the learning process but also provides the latest teaching methods.
One of the main advantages of AI in mathematics education is the ability to offer personalized learning. By analyzing individual data related to each student's learning style, AI systems can precisely adjust educational programs. This implies that each learner will follow a learning route that is suited to their knowledge level and needs. These technologies can help to diversify the learning process, catch students' interest, and boost their excitement for active engagement in the learning process. In this post, course content was personalized using the Protus 2.1 educational system.

1. Introduction

Education is essential for developing individual and social habits in any country. Educational activities may be viewed as an investment in one generation to benefit future generations, with the goal of personal and human growth. The purpose of education is to increase individuals' awareness and potential. Mathematics is a topic that contributes significantly to the quality of education. It entails thinking skills focused on comprehending and presenting issue situations, explaining essential ideas, organizing, analyzing, and categorizing relevant material, and defining problem-solving methodologies [1, 2]. In today's world, technology and artificial intelligence (AI) have rapidly infiltrated all aspects of our lives, including education. Mathematics education, as a vital and fundamental field, has moved towards optimal and personalized learning processes by harnessing the capabilities of AI [3].
The application of artificial intelligence in math education opens up several potentials for both instructors and pupils. These technologies include data analysis capabilities, detecting each student's strengths and limitations, providing appropriate activities, and improving the learning experience. AI, taking into account learning patterns, can help improve the quality and efficiency of arithmetic teaching [4].

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ISSN: 1817-2695 (Print); 2411-524X (Online)
Online at: https://jou.jobrs.edu.iq

Protus 2.1 [5, 6, 7] is a tutoring system utilized for customizing the course content based on learners' individual learning styles. This system incorporates learning styles, knowledge levels, and techniques like collaborative tagging to tailor the content to meet the specific needs of learners. Two co-authors of this paper have played a crucial role in the invention, design, implementation, and utilization of the Protus 2.1 system, giving them comprehensive knowledge of its functionalities, advantages, quality, and future upgrades.

Given the widespread use of Moodle, it becomes crucial to highlight the benefits of incorporating personalization into it. Furthermore, comparing the enhanced Moodle with a system explicitly designed for personalization from the outset is essential. In light of the mentioned considerations, we aim to use personalized e-learning systems: PLeMSys, conceived as a dedicated personalized learning system [8].

In most cases, we observe that students encounter difficulties in learning mathematics. To address this issue, advancements in computer technology, particularly Artificial Intelligence (AI), provide an opportunity to assess individual learning challenges and offer personalized support to optimize success in math classes. Given that researchers, especially beginners, need a comprehensive understanding of AI's role in math teaching, this study initially identifies learning patterns in students through the use of the Inventory of Learning Styles (ILS) questionnaire. Learning habits are then discovered using data mining methods, and the appropriate type of education is determined for each student. The educational content is then tailored and organized according to preferred learning styles in the software, allowing students to enter the learning environment and commence their learning journey [9,10].

After implementing the described teaching method, the study evaluates the level of comprehension, problem-solving skills, active participation, and progress in mathematical learning. To assess the understanding of the material, students are asked to respond to exercises and short assignments to ensure a proper grasp of the concepts. Additionally, students are required to explain concepts in their own words, demonstrating their understanding of the content [11,12].

To evaluate problem-solving abilities, the presentation of practical exercises and challenging problems is employed, serving as indicators of students' problem-solving skills. To assess active participation through discussion and solution presentation, students are allowed to explain their solutions to others, allowing scrutiny of their problem-solving skills and critical thinking. Participation in projects and report development also serves as an indicator of students' engagement and interaction with the material. The progress in students' learning is examined through assessments and examinations [13.14].

Protus 2.1 [15, 16, 17] is a tutoring system that personalizes the content of the course based on learners' learning styles. It uses learning styles, knowledge levels, and techniques such as collaborative tagging to personalize the content that best matches learners' needs. This paper has played an essential role in developing, designing, implementing, and exploiting the Protus 2.1 system.

Overall, AI has made significant contributions to mathematics by automating tedious tasks, providing new insights, and enhancing the efficiency of problem-solving processes. However, it's important to note that AI is a tool for mathematicians rather than a replacement for human creativity and intuition in mathematical discovery [18]. The methodology in this article involves leveraging the Protus 2.1 educational system for personalized course content, highlighting the role of Artificial Intelligence (AI) in revolutionizing mathematics education by facilitating personalized learning paths tailored to individual student's needs and learning styles.

Given these considerations, the assessment of the new teaching method can be conducted, assuring students' progress. As a result, by implementing learning patterns, artificial intelligence plays a prominent role in creating a dynamic, flexible, and personalized learning process in mathematics education. This experience allows students to grasp mathematical concepts with the utmost efficiency and effectiveness, guiding them toward success in this field.

2. Protus

Individuals exhibit diverse preferences and strengths when it comes to processing and assimilating information; in other words, they possess distinct learning styles. As defined by Keefe

in [10], a learning style is a "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.
Protus 2.1 is a learning system meticulously crafted to accommodate personalization based on learning styles. Functioning as an interactive platform, its primary objectives include presenting learning materials to users and evaluating their acquired knowledge [19.20].

2.1 System Architecture

The architecture of Protus 2.1 facilitates the development of courses in three distinct phases:
1. Creating a course framework using the Vaadin Java framework [11].
2. Developing courses along with associated materials and tests for each lesson.
3. Presenting personalized learning materials to individual learners.

All courses within Protus 2.1 adhere to a standardized learning process, involving the monitoring of learners' activities, development of the learner model, and customization of content.

2.2 Course Structure

Courses in Protus 2.1 are segmented into lessons, each comprising materials presented in various formats to facilitate personalization. These formats include introductions, explanations, syntax diagrams, examples, practical assignments, and tests serving as benchmarks for learners' progress. Upon completing the sequence of learning contents, the system assesses the learner's knowledge level through a test featuring multiple-choice questions and code completion tasks. Subsequently, Protus 2.1 provides feedback on the learner's responses and offers correct solutions. Furthermore, a recommendation process, suggesting the next steps in learning, is executed using the collaborative filtering approach described in [5].

2.3 Adaptive Learning and Personalization in Protus 2.1

To tailor content delivery to individual learners based on their unique learning characteristics, preferences, styles, and goals, Protus 2.1 employs a variety of techniques. The system incorporates three levels of personalization, as outlined in literature [12]: self-described personalization, segmented personalization, and cognitive-based personalization.

2.4 Self-described Personalization

Learners articulate their preferences and common attributes through a questionnaire at this level. They also describe their backgrounds and previous experiences, establishing the basic learner model. Protus 2.1 then monitors learners' achievements and modifies the learner model accordingly.

2.5 Segmented Personalization

Learners are divided into smaller, more recognizable groups based on their learning patterns. Parts of the necessary content and instructions are subsequently adapted to these groupings, with uniform application to all members of each segmented group.

2.6 Cognitive-based Personalization

This level entails tailoring and providing content and training to certain categories of learners based on knowledge of their talents, learning styles, and preferences. Examples include a learner's choice for certain examinations or activities, a preference for linear sequencing versus hyperlinked grouping, and awareness of the learner's reasoning capability, which includes the ability to reason inductively. Data gathering, constant monitoring of the learner's behaviors, comparison with other learners' behavior, constructing a dynamic learner model, and anticipating and advising the learner's next steps or content preferences are all required when implementing cognitive-based customization.

3. Learning Styles and Personalization in Protus 2.1

To present learning materials in a tailored manner, it is critical to understand each learner's learning style. Understanding a learner's style is essential for adapting the learning process and delivering knowledge in a way that is appropriate for their preferences. Learners' preferences vary, from visually structured resources with graphics and flowcharts to textual learning material. Various tools may be used to assess a learner's learning style. Protus 2.1 was evaluated using the Index of Learning Styles (ILS) [11]. The ILS has 44 questions divided into four domains: information processing, perception, reception, and understanding.

3.1 Information Processing

Active learners participate in action and cooperation, whereas reflective learners prefer to gather and analyze data individually.

3.2 Information Perception

Sensing learners enjoy real, practical instances and facts, whereas intuitive learners prefer conceptual and theoretical understanding.

3.3 Information Perception (Again, Correction)

Visual learners prefer material expressed by visuals, diagrams, and charts, whereas verbal learners prefer written or spoken explanations.

3.4 Information Understanding

Sequential learners succeed at regularly taking little steps, whereas global learners understand bigger units better. In the Java programming course in Protus 2.1, the user interface is customized in the following ways based on the learner's learning style.

3.5 Active and Reflective Learners

The order of presentation varies, with active learners starting with an activity followed by theory, explanation, and examples. Reflective learners, on the other hand, experience a different sequence: example, explanation, theory, and finally, an activity.

3.6 Sensing and Intuitive Learners

Sensing learners have additional clickable material, while intuitive learners are provided with abstract content, formulas, and concepts in the form of block diagrams or exact syntax rules.

3.7 Verbal and Visual Learners

Verbal learners receive detailed explanations of syntax rules, while visual learners are presented with block diagrams.

3.8 Sequential and Global Learners

Sequential learners progress through lessons in a predefined order, whereas global learners are given an overview of the entire course upfront and can navigate arbitrarily. Research [13, 14] suggests that a learner's style may change based on mastered tasks and the content and duration of learning. Therefore, Protus 2.1 allows learners to freely switch between presentation methods and styles using the experience bar. As learners progress and learn, they may find that their initial learning style is no longer suitable, prompting them to explicitly change their learning style. Protus 2.1 introduces an enhancement to previous versions through tag-based recommendations [15].
This feature enables learners to tag resources in the course, combining tutoring systems with collaborative tagging methods. Collaborative tagging offers benefits such as improving resource

metadata with learners' tags and providing alternative ways of classifying and retrieving educational resources based on folksonomies.

Results

In any research, elucidating and describing the current conditions holds particular significance. However, one of the fundamental objectives of research, beyond description and elucidation, is to examine inferential connections and hypotheses. These hypothetical relationships emerge throughout the research, resulting from inference and formulation of hypotheses. These hypotheses serve as the foundation for addressing the issues raised in the research, providing a meaningful guide for decision-making regarding the direction of the investigations.

In this regard, various methods of analysis are employed to scrutinize the accuracy and validity of the hypotheses. Data analysis, derived from information collected in the research environment, is performed using statistical techniques. This process transforms raw data into usable information, assisting researchers in achieving more accurate and meaningful results.

In this study, math education was conducted using the mentioned method for one academic term among selected students from three high schools (one girls' school and two boys' schools) at the second-grade level. After the education in this academic term, an investigation was carried out on the level of understanding of the subjects, problem-solving, active participation of students, and the average grades of the students.

The table below presents the statistics of the students and the results of the assessment regarding the level of understanding of the subjects, problem-solving, active participation of students, and the average grades of the students.

Table 1. The results

Students	Total Number	Respondents to Exercises	Explanation of Exercises	Explanation of Exercises
Female	123	78	110	115
Male	179	120	120	160
	303	198	240	175

The participants in this study consist of 59% males and 41% females, with a higher number of male participants in this field. The results are presented in Table 1. After the training period, students were assessed in the following areas using this method. In the first stage, several conceptual exercises were designed, and students were asked to solve them. The results are shown in the second column of Table 1. This table indicates the number of individuals who answered more than half of the exercises. As the results show, 63% of female students answered more than half of the questions, and 67% of male students also answered more than half of the questions. In total, 65% of students answered the questions, indicating that, despite the exercises being conceptual, the majority of students responded to more than half of the exercises, demonstrating the effectiveness of the teaching method. In the next stage, one exercise from the given exercises is selected, and students are asked to explain the solved exercise to their classmates. The results are as follows. This table shows the number of individuals who were able to explain the exercise to their classmates. As the results show, 90% of female students and 83.7% of male students were able to easily convey the concept of the exercise to their classmates. In total, 76% of students were able to convey the concept of the exercise, which is an acceptable result. Finally, a standardized test was administered to the students. The results are presented in the last column. In the end, to assess the progress of the students, a standardized test was administered to them. As the results in the table show, 95% of female students and 91% of male students passed the exam. In sum, 91% of pupils passed the exam, demonstrating that the strategy described above was quite efficient.

Conclusion

In a traditional learning system, instructional courses usually feature standardized lessons accessible to all learners, with little consideration for individual learning styles or knowledge levels [1].

Some customization is required to ensure learners get the most out of the courses. Personalized learning combines experiences, techniques, and strategies designed to meet learners' different needs, hopes, interests, and backgrounds [2].

It recognizes each learner's unique characteristics and gives a learning experience that is personalized to the individual. As defined in source [3], personalized electronic learning systems are systems that participate in activities targeted at tailoring course material to learners' requirements, interests, and skills. This customization improves the learning experience by making the information more relevant and interesting to each learner. The Moodle electronic learning system is one of the most popular nowadays because of its simplicity of course development, capacity to construct tests, grade entry, layout modification, language support, and different plugins for customizing. However, while this system offers many advantages to its users, it cannot personalize content based on the individual needs of learners. Therefore, an add-on model was developed at the "Saint Clement Ohridski" University's Faculty of Information Technology and Communication—the Personalized Learning Management System (PLeMSys). This system identifies the learning styles and knowledge levels of learners, adjusting the learning content accordingly [3.4,5].

On the other hand, Protus 2.1 is a counseling system used for personalizing course content based on learners' learning styles. It employs learning styles, knowledge levels, and techniques such as collaborative labeling to customize content to best match learners' needs. The two co-authors of this article played a fundamental role in the innovation, design, implementation, and operation of the Protus 2.1 system. Therefore, they are fully familiar with all features, advantages, quality, and future updates of this system [7,8,9].

Given the difficulties raised in this study, it was determined to use personalized spaces to address the challenges students have when studying mathematics and to investigate the results. Given that Protus 2.1, as a tailored learning system, has demonstrated comprehension, an attempt has been made to employ this software in a mathematics classroom context for this study. The goal is to use students' data to determine how successful they will be in mathematics classes.

In this study, individualized spaces were used to address the obstacles that students have in math instruction. The Protus 2.1 software was utilized as a customized learning system. This program, with its individualized learning features, was investigated in the mathematics classroom setting. The purpose of Protus 2.1 is to gather and analyze student data to measure their progress in math class. The Protus 2.1 software's comprehensibility and the provision of a personalized area enhance each student's learning experience.

The use of personalized spaces and Protus 2.1 is a personalized learning system in the mathematics classroom not only helps students approach mathematical topics with greater understanding and gain a deeper insight into the subjects, but it also improves their overall success by enhancing their learning experience. The results show that this strategy not only motivates students to participate more actively in math sessions but also solves their learning difficulties. These results show that this tailored area has a significant favorable influence on the teaching and learning of mathematics. When comparing the math results of students enrolled in the reviewed course to the prior one, there was a considerable improvement in average grades, demonstrating the efficacy of this strategy. This statement highlights the study's key findings, giving the reader an overview of the significance and benefits of this technique in mathematics teaching.

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Journal of Basrah Researches (Sciences) **50**(2), 1 (2024)
DOI: https://doi.org/10.56714/bjrs.50.2.1

فعالية الذكاء الاصطناعي في تدريس الرياضيات بواسطة Protus 2.1

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معلومات البحث

الاستلام	23 كانون الثاني 2024
المراجعة	5 تشرين الثاني 2024
القبول	15 تشرين الثاني 2024
النشر	31 كانون الاول 2024

الكلمات المفتاحية

الذكاء الاصطناعي، تعليم الرياضيات، أساليب التعلم، بروتوس.

الملخص

أدى استخدام الذكاء الاصطناعي (AI) في مجال تعليم الرياضيات كأداة جديدة إلى تقديم قدرات جديدة في عمليات التعلم والتدريس. لا تساعد هذه التكنولوجيا المعلمين والطلاب في تعزيز عملية التعلم فحسب، بل توفر أيضًا أحدث طرق التدريس.
إحدى المزايا الرئيسية للذكاء الاصطناعي في تعليم الرياضيات هي القدرة على تقديم التعلم المخصص. ومن خلال تحليل البيانات الفردية المتعلقة بأسلوب التعلم لكل طالب، يمكن لأنظمة الذكاء الاصطناعي ضبط البرامج التعليمية بدقة. و هذا يعني أن كل طالب سيكون لديه مسار تعليمي مخصص وفقًا لمستوى معرفته واحتياجاته. يمكن لهذه الأدوات تنويع عملية التعلم، وجذب انتباه الطلاب، وزيادة حماسهم للمشاركة الفعالة في عملية التعلم. في هذه المقالة، تم استخدام النظام التعليمي Protus 2.1 لتخصيص محتوى الدورة التدريبية.

Citation: H.M. AL- Alhalafi et at., J. Basrah Res. (Sci.) **50**(2), 1 (2024). DOI: https://doi.org/10.56714/bjrs.50.2.1

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ISSN: 1817-2695 (Print); 2411-524X (Online)
Online at: https://jou.jobrs.edu.iq