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A PERSONALIZED LEARNING TO PROMOTE STUDENTS' LEARNING ON PROGRAMMING

Today's secondary school curriculum includes computer science as one of its core disciplines, with an emphasis on the fundamentals of programming. Students who are learning write computer code by following the textbook step-by-step without realizing the connections between concepts. Because of this, a lot of students find it difficult to grasp even the most basic programming ideas, making it difficult for them to develop basic programs and eventually acquire and understand more sophisticated ideas. In light of this, this study suggests a customized learning environment that is built on a variety of sources of unique student data, such as learning challenges, learning preferences, and grade levels. Exam response analysis aids in determining the learning challenges that students encounter. Furthermore, a learning styles questionnaire is employed to adjust the presenting style according to the distinct learning type of every learner. Each student's learning resources are also arranged according to their performance level, which is divided into three categories: high, medium, and low. According to data analysis, students who made use of the tailored learning environment were successful in learning the fundamentals of computer programming. The study included quantitative surveys on student views, engagement, satisfaction, and tailored learning preferences in addition to qualitative test analysis.

In order to improve students' abilities and learning outcomes, the research focused on the emotional and psychological components of the individualized approach, involving eighth-grade students from Nazarbayev Intellectual School of Physics and Mathematics in Taraz city.

Key words: individual approach, programming skill, personalized learning.

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Оқушылардың бағдарламалау бойынша оқуын ынталандыру үшін дербестендірілген оқыту

Қазіргі орта мектептің оқу бағдарламасы информатика пәнін негізгі пәндердің бірі ретінде басты назар аударып, оның ішінде бағдарламалау негіздері бөлімін қамтиды. Оқушылар оқып жатқан ұғымдар арасындағы байланыстарды түсінбей, оқулықтағы қадамдарды орындау арқылы компьютерлік кодты жазады. Осыған байланысты көптеген оқушылардың тіпті ең қарапайым бағдарламалау идеяларын түсіну қиынға соғады. Бұл оларға негізгі бағдарламаларды әзірлеуді қиындатады және сайып келгенде, неғұрлым күрделі идеяларды меңгеріп, түсінуді қиындатады. Осыны ескере отырып, бұл зерттеу оқу қиындықтары, оқу қалауы және сынып деңгейлері сияқты бірегей оқушылар деректерінің әртүрлі көздеріне негізделген дербестендірілген оқу ортасын ұсынады. Тесттерге жауап беруді талдау оқушыларға кездесетін оқу қиындықтарын анықтауға көмектеседі. Одан басқа, әр оқушының ерекше оқу түріне сәйкес көрсету стилін реттеу үшін оқу стильдері сауалнамасы қолданылады. Әр оқушының оқу ресурстары да олардың орындау деңгейіне қарай реттеледі, ол үш деңгейге бөлінеді: жоғары, орташа және төмен. Деректерді талдауға сәйкес, дербестендірілген оқу ортасын пайдаланған оқушылар бағдарламалау негіздерін меңгеруде табысты болды. Зерттеуге сапалы тесттік талдаудан басқа, оқушылардың көзқарастары, қатысуы, қанағаттануы және дербестендірілген оқу қалауы бойынша сандық сауалнамалар қамтылды.

Оқушылардың қабілеттері мен оқу нәтижелерін арттыру мақсатында Тараз қаласындағы физика-математика бағытындағы Назарбаев Зияткерлік мектебінің 8-сынып оқушыларын қатыстыра отырып, дербестендірілген оқытудың эмоционалдық-психологиялық құрамдас бөліктеріне назар аударылды.

Түйін сөздер: индивидуалды әдіс, бағдарламалау дағдысы, дербестендірілген оқыту.

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Персонализированное обучение для улучшения навыков по программированию у учащихся

Учебная программа средней школы включает информатику в качестве одной из основных предметов с упором на основы программирования. Учащиеся изучают компьютерный код, шаг за шагом следуют учебнику, не осознавая связи между концепциями. Из-за этого многим учащимся трудно понять даже самые базовые идеи программирования, что затрудняет написание базовых программ и, в конечном итоге, использование и понимание более сложных идей. В связи с этим в настоящем исследовании предлагается персонализированная среда обучения, построенная на основе различных источников уникальных данных об учащихся, таких как трудности обучения, предпочтения в обучении и уровни классов. Анализ ответов теста помогает определить проблемы обучения, с которыми сталкиваются учащиеся. Кроме того, используется опросник по стилям обучения, позволяющий адаптировать стиль изложения в соответствии с конкретным типом обучения каждого учащегося. Учебные ресурсы каждого учащегося также упорядочены в соответствии с его уровнем успеваемости, который разделен на три категории: высокий, средний и низкий. Согласно анализу данных, учащиеся, которые использовали персонализированную среду обучения, успешно освоили основы программирования. Исследование включало в себя количественные опросы о интересах, их вовлеченности, удовлетворенности и индивидуальных предпочтениях в обучении в дополнение к качественному тестовому анализу.

В целях улучшения способностей учащихся и результатов обучения в исследовании основное внимание уделялось эмоционально-психологической составляющей персонализированного подхода с участием учащихся 8 классов Назарбаев Интеллектуальной физико-математической школы города Тараз.

Ключевые слова: индивидуальный подход, навык программирования, персонализированное обучение.

Introduction

Programming has become an essential competency in the contemporary digital era, with its integration into educational curricula playing a pivotal role in fostering computational thinking and problem-solving skills. Its relevance spans various educational levels, from primary to tertiary education. Despite its widespread inclusion in academic programs, students encounter considerable difficulties in mastering programming concepts, primarily due to the abstract nature of these concepts and the variations in their prior knowledge, which impede effective learning.The rationale for selecting this theme stems from the need to address the persistent challenges associated with programming education. While previous research has investigated various pedagogical approaches, there remains a notable gap in understanding how personalized learning environments can be effectively employed to support diverse learners, particularly in introductory programming courses. This study acknowledges these gaps and seeks to explore the design and impact of tailored learning approaches in addressing these issues.

The relevance of this research is demonstrated by the increasing demand for innovative educational practices that not only facilitate access to programming for all students but also adapt to their individual learning needs. The practical significance of this work lies in its potential to enhance teaching strategies and provide educators with effective tools for accommodating diverse learning preferences. Theoretically, it contributes to the field of computer science education by examining the application of personalized learning frameworks, with the objective of improving student engagement and learning outcomes.

Materials and methods

In this study, the following queries are raised:

Hypothesis1: Increase in understanding of the basics of programming through personalized learning

Expected results:

- Increase in students' average test scores by 40%.
- 30% reduction in error rate in tasks related to arrays, comparing results from pre and post tests.

Verification methods:

- Conducting pre and post testing, including questions on key topics: variables, loops, arrays, logical operators.

- Using weight coefficients to assess the relationship between students' errors and topics not fully understood.

• Evaluation methodology:

- Calculation of Normalized Gain of Knowledge.

Hypothesis 2: Influence of adaptation of learning styles on student engagement

Expected results:

- Increase in the level of student engagement (for example, measured by Likert scale questionnaires) by 25%.

Verification methods:

- Application of Felder and Soloman's learning style index to classify students into groups.

- Introduction of individualized tasks for each group and subsequent testing.

Evaluation methodology:

- Analysis of questionnaire results based on the Likert scale. Questions include: "How interesting do you find the material?", "Is the presented content easy for you to understand?".

- Comparison of average performance in subgroups.

Hypothesis 3: The role of concept-effect correlations in overcoming educational difficulties.

Expected results:

- 85% of students successfully revise the topics they have not mastered after analyzing concept-effect connections.

- Reduction of the number of "poorly mastered paths" by 50%.

Verification methods:

- Development of a diagnostic test with weighting coefficients for each question reflecting the strength of the connection with the concept.

- Automatic analysis of error percentage data (PIA) through Google Forms or Excel.

Evaluation methodology:

- Creating a "difficulty map" for each student highlighting problem nodes.

- Comparing the number and difficulty of nodes before and after using the model of conceptual-effect connections.

Based on the findings of the students' programming placement test on the subjects taught in grades 7-8, this study was carried out among eighth-grade students at the Nazarbayev Intellectual School of Physics and Mathematics in Taraz City. In order to solve the gaps in students' comprehension of basic programming principles, this research suggests implementing a tailored learning environment.

The presenting style of the course contents was modified to accommodate each student's unique learning style using Felder and Soloman's Index of Learning Style (2005) questionnaire.

Additionally, learning resources are customized for each student based on their learning successes, which are grouped into high, moderate, and low levels. This promotes a more successful learning environment. When teaching pupils the fundamentals of computer programming, the Panjaburee et al. improved concept-effect connection model is used to determine which areas they are having difficulty with the interdependencies between ideas and how they affect learning outcomes within the topic area are displayed in this model (Table 1)(2010). It illustrates how grasping more complex ideas is essential to comprehending basic ideas. For example, it is considered necessary to have a working knowledge of *Basic Data Types, Variables, Input and Output Operators,* and *Loop Algorithms* prior to learning Array.

Similar to this, understanding *Basic Data Types, Variables*, *Input and Output Operators,* and *Arithmetic Expressions* all start with an understanding of the *Program Structure*. The diagnosis of pupils' learning challenges depends heavily on these linkages between ideas. For example, if a student has trouble with Array test items, it is likely that they do not grasp Variables, Basic Data Types, and Loop Algorithms.

Based on the identified concept-effect correlations, creating a multiple-choice test questionnaire that covers all pertinent concepts is essential. With 0 suggesting no discernable association and 5 showing a high degree of relevance, the weight values, which range from 0 to 5, indicate the strength of the relationship between each test item and its related idea. Once the weight values are determined, the diagnostic procedure may run smoothly. Google Forms will be used by students to access the exam questionnaire. Students will be presented with the test questionnaire by the system based on predetermined concept-effect correlations. With the use of concept-effect linkages that have been found and an analysis of the replies, the instructor will be able to provide each student with individualized learning support.

Table 1 – Related topic in 7-10 grades

7 grade	8 grade	9 grade	10 grade
T1: Graph			
T2: The framework of the program			T17: Class, Object, Properties, Method, and Event in OOP Concepts
T3: basic data types, variables		T13: local and global variables	
T4: input and output operators, arithmetic expressions			T18: Components, input and output data
T5: linear algorithms	T9: Loop algorithms	T14: Nested loops	T19:Implementing previous learning all concepts for objects
T6: conditional operator	T10: Array	T15: two-dimensional array	
T7: the selection operator	T11: One-dimensional array by criteria	T16:Two-dimensional array by criteria	
T8: nested conditions	T12: String array	T16: Procedures and functions	

In order to detect poorly learned routes, the created concept-effect correlations exhaustively investigate every potential learning path. Table I displays two possible educational pathways:

PATH1: T3-T4-T9-T10

PATH2: T2-T3-T10

These pathways are shown below, assuming that the percentages of incorrect responses (PIA) for the concepts-related exam items are as follows:

PATH1: T3(20%)-T4(53%)-T9(70%)-T10(80%)

PATH2: T2(20%)-T3(60%)-T10(80%)

The allowable failure rate is determined by a threshold value, represented by the number 0. A prompt to revisit and relearn idea Tj is given to the student if the PIA for that particular concept Tj is equal to or greater than 0. On the other hand, if Tj's PIA is less than 0, it means that the idea was not learnt well enough, designating Tj as a node in the poorly learned pathways. 0 is regarded as 51% in our tailored learning environment.

These routes are selected as the poorly learnt ones based on this threshold:

PATH1: T9(70%)-T10(80%)

PATH2: T3(50%)-T10(70%)

Consequently, the student's learning problems could result from T3 and T2 ideas' misinterpretation. As so, it is advised that before advancing to ideas T9 and T10, students concentrate on learning T3 and T2. PATH1 shows the greatest PIA (80%), which suggests a noteworthy learning difficulty along this pathway. Students' programming difficulties that including variables, conditions, loops, and arrays were found using a written test. Moreover, a proficiency exam was carried out to assess the ability of the pupils based on their capacity. The short tests were completed to satisfy various demands of the pupils. Evaluations of the concept-effect correlations have helped students develop their programming abilities. The study findings have turned out favorably.

Eighth graders were asked questions as part of the research covering many facets of their experience with the personalized learning environment on stepik.org. Students were first questioned about their overall level of happiness and enjoyment of the individualized learning on stepik.org. Furthermore, the questions concerning the learning materials and comments on the assignments have been asked to assess their viewpoint of the quality, applicability, and potency of the theoretical knowledge presented. Last but not least, clarity of learning objectives and support and instructions have been evaluated to ascertain whether the students clearly expressed and comprehended the objectives and outcomes of the learning environment as well as the efficacy of the available tools, materials, and support.

Designed by Felder and Solomon, the Index of Learning Style questionnaire (2005) is a viable model for spotting individualized learning settings. Particularly with its sequential/global component, this questionnaire is absolutely essential for understanding how pupils absorb and evaluate knowledge. Customized learning environments help every learner to better grasp their learning style. Students that prefer studying idea by concept that is, those with a sequential learning style cause linear learning development.

Students that have a global learning style that is, who learn in big leaps show holistic thinking. Although they seem to acquire knowledge at random, they finally see the complete picture, which helps to solve difficult problems and create new relationships. Concept-effect linkages have been developed as well as professionals have been involved in the project to assess the link between every concept and test question in order to improve the efficacy of identifying students's learning issues. This method enables kids' test responses to be analyzed, therefore allowing focused intervention. We also used the ILS questionnaire to match each student's presenting style. Moreover, the learning results of students classified as high, intermediate, and low levels informed the layout of the content to satisfy different student requirements. Combining these elements, the created model of a personalized learning environment shown in Table II creates a tailored and practical learning experience fit for every student's need and inclination.

Literature review

Not only is programming a crucial component of computer science, but it is also a vital tool for promoting the cognitive abilities linked to computational thinking(Grover S., 2013). Because of this knowledge, programming is now included in elementary and secondary educational standards. Additionally, it is the primary focus of development for after-school learning programs and educational technology enterprises (Falkner K., 2015). We want to overcome the following obstacles to students' programming skill development in the case study, despite its broad adoption:

1 Content Difficulty: Learning programming presents difficulties for students. The abstract nature of programming ideas, the requirement for exact syntax and logic, and the progressive nature of learning programming languages might all be contributing factors to these challenges.

2 Variation in Student Prior Knowledge: When enrolling in programming classes, students frequently have varying degrees of prior knowledge and expertise. Variations in prior knowledge can affect learning effectiveness, speed, and capacity to study more complex subjects.

3 Difficulty in Teaching Programming: Teachers have difficulties when it comes to teaching programming because of a lack of resources, a variety of teaching approaches, and the need to accommodate varied learning preferences and styles.

Our goal is to provide a case study that offers learners assistance and direction by recognizing and resolving three main obstacles: topic complexity, student variance in prior knowledge, and teaching programming challenges. This strengthens their programming abilities and creates a more inviting and effective learning environment.

It is common for students to struggle with creating fundamental programs because they do not grasp the links between concepts, which makes it harder for them to learn more complex topics later on. According to Govender(2006), learning to program involves a number of different skills and sophisticated mental processes, which makes it one of the main challenges in computer science education. For students to properly write programs, they must understand syntax and logic. According to Bennedsen and Caspersen (2019), this raises the cognitive demands placed on students, which lowers their first-year pass rates in programming courses at universities. Students' difficulty switching from simpler visual programming – often taught using graphical elements – to more complex textual syntax settings is a major contributing reason to this occurrence (Saeli M., 2011). To enable a more seamless shift from visual to textual programming paradigms, incorporating more effective teaching methodologies is perhaps the most crucial objective when building programming tools.

The second challenge is the stark differences in students' interests and programming expertise. While newcomers are engaged by informal learning, not all students are drawn to these kinds of activities (Salac J. and etc., 2021). As a result, there are differences in the interests and programming expertise of the pupils. It's important to consider each kid's requirements while creating resources for different student groups. Numerous sorts of personalization have emerged as a result of the development of the area of digital customized learning(Bernacki M. L, 2021). For the target population, the most appropriate customization type must be determined and implemented in order to maximize program efficacy.

A through analysis of 53 sources was used to develop the notion of personalized learning(Xie H, 2019). According to the rearch Van Schoors R. (2021) “Personalized learning occurs in a digital learning environment that adjusts to each learner specifically in order to maximize individual and/or group learning processes, emphasizing efficiency, motivation, affective, cognitive, and metacognitive outcomes. This customization or adaptation:

1) Takes into account the learner’s cognitive, emotional, motivational, and metacognitive traits.

2) Has to do with every facet of the learning environment, such as the kind, quantity, and order of the learning activities, the subject matter, and the guidance and assistance that the environment offers.

3) Combines data gathered by the digital environment with data supplied by the instructor or student.

4) Is improved by the instructor via the efficient use of data obtained via digitally customized instruments.”

Kazakhstani researchers have played a major role in advancing the educational information environment by implementing personalized and individualized concepts. E.Bidaybekov(2021) discussed the digitalization of secondary education, the efficiency of information tools in education, and contemporary information technologies for learning in his works. G.Erkibaeva(2017) also studied the importance of personalized and differentiated learning. In research conducted by I.Sayfurova(2020), it was determined that utilizing a personalized approach is an effective teaching method for programming. G. Bekmanova(2021) and her colleagues examined the blended personalized learning model.

Results and discussion

The findings of the study seek to evaluate students’ views toward the created customized learning environment and investigate how their knowledge levels have been changed by their experience with it. Pre- and post-conceptual examinations as well as 155 students’ semi-structured interviews helped to gather data. The results are presented in Table II below:

With a normalized gain of 0.37, the results reveal a notable increase in students’ conceptual understanding following interaction with the created tailored learning environments. The percentage of mastering topics such as variables, loops, and arrays has increased, while the error rate in array tasks has decreased from 80% to 30%. First conclusion: this reflects the success of individualized learning in improving students’ learning results as it shows that they developed significant comprehension of the subject. The results demonstrate that the adaptation of materials and analysis of students’ difficulties play a key role in achieving positive educational outcomes.

Table 2 – Result of summative assessment

Test Type	n	Mean Score	% Score	Normalized Gain
Pre-test	13	15.2	38	0.37
Post-test	13	34.7	86.75	

Furthermore exposed is the favorable attitude of the involved pupils about the created e-learning environment. Eighty percent of students said they were ready to grow in computer programming as they better recognized their skills and shortcomings. 54% of students said the surroundings improved their knowledge of the topic and provided appropriate tools and resources to satisfy their requirements. Furthermore, 61% of students said that the e-learning platform might improve students’ excitement for studying by means of interesting interactive activities and thus advance better learning. Second conclusion: adapting materials to students’ learning styles positively affects their engagement and motivation. High levels of satisfaction and improved perception of topics confirm the importance of an approach focused on the individual characteristics of students. This approach not only contributes to academic performance improvement, but also enhances motivation for independent learning of programming.

Analysis of conceptually effective connections helped identify key problematic areas, such as T3 (variables) and T9 (loops), which most often caused difficulties when studying arrays. The use of the model has reduced the number of poorly mastered paths by 50%, while the number of successfully mastered topics has increased by 30%. Conclusion:the model of concept-effect connections has demonstrated high efficiency in diagnosing and eliminating educational difficulties. It allowed for the personalization of the learning process, focusing on the misunderstood topics and improving students' progress in studying interconnected concepts. The results underline the importance of a systemic approach to eliminating educational gaps in order to achieve sustainable knowledge.

Thirty-one percent of students said the availability of self-assessment and the platform's capacity to offer tools to handle their learning challenges. These answers show students's opinions, underline the supposed advantages of tailored learning in an e-learning environment, and point out possible chances for future improvement.

Conclusion

This paper presents a novel method of tailored learning meant to improve students' grasp of Basic Computer Programming. Personalized learning, difficulties, learning styles, and successes all help a teacher design course of instruction that fits certain pupils. Based on every student's achievement, the learning platform offers individualized direction and suitable resources. The study involved thirteen students to evaluate this method's success. Two primary benefits have been noted: better post-test and summative assessment scores and student growth has been facilitated. The results reveal how well the tailored learning environment enhances students' conceptual understanding and shapes favorable views about education. Personalized learning may provide students individualized help and direction by addressing programming issues such material difficulty and variations in prior knowledge, therefore improving learning outcomes creating a more immersive learning environment.

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