ADAPTIVE EDUCATION AS A KEY ELEMENT FOR ENHANCING THE EFFECTIVENESS OF LEARNING PROCESSES

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Abstract. This article explores issues related to the adaptive learning of students in higher education institutions, presenting the main characteristics of both traditional and contemporary educational paradigms. It describes the latter's advantages in the context of the dynamic changes of the modern world and, specifically, the demands on the process and outcomes of higher education. In discussing modern learning concepts, those foundational to adaptive learning are examined separately. The authors provide a description, objectives, methods, and results of the study conducted as an experiment with first-year undergraduate students. The results are assessed in the conclusion, and recommendations for their practical application are presented.

Keywords: adaptive learning, traditional learning, higher education, statistical analysis, personalized education, student-centered learning, educational technologies, innovative educational approaches.

Conflict of interests. The authors declare no conflict of interests.

АДАПТИВНОЕ ОБРАЗОВАНИЕ КАК КЛЮЧЕВОЙ ЭЛЕМЕНТ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ УЧЕБНЫХ ПРОЦЕССОВ

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Аннотация. В статье рассматриваются вопросы адаптивного обучения студентов высших образовательных учреждений, приводятся основные характеристики традиционной и современной образовательных парадигм. Описываются преимущества последних в свете динамических изменений современного мира и, в частности, требований к процессу и результатам высшего образования. В рамках обсуждения современных концепций обучения отдельно рассматриваются те из них, которые лежат в основе адаптивного обучения. Авторы приводят описание, цели, методы и результаты исследования, проведенного в форме эксперимента с учащимися первого курса программы бакалавриата. Даны оценка полученных результатов и рекомендации для их практического применения.

Ключевые слова: адаптивное обучение, традиционное обучение, высшее образование, статистический анализ, персонализированное обучение, студенто-центрированное обучение, образовательные технологии, инновационные подходы в образовании.

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Introduction

In the contemporary world, where technologies evolve at an incredible pace, the educational process cannot remain unchanged. Among the innovative approaches taking a central place in pedagogy in recent years, adaptive learning stands out prominently [1]. This method implies the individualization of the learning process, making it maximally effective for each student. It considers the unique features, pace of material assimilation, and students' interests, thereby ensuring a deep understanding of the subject and durable retention of information.

The use of adaptive technologies in education not only enhances student motivation but also makes the learning process more flexible and accessible [2]. The relevance of adaptive learning is undeniable – this educational approach recognizes that traditional teaching methods, which assume a uniform program for all, no longer meet the requirements of the times. This method offers a solution that allows the educational process to be more flexible and individualized. The significance of researching adaptive learning becomes particularly relevant in the context of remote and blended education, which has become an integral part of life for many students and teachers worldwide [3]. In such conditions, adaptive learning technologies can offer effective tools for maintaining student engagement, motivation, and success in learning despite the absence of traditional personal interaction [4].

Furthermore, the importance of adaptive learning is underscored by the necessity to prepare students for working in conditions requiring a high degree of variability, critical thinking, and the ability to learn independently. In this respect, adaptive systems serve not only as a method to enhance academic success but also as a means to develop skills necessary for successful careers and continuous professional growth in the future [5]. Thus, the relevance of researching adaptive learning is determined by its potential to significantly improve the quality and accessibility of education, tailor learning to the needs and capabilities of each student, and prepare students for effective work and life in an ever-changing world [6].

Traditional teaching methods, characterized by a standardized approach to teaching, have played a crucial role in the education system for many years. However, considering modern requirements and the dynamically changing educational environment, these approaches increasingly demonstrate their shortcomings rather than advantages. Let us consider the main aspects of traditional teaching methods that do not meet today's requirements.

Firstly, the classical teaching system implies a unidirectional knowledge transfer process from teacher to student, often using lectures and oral explanations. In other words, the "teacher-student" relationships are structured according to a the subject-object system, where the learner plays the passive participant affected by the teaching process [7], this limits active participation in the educational process and does not facilitate the development of critical thinking and independence.

Traditional teaching methods often rely on a standardized curriculum, assuming the same volume and content of material for all students, which does not consider the individual characteristics of students, their learning pace, and interests [8]. Such an averaged approach to learners can decrease motivation and academic performance. These methods also involve assessing results by a single standard – using uniform tests and exams for all students, not always adequately reflecting individual achievements and skills. Besides producing inaccurate evaluation outcomes, this approach negatively affects students' self-esteem and attitude towards learning.

Educational systems adhering to the a traditional pedagogical approach often demonstrates low flexibility in adapting to changes and innovations [9], this relates both to the incorporation of new technologies and the application of innovative teaching approaches. Thus, the system is characterized by a high degree of inertia, making it even less effective in the conditions of the modern dynamic world.

Another characteristic is the insufficient focus on practical skills. Many traditional methods are centred on theoretical knowledge, paying inadequate attention to developing applied competencies [10]. As a result, students struggle to apply the knowledge gained in real-life and professional situations, not to mention doubts regarding the relevance of the knowledge obtained.

Such problems with traditional educational methods highlight the need for their reevaluation and significant adjustment, considering the modern requirements of the external environment relative to educational institutions. In response to this and considering significant changes in the modern world, new

educational concepts have emerged. They form the foundation of adaptive learning, offering innovative educational approaches to make learning more personalized, flexible, and effective. Let us examine some of them that have facilitated the development of adaptive learning.

Differentiated learning involves creating diverse learning paths and tasks adapted for each student. This concept acknowledges students' rights to possess different abilities, preferences, and learning styles, and offers corresponding methods to maximize engagement, and effectiveness of learning for each individual [11].

Competency-based learning focuses on students acquiring specific skills and knowledge necessary for successful activity in a particular area. Unlike traditional learning, where the emphasis is on the time spent studying material, competency-based learning focuses on demonstrating actual abilities and achievements [12].

Flexible learning creates an educational environment that gives students a choice regarding how, when, and where they learn [13]. This approach includes the use of various educational technologies and methods – such as online courses, blended learning, and self-study – to provide students with maximum flexibility and access to educational resources.

Another concept, **personalized learning**, strives to tailor the educational process to the personal characteristics, needs and goals [14]; this is achieved through the use of adaptive educational platforms, learning analytics, and individualized study plans, allowing students to progress through the educational route at their own pace and focus on the most significant aspects of the learning content for them.

The contemporary educational methodologies signify a departure from uniform, one-size-fits-all approaches towards more dynamic and student-centered strategies, showcasing a worldwide shift from a teacher-centric to a learner-centric paradigm [15]. This learner-centric paradigm heralds a pivotal shift in educational strategies, diverging from the conventional model that places teaching at the forefront, to a new model that prioritizes the learner and their educational journey. Within this paradigm, the emphasis is on the proactive involvement of students in their own learning, underscoring the necessity of an educational atmosphere that nurtures independent learning, critical analysis, and the applied use of knowledge. Essential elements of this learner-centric paradigm encompass:

– *learner-centric focus* – contrasting with the traditional paradigm where the educator is seen as the main conduit of knowledge, this new paradigm places the learner at the heart of the educational experience. The structuring of the educational process is thus designed to fully accommodate each learner's unique characteristics and learning preferences;

– *engaged learning* – this principle advocates for the students' active engagement in their educational pursuits, encompassing activities that foster critical thinking, project-based learning, group discussions, and autonomous investigation. Engaged learning is instrumental in cultivating a profound comprehension of subjects and honing skills vital for addressing challenges in the real world;

– *cooperative engagement and interaction* – the paradigm underscores the significance of mutual cooperation and interaction, both among peers and between students and educators. This collaborative engagement and idea exchange are crucial for enriching understanding of the curriculum and fostering interpersonal skills;

– *technological integration* – the adoption of digital technologies within the learning process is a cornerstone of this modern paradigm. Such technologies afford learners access to an expansive array of informational resources, collaborative tools, and platforms for exchanging knowledge;

– *lifelong learning* – recognizing education as an ongoing journey that transcends the confines of the classroom, this aspect views learning not as a finite phase but as an enduring component of life. It champions continuous self-improvement and the perpetual refreshment of knowledge and abilities.

It is worth noting that adaptive learning, formed on the principles of the described paradigm, is not just theory. Implementing various educational programs – from experimental to integrated into the educational process – confirms their practical effectiveness. Such programs facilitate targeted learning and improve educational outcomes in colleges and universities [16]. Educational platforms created to provide adaptive education allow students to access learning content that matches their individual needs and learning styles, ultimately enhancing academic performance [17]. Systems developed can integrate various learning styles, significantly improving the efficiency of education [18]. Data analytics and adaptive technologies also contribute to the personalization of learning, satisfying individual educational preferences [19]. A separate mention is the research dedicated to developing an adaptive learning system based on EEG brainwaves of students, which is also aimed at improving the efficiency of education by personally adapting learning materials to students' strengths [20]. Individually oriented solu-

tions offered by adaptive e-learning educational systems create specially designed environments using learning style analytics, i.e., student patterns [21]. Adapting courses to students' preferences in adaptive educational systems can also increase satisfaction with the learning process [22].

A review of numerous studies confirms the significance of adaptive learning as a tool for enhancing student learning, demonstrating the practical possibility of meeting individual educational needs. Within the scope of studying the described area, the authors conducted research aimed at a comparative evaluation of the effectiveness of adaptive learning compared to traditional methods based on the analysis of educational data collected during the learning process. The research methods included an experiment and statistical analysis of the collected data. Participants in the experiment were first-year undergraduate students – two groups of 30 students each. One group was taught using an adaptive (experimental) program, the other with a traditional (control group) program.

Before the start of the learning, preliminary testing of both groups was conducted to determine the initial level of knowledge in subject. The average score of both groups was 55.72 and 54.26 out of a possible 100. The experimental group followed the adaptive program scenario during the subsequent learning, while the control group followed the traditional one. The observation period lasted one academic semester.

Research results and discussion

After completing the course, both groups underwent final testing. The scoring system used was on a hundred-point scale. The average final score of the experimental group was 83.27, and for the control group it was 66.12 (Fig. 1).
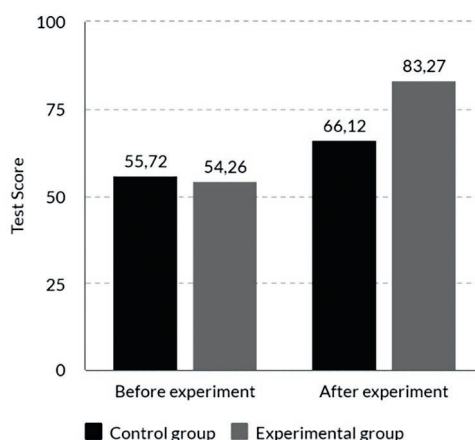

Fig. 1. Test results for both groups before and after the experiment

The following data were taken for subsequent statistical analysis:
– sample size (n): 30 students in each group;
– mean values (M): $M_1 = 83.27$ (adaptive learning), $M_2 = 66.12$ (traditional learning);
– standard deviation (SD): $SD_1 = 8$ for the experimental group and $SD_2 = 10$ for the control group;
– the standard error of the mean (SEM), calculated using the formula $SEM = sqrt((SD_1^2/n_1) + (SD_2^2/n_2))$, was $SEM \approx 2.07$, t-value: $t = (M_1 - M_2)/SEM \approx 8.28$ (for convenience, the results are rounded to the nearest hundredth within this text).

Using the t-distribution table, with 58 degrees of freedom ($n_1 + n_2 - 2$) and a t-value $\approx$ of 8.28, the p-value is less than 0.001, significantly below the standard threshold of 0.050 for statistical significance. It indicates that the differences between the groups are statistically significant.

The implementation of adaptive learning in the educational landscape presents a compelling approach to customizing and enhancing each student's learning journey. This study underscores the pivotal role adaptive learning plays in modern education, particularly highlighting its capacity to cater to students' unique learning styles, paces, and interests. Through the deployment of adaptive technologies, education becomes not only more accessible but also significantly more engaging and efficient for learners.

Adaptive learning's recognition of the need for a departure from one-size-fits-all teaching methods to more individualized and flexible strategies aligns with the evolving requirements of the digital age. Traditional teaching methods, while foundational to the education system for many years, often fail

to meet today's learners' dynamic and diverse needs. This research corroborates the growing consensus that adaptive learning methodologies offer a more effective and personalized learning experience, enhancing student outcomes.

One of the study's notable findings is the statistically significant improvement in learning outcomes among students who participated in the adaptive learning program compared to those in the traditional learning setup. This outcome validates the efficacy of adaptive learning strategies and significantly highlights their potential to enhance academic performance. The individualized nature of adaptive learning, with its focus on tailoring the educational content and pace to each student's specific needs, proves instrumental in facilitating a deeper understanding and retention of knowledge.

Moreover, adaptive learning's relevance is further emphasized in remote and blended learning environments. As education increasingly moves online, maintaining student engagement and motivation becomes paramount. Adaptive learning technologies emerge as crucial tools, offering innovative solutions that ensure educational continuity and effectiveness, even without traditional classroom interactions.

The study also illuminates the importance of preparing students for the complexities of the modern workforce. Adaptive learning systems aim to improve academic success and focus on developing critical skills necessary for lifelong learning and adaptability in a rapidly changing world. By fostering an environment that encourages critical thinking, self-directed learning, and the application of knowledge in practical settings, adaptive learning prepares students for successful careers and ongoing professional development.

This research advocates for adopting adaptive learning technologies in higher education. Highlighting the tangible benefits of personalized and flexible learning experiences calls for educators and curriculum developers to integrate adaptive learning strategies into their teaching practices. Such an approach enhances student engagement and satisfaction and aligns educational processes with the demands of the XXI century.

In conclusion, this study's findings reinforce the transformative potential of adaptive learning in higher education. By offering a more personalized, flexible, and effective learning experience, adaptive learning stands out as a critical factor in elevating the educational process's efficiency. As the educational landscape continues to evolve, integrating adaptive learning strategies will undoubtedly play a crucial role in shaping the future of education, making it more responsive to learners' diverse needs and aspirations worldwide.

Conclusion

1. The study demonstrates that students' learning outcomes in the experimental group are significantly higher than those of the control group. It confirms the hypothesis of a significant increase in the effectiveness of learning when applying the adaptive learning program and indicates that an individualized approach, which takes into account the unique needs and learning paces of each student, contributes to better material assimilation.

2. Such learning may also contribute to increased student engagement and motivation. Although our study did not directly focus on these aspects, it is reasonable to suggest that the higher scores achieved by the experimental group are partly due to increased motivation and interest in the learning material induced by the personalized approach. Based on the data obtained, we recommend that university teachers and course developers actively explore and implement adaptive educational technologies. It is important to consider individual differences among students and provide educational content that matches their educational preferences.

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Authors' contribution

The authors contributed equally to the writing of the article.

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