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Unveiling the Needs: Developing AI-Based Chatbots in Blended Learning to Enhance Computational Thinking and Self-Regulated Learning in Mathematics Education

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Abstract: The advancement of Artificial Intelligence (AI) in education has introduced innovative learning tools, including AI-based chatbots, which have the potential to enhance student engagement and personalized learning. This study focuses on the Analysis phase of the ADDIE model to investigate the needs and feasibility of developing an AI chatbot for blended learning, specifically to improve Computational Thinking (CT) and Self-Regulated Learning (SRL) among undergraduate mathematics education students. A mixed-method approach was employed, utilizing SRL questionnaires, computer literacy questionnaires, CT tests, and preliminary interviews with students and lecturers. The SRL questionnaire assessed students' challenges in self-regulation and their preferences for technology-assisted learning. The computer literacy questionnaire explored students' familiarity with digital tools. The CT test provided insights into students' computational thinking skills, while interviews offered qualitative perspectives on learning difficulties and expectations regarding AI chatbots. Findings from this analysis phase reveal that students require adaptive and interactive learning support to enhance their computational thinking skills and autonomous learning. Moreover, while students express strong interest in AI-based chatbots, concerns regarding usability, integration, and effectiveness in mathematical problem-solving remain. The results of this study lay the groundwork for designing an AI chatbot framework that aligns with students' academic needs and technological readiness, providing a foundation for future development and implementation.

Keywords: AI chatbots, Blended learning, Computational thinking, ADDIE model

Introduction

The rapid advancement of Artificial Intelligence (AI) in education has transformed the way students learn and interact with digital resources. One of the most promising applications of AI in education is the AI-based chatbot, which can serve as a virtual tutor by providing real-time feedback, answering students' questions, and guiding them through problem-solving processes. Research indicates that AI chatbots can significantly enhance student engagement and motivation, particularly in mathematics education, by offering personalized, adaptive, and interactive learning experiences (Baskara, 2023; Pimentel et al., 2024). In an era where blended learning is becoming the norm, AI chatbots have the potential to bridge gaps in traditional instruction, although their effectiveness in fostering specific cognitive and metacognitive skills remains an area of ongoing exploration (Jia-qi et al., 2020).

Within the domain of mathematics education, students are expected to develop two essential skills: Computational Thinking (CT) and Self-Regulated Learning (SRL). CT is a foundational skill that enables students to analyze problems, recognize patterns, formulate solutions algorithmically, and apply logical

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reasoning—all of which are critical for mathematical problem-solving (Wing, 2006). Meanwhile, SRL refers to a student's ability to set learning goals, monitor progress, and adapt strategies for continuous improvement, promoting independent learning habits (Pintrich, 2000). Despite their importance, many undergraduate students in mathematics education face difficulties in developing and applying CT and SRL strategies effectively, often due to the lack of individualized support, inadequate problem-solving guidance, and limited access to real-time feedback (Manzanares et al., 2023). The integration of AI chatbots in educational settings can potentially address these challenges by providing tailored support and resources that foster both CT and SRL.

AI-based chatbots have the potential to enhance CT and SRL development by offering a structured, responsive, and engaging learning environment. Through tailored feedback and interactive problem-solving guidance, chatbots can help students break down complex mathematical concepts, provide hints when they struggle, and encourage self-reflection on learning strategies (Pernaa, 2023). Furthermore, chatbots can foster continuous engagement by integrating AI-driven prompts, reminders, and reinforcement mechanisms that align with students' learning needs (Kung et al., 2023). However, the successful integration of AI chatbots in blended learning for mathematics education requires a clear understanding of students' needs, technological readiness, and the practical challenges associated with AI implementation (Eslit, 2023).

This study focuses on the Analysis phase of the ADDIE instructional design model, which is crucial in determining whether AI chatbots can effectively support the learning process. Before designing and implementing an AI-based chatbot, it is essential to identify students' learning challenges, preferences, and expectations regarding AI-driven educational tools (Chien et al., 2022). A thorough needs analysis will help determine the feasibility of integrating AI chatbots into the mathematics learning process, ensuring that the chatbot aligns with students' specific academic needs and enhances their ability to develop CT and SRL skills in a blended learning environment (Baglivo et al., 2023). This approach is supported by findings that emphasize the importance of aligning educational technologies with learner characteristics to maximize their effectiveness (Parsakia, 2023).

The findings from this study will contribute to the development of AI-driven learning frameworks that support mathematics education students in becoming more proficient in computational thinking, independent learning, and problem-solving. By addressing key challenges and leveraging the capabilities of AI, this research aims to bridge the gap between technology-driven instruction and effective mathematics learning, ultimately helping students gain the skills necessary for success in an increasingly digital world (Topal et al., 2021). The integration of AI chatbots not only enhances learning outcomes but also fosters a more engaging and interactive educational experience (Bearman et al., 2022).

As AI chatbots continue to reshape the educational landscape, understanding their role in blended learning for mathematics education is critical. This study seeks to provide insights that will guide the future development of AI-based chatbots, ensuring that they are designed not just as digital tools but as effective learning companions that empower students to think critically, regulate their learning, and navigate mathematical challenges with confidence (Swindell, 2024). The potential of AI chatbots to facilitate metacognitive strategies, such as self-reflection and goal setting, further underscores their value in educational contexts (Hoai Nam & Giang, 2023).

In conclusion, the integration of AI chatbots in mathematics education presents a promising avenue for enhancing student engagement, motivation, and learning outcomes. By focusing on the development of CT and SRL skills, educators can leverage these technologies to create personalized learning experiences that meet the diverse needs of students.

Method

This study employs a needs analysis approach within the Analysis phase of the ADDIE model to assess the learning needs, technological readiness, and feasibility of integrating AI-based chatbots in a blended learning environment for mathematics education. Using a descriptive research design, both quantitative and qualitative data are collected to explore students' challenges and expectations regarding AI-driven learning support. The participants consist of 85 undergraduate mathematics education students from a private university in Indonesia, selected through purposive sampling based on their experience with blended learning. Additionally, mathematics education lecturers are included to provide insights into pedagogical challenges and opportunities for AI chatbot integration.

Four primary instruments are used in data collection. The SRL questionnaire assesses students' ability to plan, monitor, and regulate learning. The computer literacy questionnaire evaluates familiarity with digital learning tools and AI-based systems. The CT test measures students' ability in decomposition, pattern recognition, abstraction, and algorithmic thinking. Lastly, semi-structured interviews with students and lecturers provide qualitative insights into learning difficulties, expectations, and AI chatbot feasibility.

Data collection occurs in multiple phases, beginning with the distribution of SRL and computer literacy questionnaires, followed by the CT test, and concluding with semi-structured interviews. The collected data undergoes descriptive statistical analysis for the quantitative components, while thematic analysis is applied to qualitative responses. Ethical approval is obtained from the university, and participants provide informed consent to ensure confidentiality and voluntary participation. The results of this study will serve as a foundation for developing an AI-based chatbot framework tailored to enhancing computational thinking skill, and self-regulated learning in mathematics education.

Results and Discussion

Students' Readiness for AI Chatbot Integration

The results from the SRL questionnaire (See Table 1) and computer literacy assessment provide a comprehensive understanding of students' readiness for AI chatbot integration in a blended learning environment. While students demonstrate strengths in social learning, motivation, and goal-setting, challenges remain in learning memory, structured planning, and AI familiarity, suggesting areas where AI chatbots could provide meaningful support.

Table 1. Result of SRL questionnaire

Dimension	Indicator	Percentage
Cognition	Learning Process	82%
	Learning Memory	76%
Metacognition	Idea Planning	72%
	Goal Oriented Monitoring and Evaluation	79%
Social Behavior	Peer Learning	85%
	Feedback Handling	87%
Motivational regulation	Interest Enhancement	82%
	Motivational Self-Talk	84%
	Emotional Control	80%

The cognitive dimension results indicate that while 82% of students exhibit strong learning processes, lower scores in learning memory (76%) and idea planning (72%) highlight difficulties in retaining information and structuring problem-solving strategies. This suggests that an AI chatbot could assist by implementing memory reinforcement strategies such as spaced repetition and interactive recall exercises, as well as providing structured guidance for organizing learning tasks. Research has shown that AI chatbots can enhance students' learning performance by offering personalized support and interactive learning experiences, which can address these cognitive challenges effectively (Pimentel et al., 2024; Wu & Yu, 2023).

For metacognitive regulation, 79% of students demonstrated effective goal-setting and self-monitoring skills. However, the challenges in idea planning indicate that students may need external guidance in structuring their study approaches. AI chatbots could play a role in enhancing metacognitive skills by offering interactive goal-setting features, adaptive progress tracking, and reflection prompts to help students evaluate and adjust their learning strategies. Studies have highlighted the importance of integrating AI chatbots in educational settings to support self-regulated learning through personalized feedback and goal-setting mechanisms (D. H. Chang et al., 2023; Pillai et al., 2023).

In terms of social behavior, students exhibit high levels of peer learning engagement (85%) and feedback-handling skills (87%), suggesting that collaborative learning environments are well-received. This opens opportunities for AI chatbots to facilitate peer discussion forums, collaborative problem-solving activities, and AI-generated feedback mechanisms to support interactive learning experiences. The ability of chatbots to create virtual discussion forums and facilitate group projects has been shown to increase student engagement and motivation, thereby enhancing collaborative learning (Baskara, 2023; Liang, 2024).

The motivational regulation dimension results indicate strong interest enhancement (82%), motivational self-talk (84%), and emotional control (80%). However, mainremain engagement in self-paced learning environments remains a concern. AI chatbots could incorporate gamification features, personalized motivational feedback, and real-time learning encouragement to sustain students' motivation and promote independent learning. Research supports the effectiveness of gamification in educational contexts, demonstrating that it can significantly improve student motivation and engagement through reward mechanisms and interactive elements (Biryukov et al., 2021; Polat, 2023; Rincón-Flores et al., 2022).

Computer Literacy and AI Familiarity

The computer literacy questionnaire reveals that 78% of students feel comfortable using digital learning tools such as learning management systems, educational apps, and online resources. However, only 45% of students reported previous experience with AI-driven educational tools, indicating a gap in AI literacy and adaptability. While students expressed interest in AI chatbots as learning assistants, some concerns were raised regarding the complexity of AI integration and its role in the learning process. Previous study indicates that the introduction of AI tools in educational settings can lead to both opportunities and challenges, particularly concerning students' familiarity and comfort with these technologies (Liu, 2024). The hesitation and uncertainty surrounding AI tools often stem from a lack of prior exposure and training, which underscores the need for comprehensive educational programs that gradually introduce AI functionalities to enhance students' confidence (Liu, 2024).

Lecturers also highlighted the importance of gradual AI adoption, emphasizing that while AI-based tools can enhance learning, they should not completely replace human instruction. Instead, AI chatbots should serve as a complementary tool that supports personalized learning, provides instant feedback, and fosters computational thinking skills without reducing critical human interactions in the classroom. The integration of AI in educational contexts is best approached from a human-centric perspective, ensuring that the emotional and cognitive aspects of learning are preserved (Bing, 2024; Ouyang et al., 2023). Studies have shown that AI can effectively support personalized learning experiences and provide valuable insights for educators, but it is crucial to maintain a balance between technological assistance and human interaction to foster a holistic learning environment (Santos, 2024; Trang & Thi Thu, 2024).

Furthermore, the role of AI in education is evolving, with evidence suggesting that AI-driven tools can significantly enhance student engagement and learning outcomes when implemented thoughtfully (Adeleye, 2024; Wu & Yu, 2023). However, it is essential to address the challenges associated with AI integration, such as the digital divide and the need for substantial investment in teacher training, to ensure equitable access to these technologies (Familoni, 2024; Trang & Thi Thu, 2024). As educators explore innovative methodologies that leverage AI, they must remain vigilant about the potential pitfalls of overreliance on technology and strive to create inclusive educational practices that cater to diverse learning needs (Bing, 2024; Roshanaei, 2023).

Computational Thinking (CT) Proficiency Levels

The CT test results provide critical insights into students' problem-solving abilities, particularly in decomposition, pattern recognition, abstraction, and algorithmic thinking (Wing, 2006). These skills are essential in mathematics education, as they enable students to analyze complex problems, identify relevant patterns, filter out unnecessary details, and develop structured solutions. The findings indicate varying levels of proficiency across different CT components, highlighting areas where AI-based chatbot support could be beneficial.

Decomposition: Strength in Breaking Down Problems

The results indicate that 53% of students demonstrated proficiency in decomposition, showcasing their capability to break down complex mathematical problems into smaller, more manageable components. This finding aligns with existing literature that emphasizes the importance of problem decomposition as a fundamental skill in mathematics education. For instance, Prabawa highlights that effective decomposition not only aids in understanding mathematical concepts but also enhances students' overall problem-solving abilities (Prabawa, 2023). Furthermore, the ability to analyze problem structures and identify individual components is crucial for systematic problem-solving, as noted by Setiawan, who argues that such skills are essential for developing critical thinking and practical application in mathematics (Setiawan, 2023).

However, the remaining 47% of students faced challenges in effectively segmenting problems, which could impede their systematic approach to complex mathematical tasks. This observation is consistent with research by Iddrisu et al., who found that students' attentiveness and personal discipline significantly correlate with their performance in mathematics, suggesting that those who struggle with decomposition may also lack engagement in the learning process (Iddrisu et al., 2023). Additionally, the difficulties experienced by these students may be exacerbated by factors such as mathematics anxiety, which has been shown to negatively impact problem-solving strategies and overall performance (Guo & Liao, 2022).

To address the challenges faced by the struggling students, the integration of AI-based chatbots in mathematics education could provide valuable support. These chatbots can offer guided problem breakdowns, interactive examples, and scaffolding techniques, thereby enhancing students' decomposition skills. Moreover, the use of technology in teaching mathematics has been shown to positively influence students' performance, as highlighted by Bright, who emphasizes the importance of integrating technology to enhance learning outcomes (Bright, 2024)

In conclusion, while a significant majority of students exhibit strong decomposition skills, a notable portion requires additional support to develop these essential abilities. The implementation of AI-based chatbots in mathematics education presents a promising avenue for assisting these students, ultimately leading to improved problem-solving capabilities and enhanced academic performance. Literature underscores the critical role of technology in fostering mathematical understanding and engagement, thereby reinforcing the need for innovative educational strategies in addressing diverse student needs.

Pattern Recognition: Moderate Challenges in Identifying Recurring Structures

The CT test results show that only 49% of students demonstrated proficiency in pattern recognition, highlighting moderate challenges in identifying recurring structures, relationships, and trends across mathematical problems. This lack of proficiency in pattern recognition is concerning, as it is a crucial skill in computational thinking. Computational thinking encompasses several key skills, including pattern recognition, which allows students to generalize solutions and apply prior knowledge to new problems (Supiarmo et al., 2022). The ability to recognize patterns is fundamental in mathematics and extends to various disciplines, enhancing students' overall problem-solving capabilities (Gunawan, 2023). The lower performance in this area suggests that students may struggle with recognizing relationships between different mathematical concepts, which can lead to difficulties in predicting outcomes or optimizing problem-solving strategies. Research indicates that students who lack strong pattern recognition skills often find it challenging to connect different mathematical ideas, which can hinder their ability to solve complex problems effectively (Nordby et al., 2022). Furthermore, the inability to identify patterns can result in a fragmented understanding of mathematical concepts, making it difficult for students to apply their knowledge in novel situations.

To address these challenges, AI chatbots could play a significant role in enhancing students' pattern recognition abilities. These chatbots can provide interactive exercises, visual pattern recognition tasks, and adaptive quizzes tailored to individual learning needs. Such technology has been shown to foster engagement and improve computational thinking skills among students (Voogt et al., 2015b). By offering personalized feedback and targeted practice, AI chatbots can help students develop a more robust understanding of patterns, ultimately leading to improved problem-solving skills. Additionally, the integration of technology in education has been recognized as a means to enhance learning outcomes, particularly in mathematics, by making abstract concepts more accessible (Santika, 2023).

The findings highlight a critical gap in students' pattern recognition skills, which is essential for effective problem-solving in mathematics. The integration of AI-based tools in educational settings presents a promising opportunity to support students in developing these vital skills. By leveraging technology to provide targeted practice and feedback, educators can help students strengthen their pattern recognition abilities, thereby enhancing their overall mathematical competence and confidence in tackling complex problems.

Abstraction: Difficulty in Identifying Essential Information

Among the four components of computational thinking, abstraction remains a challenging area for many students, with only 56% demonstrating proficiency. This indicates that nearly half of the students struggle to identify core information and eliminate irrelevant details when solving mathematical problems. Since

abstraction is key to simplifying complex problems and developing generalized solutions, difficulties in this area may hinder students' ability to think flexibly and solve problems efficiently. This finding aligns with previous research indicating that abstraction is a challenging skill for many learners, often leading to confusion and inefficiencies in problem-solving processes (Handayani et al., 2022; Sun, 2023). The struggle to distinguish between necessary and extraneous information can hinder students' capabilities in mathematical modeling, algorithm design, and computational efficiency, as these areas fundamentally rely on strong abstraction skills (Amrizaldi, 2024; Saidin et al., 2021). Moreover, students with underdeveloped abstraction abilities may find it difficult to formulate generalizable solutions, which is critical in both academic and real-world contexts (Gong et al., 2020; Özdemir et al., 2021).

The implications of weak abstraction skills are profound, as they can lead to a cascade of difficulties in various domains of learning. For instance, research has shown that students who struggle with abstraction tend to have lower overall problem-solving efficacy, which can impact their performance in mathematics and science (Ridlo et al., 2022; Selby, 2012). The inability to abstract effectively can also affect students' attitudes towards mathematics, as positive self-efficacy in abstract thinking is correlated with a more favorable disposition toward the subject (Özdemir et al., 2021). Furthermore, the development of abstraction skills is not only crucial for academic success but also for fostering critical thinking and logical reasoning, which are essential competencies in the 21st century (Korkmaz, 2012; Olmo-Muñoz et al., 2023).

To address these challenges, the integration of AI-based chatbots in educational settings presents a promising avenue for enhancing students' abstraction skills. These chatbots can provide guided problem simplifications, effectively highlighting key elements in complex word problems and offering real-world application scenarios that reinforce the concept of abstraction (Chevalier et al., 2020; Rojas-López & García-Peñalvo, 2016). By engaging students in interactive learning experiences, AI chatbots can facilitate a deeper understanding of abstraction and its relevance in various contexts, thereby promoting better problem-solving strategies (Saad, 2020). Additionally, the use of gamification techniques in conjunction with AI tools has been shown to enhance student engagement and motivation, further supporting the development of computational thinking skills (Olmo-Muñoz et al., 2023).

Moreover, the role of targeted instructional strategies cannot be overlooked. Research suggests that structured approaches, such as the Concrete-Representational-Abstract (CRA) framework, can significantly improve students' understanding of abstract concepts by providing a clear progression from concrete examples to abstract reasoning (Bouck et al., 2017). This method allows students to build a solid foundation in abstraction, which is essential for tackling more complex problems in mathematics and computer science (Brieven & Donnet, 2024; Ridlo et al., 2022). Furthermore, incorporating collaborative learning environments where students can engage with peers in problem-solving activities can enhance their abstraction skills through social interaction and shared learning experiences (Gong et al., 2020; Saad, 2020).

Ultimately, the low performance in abstraction among students highlights a critical area for educational intervention. By leveraging AI-based tools, structured instructional strategies, and collaborative learning environments, educators can foster the development of abstraction skills, ultimately leading to improved problem-solving capabilities and a more profound understanding of computational thinking. As the educational landscape continues to evolve, it is imperative to prioritize the cultivation of these essential skills to prepare students for the challenges of the future.

Algorithmic Thinking: Limited Proficiency in Step-by-Step Problem Solving

The CT test results reveal that only 19% of students demonstrated proficiency in algorithmic thinking, indicating a substantial gap in students' ability to develop logical, step-by-step procedures for solving mathematical problems. This low level of competency suggests that many students struggle to translate their understanding of a problem into a structured and efficient sequence of actions, which is a fundamental aspect of computational thinking and essential in mathematics problem-solving.

The challenges faced by students in developing algorithmic thinking skills are not uncommon. Studies have shown that students often find it difficult to transition from conceptual understanding to the application of algorithmic processes (Lin et al., 2021; Malik et al., 2021). This gap in skills can lead to inefficiencies in problem-solving, as students may become overwhelmed by the complexity of multi-step problems without a clear procedural framework to guide them. Furthermore, the ability to construct algorithms is critical not only in mathematics but also in various fields such as computer science and engineering, where logical reasoning and

systematic approaches are paramount (de Figueiredo et al., 2022; Santika, 2023). Therefore, fostering algorithmic thinking in educational settings is essential for preparing students to navigate complex challenges in their academic and professional futures (Katyetova, 2023).

To address these challenges, the integration of AI chatbots into the educational process presents a viable solution. These chatbots can be programmed to guide students through problem-solving steps, providing interactive exercises that focus on algorithm-building and offering real-time feedback on their logical reasoning and approach (Kayama et al., 2013; Voogt et al., 2015a). By simulating a supportive learning environment, AI chatbots can help students practice and refine their algorithmic thinking skills in a low-pressure setting, thereby enhancing their confidence and competence in tackling complex problems (Maharani et al., 2019). Additionally, research has shown that technology-enhanced learning environments can significantly improve students' engagement and motivation, which are critical factors in the development of computational thinking skills (Nijenhuis-Voogt et al., 2020).

Moreover, the implementation of structured instructional strategies, such as project-based learning and collaborative problem-solving, can further enhance students' algorithmic thinking abilities (M. Figueiredo et al., 2021; Kayama et al., 2014). These approaches encourage students to work together to devise solutions, thereby promoting a deeper understanding of algorithmic processes through peer interaction and shared learning experiences. Such collaborative environments have been shown to foster critical thinking and creativity, which are essential components of effective problem-solving (Zhong et al., 2015). As educators continue to explore innovative methods for teaching algorithmic thinking, it is crucial to consider the diverse needs of students and tailor instructional strategies accordingly (Milková, 2015).

Developing strong algorithmic thinking skills is crucial for students to navigate complex mathematical challenges, yet current findings reveal only moderate competency in this area. This gap highlights the need for innovative, targeted interventions that foster structured problem-solving abilities. Integrating AI chatbots, refining instructional strategies, and promoting collaborative learning can provide the necessary support to strengthen students' algorithmic thinking. As education continues to evolve in the digital age, ensuring that students are equipped with these essential skills is more critical than ever, preparing them for success in mathematics and beyond.

Perceptions and Expectations of AI Chatbot Usage

The perceptions and expectations of students and lecturers regarding AI chatbot integration in mathematics education provide valuable insights into the potential benefits and challenges of implementing such technology. While many students express enthusiasm for AI-driven learning tools, some remain skeptical about their effectiveness and adaptability. Similarly, lecturers recognize the potential of AI chatbots in enhancing computational thinking (CT) and self-regulated learning (SRL) but emphasize the importance of pedagogical alignment and human interaction in the learning process.

Students' Perceptions: Interest in AI Chatbots as Personalized Tutors

A majority of students view AI chatbots as valuable learning assistants, particularly for providing instant feedback, guiding problem-solving, and offering structured learning experiences. This perception is supported by research indicating that AI tools can enhance student engagement and satisfaction by offering immediate assistance, especially in complex subjects such as mathematics (Baskara, 2023; Lee et al., 2024). Many students highlighted their struggles with understanding intricate mathematical concepts without immediate support, making AI-driven chatbots an appealing tool for on-demand assistance. The expectation is that chatbots will serve as 24/7 virtual tutors, capable of explaining computational thinking concepts, breaking down complex problems, and adapting to individual learning styles (Xu et al., 2024).

However, some students raised concerns about the accuracy and adaptability of AI-generated responses. They questioned whether AI chatbots could effectively address unique problem-solving approaches or provide explanations as detailed as those from human instructors. This concern is echoed in studies that emphasize the importance of personalized feedback and the limitations of AI in replicating the nuanced understanding that human educators bring to the learning process (Chang et al., 2021; Oh et al., 2021). Additionally, some students expressed worries about over-reliance on AI tools, fearing that chatbots might reduce their critical thinking

skills if not implemented correctly. This highlights the need for AI chatbot designs that emphasize interactive learning rather than simply providing direct answers (Černý, 2023; Hu et al., 2024).

The potential for AI chatbots to enhance learning is significant, but it must be balanced with an awareness of their limitations. Research suggests that while AI chatbots can effectively support students in problem-solving by providing immediate feedback, they may not always be able to cater to the diverse cognitive needs of learners (Luo et al., 2021). This necessitates a design approach that prioritizes interactivity and encourages students to engage critically with the material. Furthermore, the integration of AI chatbots into educational settings should be accompanied by pedagogical strategies that promote active learning and critical thinking, ensuring that students do not become overly dependent on technology for their learning (Liang, 2024; Mushaddiq, 2024).

In conclusion, while the majority of students view AI chatbots as beneficial learning tools, it is crucial to address the concerns regarding their accuracy, adaptability, and potential impact on critical thinking. By designing AI chatbots that emphasize interactive learning and integrating them thoughtfully into educational practices, educators can harness the power of technology to enhance students' understanding of complex concepts while fostering essential cognitive skills.

Lecturers' Expectations: AI as a Complementary Tool, not a Replacement

Lecturers acknowledged the potential of AI chatbots in fostering independent learning and strengthening computational thinking skills. The integration of AI chatbots into educational frameworks has been shown to enhance student engagement and learning outcomes through personalized support and collaboration, particularly in mathematics education (Baskara, 2023). These chatbots can assist in reinforcing mathematical concepts by providing step-by-step guidance, which promotes self-regulated learning behaviors among students (Van Doc et al., 2023). Furthermore, the adaptability of AI chatbots allows for customized learning paths tailored to individual students' strengths and weaknesses, thereby enhancing their learning experience (Liang et al., 2024). This adaptive learning capability is crucial as it aligns with contemporary educational practices that emphasize personalized learning environments (Pimentel et al., 2024).

Despite these advantages, lecturers expressed caution regarding the extent to which AI chatbots should be integrated into teaching methodologies. Many emphasized that human interaction remains essential in mathematics education, particularly for fostering higher-order thinking, critical analysis, and conceptual understanding (Wu & Yu, 2023). The fear that AI chatbots could lead to a passive learning experience is well-founded; students might rely excessively on automated answers rather than engaging in deep problem-solving (Wilkins et al., 2023). This concern is echoed in various studies that highlight the importance of maintaining a balance between technology use and traditional instructional methods to ensure that students remain actively engaged in their learning processes (Ilieva et al., 2023). Lecturers recommended that AI chatbots be utilized as supportive tools rather than substitutes for traditional instruction, thereby ensuring that students continue to participate in collaborative discussions, teacher-led explanations, and interactive problem-solving sessions (Fidan & Gencel, 2022).

The role of AI chatbots in education extends beyond mere content delivery; they can also facilitate metacognitive awareness and engagement through adaptive feedback mechanisms (Liang, 2024). This capability is particularly beneficial in environments where immediate feedback is crucial for learning, as it allows students to reflect on their understanding and adjust their strategies accordingly (Abusahyon et al., 2023). Moreover, the use of chatbots can stimulate curiosity and creativity, helping students to understand and apply mathematical concepts to real-world scenarios (Van Doc et al., 2023). However, it is essential to recognize that the effectiveness of AI chatbots is contingent upon their design and implementation, as poorly designed chatbots can lead to frustration and a decline in motivation among students (Wu & Yu, 2023). Therefore, careful consideration must be given to the development and deployment of these technologies to maximize their educational benefits.

In addition to enhancing learning outcomes, AI chatbots can also serve as tools for promoting collaborative learning experiences. By facilitating peer interactions and discussions, chatbots can create a more dynamic learning environment that encourages students to engage with one another and share their insights (Wollny et al., 2021). This collaborative aspect is vital for developing critical thinking skills, as students are often required to articulate their reasoning and challenge each other's perspectives in a supportive setting (Kooli, 2023). Furthermore, the integration of chatbots into educational practices can help bridge the gap between traditional

teaching methods and modern technological advancements, thereby preparing students for a future where digital literacy is paramount (Mahdavi, 2023).

Despite the promising potential of AI chatbots in education, it is crucial to address the ethical implications associated with their use. Concerns regarding data privacy, algorithmic bias, and the potential for miscommunication must be carefully considered to ensure that the deployment of AI technologies does not inadvertently disadvantage certain student populations (Kooli, 2023). Additionally, the reliance on AI chatbots should not overshadow the importance of human educators, who play a critical role in guiding students through complex concepts and fostering a supportive learning environment (Klímová & Seraj, 2023). Therefore, a balanced approach that integrates AI chatbots while preserving the essential elements of human interaction in education is necessary for achieving optimal learning outcomes.

To sum up, while AI chatbots present significant opportunities for enhancing independent learning and computational thinking skills, their integration into educational practices must be approached with caution. The potential benefits of personalized learning, adaptive feedback, and collaborative experiences must be weighed against the risks of passive learning and ethical concerns. By leveraging AI chatbots as supportive tools rather than replacements for traditional instruction, educators can create a more engaging and effective learning environment that prepares students for the challenges of the 21st century.

Conclusion

The findings from this study indicate that students are open to AI chatbot integration, particularly for CT and SRL development. However, challenges such as technological adaptation, instructional alignment, and effective engagement strategies must be addressed. Moving forward, the design and implementation of AI-based chatbots should be student-centered, interactive, and adaptive, ensuring that they serve as meaningful learning companions rather than passive instructional tools.

Recommendations

To enhance the effectiveness of AI-based chatbots in mathematics education, it is recommended that they be designed to specifically support computational thinking skills—including decomposition, pattern recognition, abstraction, and algorithmic thinking—while also embedding features that foster self-regulated learning, such as goal-setting prompts and progress tracking. Chatbots should offer adaptive, personalized learning paths, be seamlessly integrated into existing learning platforms, and include gamified elements and opportunities for peer interaction to maintain student engagement. Additionally, providing training for students and lecturers and conducting ongoing evaluation and refinement are essential to ensure the chatbot remains pedagogically relevant, user-friendly, and aligned with learning goals.

Scientific Ethics Declaration

* This research was conducted in strict accordance with ethical standards governing scientific inquiry. All procedures involving human participants were reviewed and approved by the research ethics committee of the affiliated institution. Prior to data collection, informed consent was obtained from all participants, ensuring that they were fully aware of the purpose of the study, the voluntary nature of their involvement, and their right to withdraw at any time without consequence. All data were treated with strict confidentiality and anonymity and were used solely for academic purposes. No part of this research involved plagiarism, data fabrication, or manipulation. The researchers affirm that the study adheres to the principles of integrity, objectivity, transparency, and respect for participants' rights and dignity, in alignment with the ethical guidelines for educational research.

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

Conflict of Interest

* The authors declare that there is no conflict of interest regarding the publication of this article. All stages of the research, including data collection, analysis, interpretation, and reporting, were conducted independently and without influence from any external parties or funding sources that could affect the objectivity or integrity of the findings.

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