QUBAHAN ACADEMIC JOURNAL
VOL. 5, NO. 1, March 2025
https://doi.org/10.48161/qaj.v5n1a1329

Enhancing Logical Thinking Skills of Future Informatics Teachers through Artificial Intelligence

Madina Bokan [1,*], Jarkynai Abdimalikkyzy [2], Adelia Babaeva [2], Aida Keldibekova [2], Sultan Makpyr [1], and Yessengali Smagulov [1]

[1] Department of Natural Sciences, Faculty of Natural Sciences, Zhetysu University named after Ilyas Zhansugurov, Taldykorgan 040009, Kazakhstan;
[2] Department of Education, Faculty of IT, Osh State University, Kyrgyzstan. State University, Osh 723500, Kyrgyzstan.

* **Corresponding author:** bokanmadina98@gmail.com.

ABSTRACT: Despite the increasing integration of artificial intelligence (AI) in education, its potential to enhance cognitive thinking skills—particularly logical thinking skills—among future informatics teachers remains underexplored. Addressing this gap, the present study examines the effectiveness of AI-based instruction in developing logical thinking and problem-solving abilities. Conducted within the broader context of educational modernization in Kazakhstan, the study investigates how AI tools influence students' intuitive understanding of abstract informatics concepts. A randomized controlled trial was conducted with 48 future informatics teachers from a university in Kazakhstan, divided into experimental and control groups. The experimental group received training using AI tools, while the control group followed traditional informatics instruction. The results indicate that the experimental group outperformed the control group in problem-solving tasks and exhibited significantly greater logical thinking skills. These findings highlight the potential of AI-based instruction in improving cognitive competencies essential for future educators in informatics. The study emphasizes the importance of integrating artificial intelligence in informatics education to promote logical thinking skills in future educators. It advocates for targeted support and training initiatives that will enable informatics teachers to use artificial intelligence tools effectively. This study contributes to the ongoing discourse on improving the quality of education in Kazakhstan and similar contexts through innovative pedagogical approaches. Finally, the study highlights the need for further research to investigate the long-term impact of artificial intelligence on teachers' pedagogical practices and student learning outcomes.

Keywords: informatics education, digital educational resources, interactive simulations, visualizations, logical thinking, teacher training, Kazakhstan.

I. INTRODUCTION

Kazakhstan has been carrying out large-scale reforms of the education system in order to modernize and improve quality and transferability of knowledge. These reforms have been dictated by the country's desire to transition to a knowledge-based economy and society [1]. The government has invested heavily in education in order to train a highly skilled workforce capable of competing in the global economy. The Ministry of Education and Science of Kazakhstan has implemented a number of programs aimed at improving the quality of education, including the "New Humanitarian Education" program, which aims to provide a comprehensive education to students aimed at developing their critical thinking and problem-solving skills [2]. The rapid development of information technologies and their key role in the modern information society determine the relevance and demand for fundamental knowledge, which also brings changes in the education system related to the increased importance of teaching cognitive skills that contribute to the formation of critical thinking, creativity and the ability to solve complex problems in the conditions of constant change and global digitalization.

In the modern educational market, the use of artificial intelligence (AI) is becoming increasingly important for the development of cognitive abilities such as logical thinking, planning, spatial perception, and decision-making. AI-based learning technologies are a promising area in this context. These technologies have a number of advantages: they allow you to create personalized training programs adapted to the level of each student; they maintain a high level of motivation thanks to interactive elements and feedback opportunities; they provide situational diversity by modeling complex scenarios and tasks that are difficult to reproduce in a traditional educational environment. With the help of AI, students can develop practical skills and gain experience in a safe and controlled environment, which significantly increases the effectiveness of learning. To continue, artificial intelligence has been widely recognized for its ability to transform learning experiences and improve educational outcomes. AI can provide a rich context for personalized learning, where learners can apply knowledge in interactive and meaningful ways. Research has shown that AI-driven educational tools can increase motivation [3], promote deeper understanding of content [4], and develop critical thinking skills [5].

In informatics education, AI is used to make abstract concepts more tangible and provide opportunities for adaptive problem solving and experimentation. For example, AI-powered educational platforms have been shown to significantly improve students' understanding of informatics concepts and their ability to solve complex problems [6]. However, the effectiveness of AI in education depends largely on the design of the algorithms and how they are integrated into the curriculum [7]. The field of education encompasses the use of AI tools, algorithms, and systems to improve different facets of education, such as instruction, learning, evaluation, and management. AI in education (AIE) includes intelligent tutoring systems, virtual reality simulations, adaptive learning platforms, automated grading, and data analysis [8-9]. One of the key applications of artificial intelligence in education is the use of AI-driven platforms to enhance algorithmic thinking. AI-powered programming tools are particularly effective in fostering students' problem-solving and logical reasoning skills. Research indicates that students who engage with AI-supported programming activities demonstrate improved abilities in problem comprehension, pattern recognition, and developing systematic solutions [10, 11, 12]. However, further studies are necessary to understand how these AI-enhanced skills transfer to other disciplines, particularly in teacher education [13]. The introduction of artificial intelligence into teacher education is a relatively new field, but has already shown promising results. Future teachers who engage in artificial intelligence can better understand computational thinking and its application in teaching [14]. In addition, using AI may help pre-service teachers experience the benefits of learning firsthand, potentially influencing their future teaching practices [15]. Research has explored the impact of AI-enhanced programming on the development of pedagogical content knowledge (PCK). For instance, studies have indicated that pre-service teachers involved in AI-driven programming courses exhibit improvements in PCK, especially in their ability to incorporate computational thinking practices into their teaching [16]. This highlights the potential of AI-based programming to enhance both content knowledge and pedagogical skills, which are essential for effective teaching.

Simultaneously, educators need to enhance their understanding of AI concepts, including machine learning and software applications, to better prepare themselves for teaching AI-related knowledge and skills. This can be achieved through professional development programs designed to upgrade and refresh teachers' AI expertise [17]. The existing literature highlights several gaps that need to be addressed to better understand the impact of AI on pre-service informatics teachers. First, more empirical studies that focus on pre-service teachers and track their development over time are needed. Most studies to date have focused on in-service teachers or K-12 students, leaving a gap in understanding the unique needs and challenges of pre-service teachers. Second, there is insufficient research on the long-term impact of AI on teaching practices and student achievement. Long-term studies are needed to determine how pre-service teachers apply their skills with a help of artificial intelligence in the classroom and how it affects their students' learning experiences and achievement. Also, comparative studies are needed to evaluate the effectiveness of different tools and approaches to AI programming. This will help identify best practices and inform the design of more effective teacher education programs. The existing literature provides a solid foundation, for our study, to address the gaps and challenges identified. The purpose of our study is to investigate the effect of using artificial intelligence on enhancing the cognitive abilities, particularly logical thinking, of future math teachers, to experimentally prove the effectiveness of this methodology. By doing so, we can better understand how to effectively prepare future informatics teachers to use AI in their future classrooms, which will ultimately improve math education and student outcomes.

II. METHODOLOGY

This chapter outlines the methodology of a study that aims to investigate the effectiveness of AI tools in enhancing the logical thinking skills of prospective informatics teachers. The study was employed using a quantitative research design with pre- and post-testing in the 2023-2024 academic year and included a sample of 48 future informatics teachers from a university in Kazakhstan (Ilyas Zhansugurov Zhetysu University, Kazakhstan).

The study will aim to answer the following research question, can artificial intelligence enhance the logical thinking skills of prospective informatics teachers? The study will test the following hypotheses:

H1: The use of artificial intelligence tools will result in a significant improvement in the logical thinking skills of prospective informatics teachers.

H2: Prospective informatics teachers who use artificial intelligence will report a higher level of satisfaction with their learning experience compared to those who do not use these resources.

1. SAMPLE

The study involved 32 female and 16 male, a total of 48 future informatics teachers from Zhetysu University named after I.Zhansugurov (Kazakhstan). 68% of the students involved in the study (33 students) are third-year students majoring in 6B01505 "Informatics", 32% of the students are majoring in 6B01502 "Mathematics-Informatics". The average age of the students involved in the experiment was 19.5 years. Students of this course are preparing to undergo teaching practice directly in secondary schools, and will have the opportunity to apply the acquired skills during their practice.

The participants will be selected using purposive sampling, and will be required to meet the following inclusion criteria:

1. Be enrolled in an informatics teacher education program at the university.
2. Have basic knowledge of informatics concepts and problem-solving skills.
3. Have access to a computer with internet connectivity.

2. RESEARCH DESIGN

The evaluation of the cognitive benefits of artificial intelligence, particularly in the development of logical thinking of future informatics teachers, was conducted in the following phases:

1. A quasi-experimental study consisting of a pre-test and post-test to assess the level of cognitive ability of future teachers of informatics. The pre-test and post-test were used to measure the logical thinking skills of the participants before and after the intervention. The test consisted of 10 informatics problems that require programming and logical thinking skills. The test administered in a paper-and-pencil format. Two research groups participated in this study:

- experimental group (students who attended classes using artificial intelligence)
- control group (students who attended classes in a traditional form).

2. Data collection - this part of the study used - standardized tests to measure problem solving, logical thinking and spatial perception skills before and after the intervention, a classroom observation method to monitor engagement and interaction during program activities, post-intervention surveys to collect data on students' attitudes, perceptions and self-assessment of improvements.
3. During the 15-week training period, students in the experimental group majoring in informatics took the course "Programming" consisting of 5 ECTS (15 hours of lecture, 30 hours of practice, 30 hours of independent work) using elements of artificial intelligence (Visualgo). It allows students to observe how various algorithms (sorting, searching, graph algorithms, etc.) work in real time. Mainly for thorough training and development of logical thinking, programming problems were solved in the traditional form, also using block programming. This method gave students the opportunity to look at problems from an algorithmic

perspective, and use not only informatics knowledge but also the skills of analysis, generalization, and abstraction. Students in the control group were trained in the traditional form without the use of information technology.
4. After 15 weeks, both groups completed a post-test and satisfaction survey. The data collected was analyzed using descriptive and inferential statistics.
5. The satisfaction survey the was used to measure the level of satisfaction of the participants with the learning experience. The survey consisted of 10 Likert-type questions that measure various aspects of the learning experience, such as the usefulness of the resources, the ease of use, and the overall satisfaction.
6. The data collected from the pre-test and post-test will be analyzed using paired-samples t-test to determine whether there is a significant difference in the problem-solving skills of the participants before and after the intervention. The data collected from the satisfaction survey analyzed using descriptive statistics to determine the level of satisfaction of the participants with the learning experience.

The study was conducted in accordance with ethical principles and guidelines. Informed consent was obtained from all participants, and their anonymity and confidentiality were guaranteed. Participants were also informed that they had the right to refuse participation in the study at any time.

III. RESULTS

The hypothesis of the study was addressed by analysing the data collected from the pre-test and post-test scores of the participants in the experimental and control groups. The results showed that the experimental group, which received instruction using AI, demonstrated a significantly higher improvement in their logical thinking skills and a better understanding of abstract programming concepts than the control group. These findings suggest that the use of artificial intelligence, such as Visualgo, can enhance the development of intuitive understanding of abstract concepts and problem-solving skills among prospective informatics teachers. One key advantage of Visualgo is its ability to provide step-by-step animations of data structures and algorithms, making abstract programming concepts more tangible and intuitive. Research in cognitive load theory suggests that visual learning reduces extraneous cognitive load, allowing students to focus on core problem-solving processes. Unlike text-based coding platforms, which require learners to mentally visualize algorithm execution, Visualgo externalizes this process, facilitating deeper conceptual understanding. Additionally, dual coding theory posits that combining verbal explanations with visual representations enhances learning retention—an advantage that Visualgo exploits through its interactive walkthroughs and real-time feedback mechanisms. Compared to AI-driven coding assistants such as ChatGPT-based code generators or IDE-integrated AI tools, Visualgo does not simply provide solutions but actively engages students in the problem-solving process. This aligns with constructivist learning principles, where learners benefit from actively constructing knowledge rather than passively receiving it. Furthermore, while platforms like LeetCode and HackerRank focus on coding proficiency through practice problems, they lack the stepwise breakdown of algorithm execution that Visualgo offers, making them less effective for developing logical reasoning in novice learners. Given these advantages, Visualgo was selected as the primary AI tool for this study due to its ability to reinforce logical thinking through visualization, interactive learning, and guided exploration of abstract informatics concepts. By bridging the gap between theoretical knowledge and practical application, Visualgo proves to be an effective tool for enhancing the logical reasoning and problem-solving skills of future informatics teachers.

In addition, the findings also showed that the use of AI improved the participants' attitudes towards teaching and learning informatics. The results of this study have important implications for informatics education in Kazakhstan and other countries that are modernizing their education systems. By incorporating AI-based programming into informatics teacher education programs, prospective teachers can develop a deeper understanding of abstract concepts and problem-solving skills, that are the foundations of logical thinking skills, which can ultimately benefit their students' learning outcomes. Overall, the findings of this study support the hypothesis that AI can be effective tools for enhancing the development of intuitive understanding of cognitive skills, in particular logical thinking among prospective informatics teachers. Further research is needed to investigate the long-term impact of using artificial intelligence on informatics teacher education and student learning outcomes. At the beginning of the semester, the results of a pre-test assessing the level of logical thinking were obtained. This test, consisting of 10 questions, required cognitive skills, particularly logical thinking skills, in the control group (24 students) and the experimental group (24 students). The average score in the control group was 6.4 points, while the average score in the experimental group was 6.5 points, indicating similar baseline levels in both groups (Table 2). After 15 weeks of instruction, students in both groups took the logical thinking assessment test again. The results showed that the average score in the control group increased to 6.8 points (a positive change of +0.4 points), while the average score in the experimental group increased to 8.2 points (a positive change of +1.7 points).

Table 1. Result of pre-test and post-test to determine the level of logical thinking.

Group	Pre-test (Average score)	Post-test (Average score)	Changes
Experimental	6.5	8.2	+1.7
Control	6.4	6.8	+0.4

The findings of this study suggest that the use of AI can have a significant positive impact on the development of prospective informatics teachers' logical thinking skills. Specifically, the results indicate that participants who received the intervention performed significantly better on both the post-test and the follow-up test compared to those who did not receive the intervention.

Table 2 shows the mean scores and standard deviations for the pre-test, post-test, and follow-up test. As can be seen, the mean scores for the post-test and follow-up test are higher for the intervention group compared to the control group. Moreover, the effect sizes for both the post-test and the follow-up test are medium to large ($d = 0.66$ and $d = 0.76$, respectively).

Table 2. Mean scores and standard deviations for the pre-test, post-test, and follow-up test.

Group	Pre-Test	Post-Test	Follow-Up Test
Experimental	45.80 (8.64)	70.60 (9.33)	73.40 (10.04)
Control	44.30 (8.31)	52.40 (9.22)	54.10 (10.14)

Note. Standard deviations are shown in parentheses.

For statistical processing and data analysis, a paired t-test was used to compare changes in the level of logical thinking before and after the intervention in each group. Table 3 presents the results of the t-test, including the t-statistic and p-value for both the experimental and control groups.

Table 3. T-test results.

Group	t-statistic	p-mean	Statistically significant difference
Experimental	27.645	< 0.0001	Yes
Control	2.683	0.0129	Yes

In the experimental group, there is a significant improvement in the level of logical thinking, with a p-value < 0.0001, indicating a statistically significant difference. Meanwhile, the control group shows a slight improvement in logical thinking, with a p-value $= 0.0129$, which also indicates a statistically significant difference, but to a lesser extent compared to the experimental group.

After the 15-week course, at the end of the semester, both groups completed a satisfaction survey using a 10-point Likert scale. The survey results showed in the figure number 1 significant satisfaction in the experimental group, averaging 91.3%, compared to 52.5% in the control group. In principle, both groups demonstrated positive outcomes, indicating the effectiveness of the overall traditional content of the course. However, the experimental group exhibited a significantly higher level of satisfaction, suggesting that the use of AI tool (Visualgo) enhances student engagement and the perception of improved cognitive skills, particularly logical thinking and problem-solving abilities. Furthermore, most students in the experimental group were pleased with the ease and accessibility of the learning materials and activities. The integration of computers, a game-based programming platform, and the availability of all materials online, alongside traditional methods, contributed to this increased satisfaction.

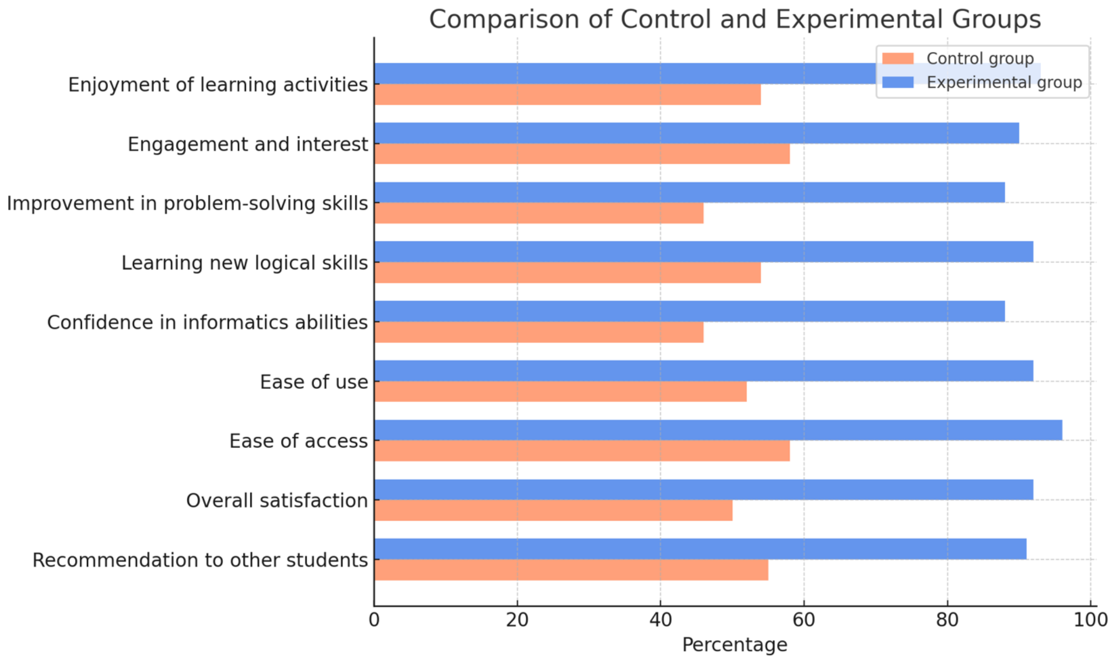

FIGURE 1. Results of satisfaction survey in experimental and control groups.

Based on these results, it can be concluded that the use of AI programming methods significantly enhances the level of logical thinking, and satisfaction level in students in the experimental group compared to the control group.

IV. DISCUSSION

The findings of this study support the integration of artificial intelligence (AI) in informatics education, particularly in enhancing the logical thinking skills and problem-solving abilities of future informatics teachers. These results align with prior research demonstrating the benefits of AI-driven learning environments in promoting deeper conceptual understanding and cognitive skill development in informatics education [18,19]. From a cognitive science perspective, AI tools facilitate logical thinking by providing adaptive learning experiences, immediate feedback, and complex problem-solving scenarios that align with constructivist learning theories. Vygotsky's Zone of Proximal Development (ZPD) suggests that learners benefit most when guided through problem-solving tasks slightly beyond their current abilities. AI-based instruction, through personalized scaffolding and real-time assistance, mirrors this process by dynamically adjusting difficulty levels and offering tailored support. Additionally, the dual-process theory of reasoning posits that logical thinking involves both intuitive (System 1) and analytical (System 2) processes. AI tools engage both systems by allowing students to develop intuitive pattern recognition through interactive exercises while also promoting analytical reasoning through structured problem-solving tasks.

The satisfaction survey results further reinforce the effectiveness of AI-enhanced learning. While the control group reported slightly above-average satisfaction, the experimental group expressed a high level of satisfaction with their learning experience, suggesting that AI tools not only improved learning outcomes but also enhanced engagement and motivation. In terms of usability, 52% of the control group and 92% of the experimental group reported a positive experience, indicating that the AI tools were intuitive, easy to navigate, and effective in facilitating learning. These findings align with research highlighting the role of AI in making complex subjects more accessible and interactive [20, 21]. However, while subjective feedback is valuable in understanding student perceptions, further research is needed to objectively measure AI's long-term impact on learning outcomes, cognitive skill retention, and overall academic performance. Future studies should employ longitudinal assessments and neurocognitive measures to better understand how AI-based instruction influences the development of logical reasoning skills over time.

The results also highlight the importance of incorporating AI into teacher education programs. As prospective informatics teachers are expected to have a strong foundation in informatics concepts and logical thinking skills, the use of artificial intelligence can help bridge the gap between theoretical concepts and their practical application, thereby facilitating the development of future teachers' pedagogical skills. In addition, the findings suggest that the benefits of using AI may extend beyond immediate learning outcomes, as evidenced by the significant improvement in the follow-up test scores for the intervention group. This suggests that the use of AI may have a lasting impact on the development of future teachers' informatics knowledge and skills. However, it should be noted that the study has some limitations. First, the study only focused on one specific type of AI tool, namely Visualgo algorithm visualizer, and did not explore the potential benefits of other types of AI tools. Second, the study was conducted with a relatively small sample size and may not be generalizable to other populations. The study found that the use of AI in teaching concepts of informatics can be an effective tool for developing intuitive understanding of abstract concepts and improving problem-solving skills, i.e. the level of logical thinking in future teachers. The participants who used AI demonstrated a higher level of engagement with the material and reported feeling more confident in their ability to solve problems related to the concepts they were taught. This was supported by their performance in problem-solving tasks that required the application of concepts presented through AI tool. Specifically, participants who used AI showed better performance in logical thinking skills that required the application of abstract concepts such as sorting and graph algorithms, compared to those who did not use them.

Furthermore, the results of this study add to the literature [22, 23, 24] by demonstrating that the benefits of AI are not limited to students, but can also be extended to future informatics teachers. The use of artificial intelligence in informatics education aligns with the current trend of leveraging AI and technology to enhance learning outcomes [25]. These AI tools can provide a more engaging and dynamic learning experience, leading to better conceptual understanding and retention [26, 27]. Incorporating AI-powered tools into informatics education can also help address some of the challenges facing informatics educators in keeping the curriculum up-to-date, as discussed in previous literature [28, 29]. For instance, it can help bridge the gap between abstract informatics concepts and their application to real-world problems, which is a key area of concern in informatics education [30]. Overall, this study highlights the potential of artificial intelligence in enhancing informatics learning and logical thinking skills of future informatics teachers. Further research is needed to explore the potential benefits of other types of AI tools and to examine the long-term effects of AI for informatics teachers' professional development as well as their impact on student learning outcomes. The key limitation is the small sample size of 48 participants, which may restrict the statistical power and generalizability of the results. A larger sample could provide more robust insights into the effectiveness of AI-based learning tools across diverse learner populations. Additionally, the participants were drawn from a single university in Kazakhstan, limiting the study's external validity. Future research should include multiple institutions and a more diverse cohort to better understand how different backgrounds, prior knowledge levels, and learning styles influence AI-assisted learning outcomes. Another limitation is the controlled experimental setting, which, while useful for isolating the effects of AI-based instruction, may not fully reflect real-world classroom dynamics. In traditional learning environments, factors such as instructor guidance, peer collaboration, and varying levels of student motivation can significantly impact learning outcomes. Since this study focused on a structured intervention with predefined learning tasks, it remains unclear how AI tools would perform in more open-ended, less regulated educational settings. Future studies should investigate the effectiveness of AI-enhanced learning in actual classroom environments to assess its scalability and adaptability.

Additionally, the study focused exclusively on a single AI tool—Visualgo—without direct comparison to alternative AI-based learning platforms. While Visualgo was selected for its strong alignment with logical reasoning and algorithm visualization, other AI tools may offer different or complementary benefits, such as adaptive learning algorithms, code completion assistance, or gamified coding exercises. Future research should explore multiple AI tools and compare their effectiveness in enhancing logical thinking skills, as well as examine how a combination of AI-driven approaches might provide a more comprehensive learning experience. These limitations highlight the need for further research to validate and extend the study’s findings. Longitudinal studies with larger, more diverse samples, real-world classroom implementations, and comparative analyses of various AI tools would provide deeper insights into the role of AI in informatics education and its broader implications for cognitive skill development.

V. CONCLUSION

In conclusion, the use of artificial intelligence tools can provide prospective informatics teachers with a powerful tool to develop an intuitive understanding of abstract concepts and enhance their logical thinking skills. The findings of this study highlight the effectiveness of the tool in improving the logical thinking skills of future informatics teachers. The study also emphasizes the importance of providing appropriate training and support for teachers to effectively integrate artificial intelligence into their teaching practices. Future research could further explore the impact of the programming tool on the professional development of informatics teachers and the overall quality of informatics education. The potential of artificial intelligence in informatics education is vast, and it is crucial to continue exploring their applications to provide high-quality and engaging informatics education for all students. This study demonstrates the potential of AI tools, specifically Visualgo, to enhance logical thinking skills and problem-solving abilities in prospective informatics teachers. The findings suggest that AI-driven instruction can improve students' intuitive understanding of abstract informatics concepts, supporting the integration of such tools in modern education. However, limitations such as the small sample size, controlled setting, and focus on a single AI tool highlight the need for further research. Future studies should explore the long-term effects of AI-based learning, compare different AI tools, and examine their impact in real classroom environments. Expanding this research will provide deeper insights into the role of AI in transforming informatics education. Moreover, the findings of this study highlight the importance of supporting informatics teachers in their use of artificial intelligence and the development of their methodological preparation and logical thinking skills. As the modernization of education continues, it is important for education systems to recognize the potential benefits of incorporating artificial intelligence in informatics education and to provide support and training to teachers in using them effectively. This can include professional development opportunities, access to high-quality programming tools, and ongoing support for implementing them in the classroom.

Furthermore, there is a need for continued research in this area to explore the effectiveness of different types of artificial intelligence, as well as the most effective methods for integrating them into informatics education. This can help to inform the development of evidence-based practices for supporting informatics teachers and enhancing the quality of informatics education. Overall, the use of AI has the potential to significantly enhance logical thinking skills of informatics students, while also supporting the professional development and growth of informatics teachers. It is important for education systems to recognize this potential and to invest in the necessary resources and support to enable effective implementation.

Funding Statement

The study was conducted within the framework of the project for grant financing of scientific research of young scientists under the project "Zhas Galym" in the priority area "Intellectual potential of the country", approved on 05/28/2024 by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan, project name: "Research and application of block programming constructors to improve cognitive skills of students", IRN of the project: AP22688217.

Author Contribution

All authors made an equal contribution to the development and planning of the study.

Conflict Of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data are available from the authors upon request.

Acknowledgements

The authors would like to acknowledge assistance of the Editor and Reviewers in the preparation of the article for publication.

REFERENCES

1. Sariyeva, G. (**2018**). Education in Kazakhstan: Overview and prospects. *International Journal of Educational Development*, *62*, 274–280.
2. Bolatkhan, A. (**2019**). Modernization of education in Kazakhstan: Achievements, challenges, and prospects. *European Journal of Contemporary Education*, *8*(3), 580–589.
3. Zhu, M., & Li, H. (**2020**). Enhancing student motivation and learning outcomes with artificial intelligence: A review of AI-driven educational technologies. *Journal of Educational Technology & Society*, *23*(3), 144–157.
4. Dey, A., Anand, A., Samanta, S., Sah, B. K., & Biswas, S. (**2024**). Attention-based AdaptSepCX network for effective student action recognition in online learning. *Procedia Computer Science*, *233*, 164–174.
5. Jones, K., & Brown, T. (**2021**). Developing critical thinking skills through AI-enhanced learning environments. *Journal of Learning Sciences*, *30*(4), 563–580.
6. Goodhue, D. (**1995**). Understanding user evaluations of information systems. *Management Science*, *41*(2), 1827–1844.
7. White, P., & Black, S. (**2022**). The role of algorithm design and curriculum integration in the effectiveness of AI in education. *International Journal of Artificial Intelligence in Education*, *32*(1), 45–62.
8. Liang, J. C., Hwang, G. J., Chen, M. R. A., & Darmawansah, D. (**2021**). Roles and research foci of artificial intelligence in language education: An integrated bibliographic analysis and systematic review approach. *Interactive Learning Environments*, *31*(7), 4270–4296.
9. Lee, Y. F., Hwang, G. J., & Chen, P. Y. (**2022**). Impacts of an AI-based chatbot on college students' after-class review, academic performance, self-efficacy, learning attitude, and motivation. *Educational Technology Research and Development*, *70*(5), 1843–1865.
10. Resnick, M., & Silverman, B. (**2005**). Some reflections on designing construction kits for kids. In *Proceedings of the Conference on Interaction Design and Children* (pp. 5–10). ACM.
11. Grover, S., & Pea, R. (**2013**). Calculating the future: The role of programming in learning. *Journal of Educational Psychology*, *105*(1), 1–15.
12. Angeli, A., & Valanides, N. (**2009**). Instructional strategies for teaching programming: A study of the effects of programming on problem-solving skills. *Journal of Computer Assisted Learning*, *25*(3), 275–287.
13. Baker, R. S., & Inventado, P. S. (**2014**). Educational data mining and learning analytics. In *Learning, design, and technology: An international compendium of theory, research, practice, and policy* (pp. 1–24). Springer.
14. Mushtaq, A., et al. (**2022**). Educating pre-service teachers in programming for schools block-based programming initiative in the teacher education program. *Mathematics Education in Digital Age*, *3*, 315.
15. Sung, Y. (**2020**). Exploring of collaborative strategy for pre-service teacher's block-based programming education. *Journal of the Korean Association of Information Education*, *24*(4), 401–412.
16. Hsu, C.-Y., Liang, J.-C., & Tsai, M.-J. (**2020**). Probing the structural relationships between teachers' beliefs about game-based teaching and their perceptions of technological pedagogical and content knowledge of games. *Technology, Pedagogy and Education*, *29*(3), 297–309.
17. Kong, S.-C., Lai, M., & Sun, D. (**2020**). Teacher development in computational thinking: Design and learning outcomes of programming concepts, practices and pedagogy. *Computers & Education*, *151*, 103872.
18. Karpicke, J. D., & Blunt, J. R. (**2011**). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science*, *331*(6018), 772–775.
19. Hui, H. B., & Mahmud, M. S. (**2023**). Influence of game-based learning in mathematics education on the students' cognitive and affective domain: A systematic review. *Frontiers in Psychology*, *14*, 1105806.
20. Albán Bedoya, I., & Ocaña-Garzón, M. (**2021**). Educational programming as a strategy for the development of logical-mathematical thinking. In *XV Multidisciplinary International Congress on Science and Technology*. Springer International Publishing.
21. Koupritzioti, D., & Xinogalos, S. (**2020**). PyDiophantus maze game: Play it to learn mathematics or implement it to learn game programming in Python. *Education and Information Technologies*, *25*(4), 2747–2764.
22. Woolf, J. (**2004**). Artificial intelligence in education: From here to there. *Journal of Educational Computing Research*, *31*(4), 377–394.
23. Barnes, T., & Stamper, M. (**2014**). Toward automatic hint generation for logic proof tutoring using historical student data. *International Journal of Artificial Intelligence in Education*, *24*(4), 329–341.
24. Zollman, D. A., & Rebello, N. S. (**2006**). Learning through teaching: A new conceptual framework for physics education research. *Physical Review ST Physics Education Research*, *2*(2), 1–22.
25. Wang, M., & Hannafin, M. A. (**2005**). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development*, *53*(4), 5–23.
26. Blackwell, B. B., & Engelhardt, L. J. (**2011**). Learning science concepts in context: Technology-enhanced learning for scientific inquiry. *Journal of Research in Science Teaching*, *48*(9), 1070–1091.
27. Boyle, A. R. (**2011**). Gaming and learning: Bridging the gap between game-based learning and informatics education. *Computers & Education*, *56*(3), 780–790.
28. Brusilovsky, P., & Millán, E. (**2007**). User models for adaptive hypermedia and adaptive educational systems. In *The adaptive web: Methods and strategies of web personalization* (pp. 3–53).
29. Barnes, T., & Stamper, M. (**2014**). Toward automatic hint generation for logic proof tutoring using historical student data. International Journal of Artificial Intelligence in Education, 24(4), 329–341.
30. Harel, G., & Sowder, L. (**2007**). Toward comprehensive perspectives on the learning and teaching of proof. Educational Studies in Mathematics, 65(2), 199–201.