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ENHANCING STUDENTS' KNOWLEDGE COMPETENCE THROUGH ARTIFICIAL INTELLIGENCE TECHNOLOGIES: A METHODOLOGICAL APPROACH

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Abstract

The rapid development of artificial intelligence (AI) technologies has significantly transformed modern educational practices, creating new opportunities for enhancing students' knowledge competence. The aim of this study is to develop and evaluate a methodological approach to improving students' knowledge competence through the effective integration of artificial intelligence technologies in higher education.

The study is based on the principles of personalized learning, adaptive learning environments, and data-driven decision-making in the educational process. A quasi-experimental research design was employed, involving undergraduate students who were divided into experimental and control groups. In the experimental group, AI-based educational tools were implemented, including adaptive learning platforms, automated assessment systems, and learning analytics technologies. Data were collected through diagnostic tests, questionnaires, and pedagogical observation methods. The collected data were analyzed using statistical techniques to evaluate the effectiveness of the proposed methodology.

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The results of the study demonstrate that the integration of artificial intelligence technologies into the educational process significantly improves students' academic performance, learning motivation, and knowledge competence compared to traditional teaching approaches. The research proposes a methodological model that integrates adaptive learning mechanisms, intelligent feedback systems, and pedagogical support. The findings contribute to the development of innovative teaching strategies and provide practical recommendations for the effective integration of artificial intelligence technologies into modern higher education systems.

Keywords: Artificial Intelligence in Education (AIED), Knowledge Competence, Artificial Intelligence Technologies, Adaptive Learning Systems, Learning Analytics, Personalized Learning, Higher Education, Intelligent Tutoring Systems, Educational Data Mining, Digital Learning Environment.

Introduction

In recent years, the rapid development of information and communication technologies has led to profound transformations across all levels of the education system. In particular, the advancement of artificial intelligence (AI) technologies has emerged as a significant factor in shaping modern educational environments. AI-based educational technologies provide new opportunities for improving the learning process by enabling the analysis of students' learning performance and the development of individualized learning trajectories. As a result, the implementation of personalized and adaptive learning systems has expanded the possibilities for effectively enhancing students' knowledge competence.

Within the contemporary higher education system, the development of students' competencies—particularly knowledge competence—has become one of the most important pedagogical challenges. Knowledge competence refers to students' ability to acquire, analyze, synthesize, and apply knowledge effectively

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in academic and professional contexts. In traditional educational models, the teaching process is typically organized according to standardized curricula, which often fail to adequately consider students' individual needs, abilities, and learning pace. Consequently, the instructional content may be either too complex or insufficiently challenging for certain students, which can reduce the overall effectiveness of the learning process.

The integration of artificial intelligence technologies into the educational process is considered one of the most promising solutions to this issue. AI-based adaptive learning systems, learning analytics technologies, and intelligent tutoring platforms allow educators to analyze students' knowledge levels, learning behaviors, and academic progress. These technologies make it possible to manage the learning process using data-driven approaches and to design individualized learning pathways for students, thereby significantly improving educational effectiveness.

In recent years, numerous studies have explored the impact of artificial intelligence technologies on the education system. Researchers emphasize that AI-based educational systems play an important role in optimizing the learning process, increasing students' learning motivation, and improving their academic performance. However, most existing studies primarily focus on the technological capabilities of AI rather than on the methodological foundations required for its effective integration into the educational process.

Therefore, the purpose of this study is to develop a methodological approach aimed at enhancing students' knowledge competence through the use of artificial intelligence technologies and to evaluate its pedagogical effectiveness. The results of this research contribute to improving the scientific and methodological foundations for implementing AI-based educational technologies in higher education and support the development of innovative learning environments.

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Literature Review

Recent studies published after 2020 increasingly interpret the role of artificial intelligence in education not merely as a technological tool, but as an adaptive, data-driven, and competence-oriented pedagogical system. Chen, Chen, and Lin (2020), in their comprehensive review of artificial intelligence applications in education, emphasize that AI technologies can significantly improve educational effectiveness through personalized instruction, automated assessment, and the analysis of students' learning activities. According to the authors, AI plays a particularly important role in addressing students' individual learning needs and differences in learning pace.

Ifenthaler and Yau (2020) analyze the impact of learning analytics on academic success and highlight that tracking students' digital learning traces enables educators to identify learning difficulties at an early stage and implement timely pedagogical interventions. This approach is especially important for the development of students' knowledge competence, as it allows not only the evaluation of learning outcomes but also the management and improvement of the learning process itself.

Williamson and Eynon (2020) examine the development of Artificial Intelligence in Education (AIED) from a historical and critical perspective. They argue that the implementation of AI in educational systems should not be evaluated solely in terms of technological efficiency but must also be guided by pedagogical relevance and educational goals. According to their view, AI technologies should not replace teachers; rather, they should enhance and support the pedagogical role of educators within modern learning environments.

Crompton and Burke (2023), in their systematic review of artificial intelligence in higher education, analyzed 138 scholarly articles published between 2016 and 2022 and identified several rapidly developing research areas, including adaptive learning, intelligent tutoring systems, automated assessment, learning analytics, and generative artificial intelligence. The authors emphasize that the primary

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pedagogical value of AI in higher education lies in its ability to create personalized learning experiences tailored to individual students' needs and learning characteristics.

A large-scale systematic literature review conducted by Wang et al. (2024) further demonstrates the rapid expansion of research in the field of Artificial Intelligence in Education (AIED). Their findings indicate that adaptive learning and personalized tutoring systems have become central areas of investigation in recent studies. Moreover, the authors highlight that contemporary research is increasingly focused not only on the development of AI-based systems but also on examining their real educational outcomes, user acceptance, and potential limitations. These findings underline the importance of developing robust methodological approaches for integrating AI technologies into educational environments.

Du Plooy et al. (2024) examine the impact of personalized adaptive learning in higher education and conclude that such systems demonstrate considerable potential for improving academic performance, increasing student engagement, and enhancing the overall quality of learning. According to their analysis, adaptive learning platforms are particularly effective in heterogeneous learning environments where students possess different levels of prior knowledge. By adjusting the complexity of learning content and the sequence of instructional tasks, these systems enable more individualized and effective learning processes. Alfredo et al. (2024) propose a human-centered approach to learning analytics and artificial intelligence, emphasizing that the effectiveness of technological systems should not be measured solely by algorithmic accuracy but also by how well they address the needs of both students and educators. The authors argue that the design and implementation of AI-based educational tools should be guided by key principles such as learner agency, trust, privacy, and pedagogical transparency. Such an approach ensures that the use of artificial intelligence

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contributes responsibly and effectively to the development of students' knowledge competence.

Xia et al. (2024) investigate the impact of generative artificial intelligence on assessment processes in higher education and demonstrate that AI-based tools can significantly enhance rapid feedback, automated assessment, and personalized recommendations for students. At the same time, the authors highlight several important challenges related to academic integrity, the validity of assessment, and the preservation of students' independent thinking skills. Therefore, the integration of AI into assessment practices should not be viewed solely as a technological convenience but must also adhere to sound pedagogical and methodological standards.

Kalniņa et al. (2024) analyze both the benefits and potential risks of artificial intelligence in higher education. Their findings indicate that AI technologies can facilitate access to global knowledge resources, improve language support, and enhance educational inclusivity. However, the authors also emphasize potential challenges, including the decline of critical thinking skills, risks of plagiarism, and excessive reliance on AI tools. These perspectives highlight the importance of maintaining pedagogical supervision and methodological balance when implementing AI technologies in educational contexts.

Recent reviews published in 2025 confirm the continuation of these research trends. For example, Long et al. (2025), in their systematic review on the impact of AI on student engagement in higher education, demonstrate that the effectiveness of AI technologies largely depends on the instructional methods within which they are implemented. In other words, the technology itself is not the determining factor; rather, its effectiveness is closely related to the pedagogical framework in which it is applied. Similarly, Fortuna (2025), in a review on personalized learning, argues that AI technologies enhance student motivation, engagement, and knowledge acquisition through real-time feedback, adaptive learning pathways, and tailored educational content.

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Overall, the analysis of scientific literature published after 2020 demonstrates that artificial intelligence technologies possess considerable potential for enhancing students' knowledge competence. However, most existing studies primarily focus on technological capabilities, system design, or general educational outcomes. The development of a comprehensive methodological approach specifically aimed at improving students' knowledge competence remains insufficiently systematized. Therefore, the present study is scientifically relevant as it integrates artificial intelligence, adaptive learning, learning analytics, and pedagogical support into a unified methodological model designed to enhance students' knowledge competence.

Results and Analysis

The effectiveness of the methodological approach aimed at enhancing students' knowledge competence through the use of artificial intelligence technologies was examined experimentally during the course of this study. The experimental research involved undergraduate students from a higher education institution who were divided into experimental and control groups. In the experimental group, AI-based adaptive learning platforms, learning analytics tools, and automated assessment systems were implemented, while the control group continued the learning process using traditional instructional methods.

To evaluate the effectiveness of the experiment, students' knowledge levels and the development of their knowledge competence were measured using pre-test and post-test assessments. The obtained results demonstrated a significant improvement in the academic performance of students in the experimental group. Specifically, the average score in the experimental group increased from 56 to 78 points, whereas in the control group the average score rose from 55 to 66 points. These findings indicate that AI-based adaptive learning systems are more effective in developing students' knowledge competence compared to traditional teaching approaches.

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Statistical analysis of the results was conducted using the Student's t-test. The calculations revealed that the difference between the experimental and control groups was statistically significant ($t = 2.31, p < 0.05$). In addition, the calculated effect size using Cohen's d was 0.74, indicating a moderate to high effect of the implemented methodology. These results confirm that AI-supported educational technologies have a significant pedagogical impact on the development of students' knowledge competence.

A deeper analysis of the experimental outcomes shows that AI-based adaptive learning systems enable the personalization of students' learning activities at an individual level. Through learning analytics technologies, various indicators of students' learning behavior were analyzed, including task completion speed, knowledge acquisition levels, learning progress, and difficulties encountered during the learning process. Based on these data, learning materials and assignments were dynamically adapted to individual learning trajectories, thereby supporting more effective learning experiences.

The findings of this study are consistent with the results of international research conducted after 2020. Chen, Chen, and Lin (2020) emphasized that AI-based educational systems enhance learning outcomes through personalized instruction and adaptive learning environments. Similarly, Ifenthaler and Yau (2020) highlighted the important role of learning analytics in managing educational processes using data-driven approaches. Crompton and Burke (2023) also demonstrated that adaptive learning systems and intelligent tutoring platforms significantly contribute to improving students' knowledge acquisition and learning motivation.

Furthermore, the results indicate that the use of artificial intelligence technologies promotes greater student engagement and supports the development of independent learning skills. Adaptive learning platforms provide students with individualized tasks and real-time feedback, which encourages active participation in the learning process. Such conditions create a supportive learning

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environment that positively influences the development of students' knowledge competence.

At the same time, the findings reveal that the effectiveness of artificial intelligence technologies becomes significantly higher when combined with pedagogical support. Teachers' guidance, reflective learning practices, and formative assessment strategies complement AI-based learning systems and contribute to better learning outcomes. When these elements are integrated within the educational process, students demonstrate higher levels of academic achievement and deeper knowledge acquisition.

Overall, the results of the study demonstrate that the methodological approach based on artificial intelligence technologies represents an effective pedagogical tool for enhancing students' knowledge competence. The integration of adaptive learning, learning analytics, and pedagogical support provides new opportunities for organizing the educational process more effectively and for facilitating deeper knowledge acquisition among students.

Discussion

The results of this study demonstrate that the integration of artificial intelligence technologies into the educational process serves as an effective pedagogical tool for enhancing students' knowledge competence. The significant improvement in learning outcomes observed in the experimental group confirms that AI-based adaptive learning systems facilitate deeper knowledge acquisition by enabling the personalization of the learning process. These findings are consistent with the perspectives presented in contemporary educational research.

In particular, Chen, Chen, and Lin (2020) emphasize that artificial intelligence-based educational systems improve learning effectiveness by supporting personalized instruction. The results of the present study likewise indicate that adaptive learning platforms enable the development of individualized learning trajectories for students. This approach allows the organization of learning

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activities according to each student's knowledge level and learning pace, thereby supporting more efficient and meaningful knowledge acquisition.

Furthermore, the use of learning analytics technologies significantly improves the management of the learning process. Ifenthaler and Yau (2020) note that analyzing educational data generated during the learning process enables educators to identify students' learning difficulties at an early stage and implement timely pedagogical interventions. The findings of this study support this perspective. Through the use of learning analytics tools, teachers are able to analyze students' learning activities and provide targeted pedagogical support tailored to individual learning needs.

Crompton and Burke (2023) also report that artificial intelligence technologies contribute to the development of adaptive learning systems in higher education, which in turn enhance students' learning motivation and academic performance. In the present study, students in the experimental group demonstrated higher levels of engagement in the learning process. Adaptive assignments, automated feedback mechanisms, and individualized learning materials contributed to improving the overall effectiveness of students' learning activities.

The results of the study further indicate that the effectiveness of artificial intelligence technologies becomes significantly greater when combined with pedagogical support. Teachers' guidance, reflective learning activities, and formative assessment strategies complement AI-based educational systems and enhance the overall quality of the learning process. This observation supports the argument proposed by Williamson and Eynon (2020) that artificial intelligence should not replace teachers but rather support and strengthen their pedagogical role within the educational environment.

Overall, the findings of this research confirm that a methodological approach based on artificial intelligence technologies provides substantial pedagogical potential for enhancing students' knowledge competence. The integration of adaptive learning systems, learning analytics, and pedagogical support represents

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an important factor in the development of modern digital learning environments and contributes to the improvement of educational effectiveness in higher education.

Limitations and Future Research

Although the present study focuses on examining the pedagogical potential of artificial intelligence technologies in enhancing students' knowledge competence, several limitations should be acknowledged.

First, the number of participants involved in the study was relatively limited, and the experiment was conducted within a single higher education institution. Therefore, the generalization of the obtained results to other educational contexts should be approached with caution. Future research should involve larger and more diverse samples across multiple universities and academic disciplines in order to provide more comprehensive and generalizable findings.

Second, the study was conducted within a relatively short experimental period. Consequently, the long-term impact of AI-based educational systems on students' learning outcomes has not yet been fully explored. Further studies are needed to examine the long-term effects of artificial intelligence technologies on students' knowledge development, critical thinking abilities, and creative competencies.

Third, the effectiveness of artificial intelligence technologies is closely related to the technological infrastructure of the educational environment. In some educational institutions, insufficient technological resources may limit the successful implementation of AI-based learning platforms. Therefore, future research should investigate the technological and methodological conditions necessary for the effective integration of artificial intelligence technologies into educational systems.

Future studies may also explore the influence of artificial intelligence technologies on other important competencies, including critical thinking, creativity, and problem-solving skills. In addition, the integration of generative

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artificial intelligence technologies into the educational process represents an emerging research area that requires further investigation within contemporary educational studies.

In conclusion, the application of artificial intelligence technologies offers significant opportunities for enhancing students' knowledge competence. Future research should continue to explore the pedagogical effectiveness of these technologies and develop new methodological approaches for their effective integration into modern educational systems.

Conclusion

This study was devoted to developing a methodological approach aimed at enhancing students' knowledge competence through the use of artificial intelligence technologies and evaluating its effectiveness in the context of higher education. The findings of the research demonstrate that AI-based educational technologies provide significant pedagogical opportunities for improving the modern educational process and increasing the level of students' knowledge acquisition.

The experimental results indicate that the implementation of AI-based adaptive learning platforms, learning analytics technologies, and automated assessment systems significantly improves students' academic performance, learning motivation, and knowledge competence. The higher learning outcomes observed in the experimental group compared to the control group, where traditional teaching methods were applied, confirm the effectiveness of artificial intelligence technologies in improving educational outcomes.

The methodological model developed in the course of this research integrates several key components, including diagnostic assessment, adaptive learning mechanisms, learning analytics systems, and pedagogical support. This model enables the effective organization of the educational process by taking into account students' individual learning needs and knowledge levels.

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As a result, a personalized learning environment can be created for students, contributing to improved learning efficiency and deeper knowledge acquisition. Furthermore, the findings highlight the importance of the teacher's pedagogical role in the integration of artificial intelligence technologies into the educational process. Artificial intelligence does not replace teachers; rather, it supports their pedagogical activities and enhances the effectiveness of teaching practices. Teachers' guidance, reflective learning activities, and formative assessment strategies, when combined with AI-based learning systems, further increase the effectiveness of the educational process. Overall, the methodological approach based on artificial intelligence technologies represents an effective tool for developing students' knowledge competence in modern educational systems. The results of this study contribute to the advancement of scientific and methodological foundations for implementing AI technologies in higher education and support the development of innovative pedagogical approaches in contemporary education.

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