

Leveraging Artificial Intelligence in Mathematics Education to Enhance Students' Digital Literacy and Problem-Solving Skills

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Abstrak

Perkembangan *Artificial Intelligence* (AI) dalam bidang pendidikan mendorong perlunya inovasi pembelajaran matematika yang mampu meningkatkan literasi digital dan kemampuan problem solving siswa. Kegiatan Pengabdian kepada Masyarakat (PKM) ini bertujuan untuk meningkatkan kompetensi digital guru dan siswa melalui pemanfaatan teknologi AI pada pembelajaran matematika. Metode yang digunakan meliputi penyuluhan, pelatihan, *workshop* praktik, pendampingan, dan evaluasi kepada 40 peserta yang terdiri atas guru matematika dan siswa sekolah menengah pertama. Pelaksanaan kegiatan memanfaatkan aplikasi *ChatGPT*, *Gemini AI*, *Canva AI*, dan *GeoGebra AI* sebagai media pembelajaran interaktif. Hasil kegiatan menunjukkan bahwa penggunaan AI mampu meningkatkan keterlibatan siswa dalam pembelajaran, memperkuat kemampuan problem solving matematis, serta meningkatkan kreativitas guru dalam menyusun media pembelajaran digital. Selain itu, kegiatan ini juga mendorong peningkatan literasi digital peserta secara lebih adaptif dan kontekstual. Dengan demikian, *Artificial Intelligence* berpotensi mendukung transformasi pembelajaran matematika berbasis teknologi pada era pendidikan digital.

Abstract

The rapid advancement of Artificial Intelligence (AI) in education necessitates innovative mathematics instruction that fosters students' digital literacy and problem-solving skills. This community engagement initiative aims to enhance the digital competence of teachers and students by integrating AI technologies into mathematics learning. The methodology encompassed counseling, training, practical workshops, mentoring, and evaluation involving 40 participants, comprising lower secondary school mathematics teachers and students. The program utilized applications such as ChatGPT, Gemini AI, Canva AI, and GeoGebra AI as interactive learning media. The results demonstrate that deploying AI effectively increases student engagement, strengthens mathematical problem-solving skills, and boosts teachers' creativity in designing digital learning media. Furthermore, this initiative fosters a more adaptive and contextual advancement of participants' digital literacy. Consequently, Artificial Intelligence holds significant potential to support the transformation of technology-driven mathematics education in the digital era.



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INTRODUCTION

The transformation of education in the digital era has driven a paradigm shift from conventional instruction toward technology-based learning that is more adaptive, interactive, and oriented toward the development of 21st-century skills. One of the technological advancements exerting a significant influence on education is Artificial Intelligence (AI). (Tlili *et al.*, 2023) argue that the presence of AI serves not only as a technological innovation but also as a strategic instrument for enhancing learning effectiveness, personalizing instructional content, and strengthening students' critical thinking and problem-solving skills. In the context of mathematics education, Boonlue (2024) demonstrates that AI can assist students in understanding abstract concepts through visualization, interactive simulation, and faster, more accurate automated feedback. Furthermore, the integration of AI in education is closely linked to the reinforcement of digital literacy as a core

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competence required by students in the Society 5.0 era. (Holmes *et al.*, 2022) explain that utilizing AI in education can create a more personalized, flexible learning environment while increasing student engagement. Meanwhile, (Ouyang *et al.*, 2022) emphasize that AI holds substantial potential for enhancing higher-order thinking skills through data-driven approaches and learning analytics. Conversely, the development of digital technology also poses new challenges in education, particularly regarding the readiness of teachers and students to utilize technology critically, ethically, and productively. Digital literacy is no longer defined merely as the ability to operate technological devices; rather, it encompasses the capacity to access, evaluate, manage, and utilize information responsibly to support the learning process. In mathematics education, these capabilities become increasingly crucial, as mathematics plays a strategic role in developing logical, analytical, and problem-solving skills. (Gutierrez *et al.*, 2025) state that AI can assist students in developing problem-solving skills through adaptive learning and automated feedback systems. In line with this, research by (Hwang *et al.*, 2021) reveals that the deployment of AI in mathematics instruction can enhance learning motivation, analytical skills, and student autonomy in solving mathematical problems systematically. Based on preliminary observations conducted at SMK Avicena, Tangerang Regency, it was revealed that the utilization of digital technology in mathematics education remains suboptimal. The majority of teachers still rely on conventional, lecture-centered instructional methods and repetitive exercises, while the implementation of Artificial Intelligence (AI)-based learning media is severely limited. Furthermore, students' digital literacy is relatively low, particularly in leveraging technology as a productive and educational learning tool. This condition directly impacts students' learning motivation, impedes the development of their mathematical problem-solving skills, and minimizes active student engagement in the learning process. (Firdaus *et al.*, 2025), argue that the poor integration of technology in mathematics instruction causes students to become passive and experience deep difficulties in understanding abstract concepts. In fact, the advancement of AI platforms such as ChatGPT, Gemini AI, Canva AI, and GeoGebra AI holds substantial potential to create more engaging, interactive, and contextual mathematics learning experiences. A needs assessment identified several challenges faced by the partner school. However, based on the level of urgency, the impact on instructional quality, and the feasibility of resolution through a community engagement program, three core priority issues were established as the focus of this initiative. These priorities include: (1) low teacher competence in utilizing Artificial Intelligence as a mathematics learning medium; (2) low student digital literacy in using technology productively and responsibly; and (3) deficient student mathematical problem-solving skills in addressing Higher Order Thinking Skills (HOTS)-based questions. These three interrelated issues directly impact both the process and outcomes of mathematics education at the partner school. The prioritization of these three core issues is based on the premise that teachers serve as the primary agents in implementing pedagogical innovations. Deficient digital competence among teachers prevents various available AI technologies from being optimally utilized to support the instructional process. Conversely, low digital literacy among students results in technology being used predominantly for entertainment rather than as a productive learning tool. Ultimately, these intertwined conditions contribute to students' subpar mathematical problem-solving skills, which represent an essential 21st-century competence. Consequently, an integrated initiative is critically required to address these three challenges simultaneously through training, mentoring, and the implementation of Artificial Intelligence-based mathematics education. Theoretically, this program is underpinned by constructivist theory, which posits that knowledge is actively constructed by learners through meaningful learning experiences (Kohnke *et al.*, 2023; Schunk *et al.*, 2020). Within this framework, Artificial Intelligence can function as a cognitive scaffolding tool that enables students to attain more personalized learning experiences through automated feedback, conceptual visualization, interactive simulations, and real-time error analysis. Furthermore, the program is supported by digital literacy frameworks that conceptualize the critical, creative, and responsible use of technology as a vital competence in navigating digital educational transformation (Ng *et al.*, 2021; Sebire, 2025). From the perspective of mathematics education, the integration of AI aligns with problem-solving theories that emphasize the importance of understanding the problem, devising a plan, executing the strategy, and reflecting on the outcomes obtained (Liljedahl *et al.*, 2016). Therefore, embedding AI into mathematics instruction is deemed highly effective in enhancing learning outcomes while concurrently reinforcing students' critical thinking and problem-solving capabilities. Based on these conditions, the community engagement team organized a program titled The Utilization of

Artificial Intelligence in Mathematics Education to Enhance Digital Literacy and Student Problem-Solving Skills. This program was designed in the form of training sessions, practical workshops, and implementation mentoring for various educational AI platforms, including ChatGPT, Gemini AI, Canva AI, and GeoGebra AI, targeting both teachers and students. The activities focused on reinforcing digital competence, developing interactive learning media, and leveraging AI to facilitate systematic mathematical problem-solving. A participatory approach was employed to ensure that participants not only understood AI concepts theoretically but were also capable of directly implementing them in daily instructional activities. (Zawacki-Richter *et al.*, 2023) emphasize that AI training for teachers is paramount to enhancing digital pedagogical readiness and supporting technology-based learning transformation. Furthermore, research by (Er *et al.*, 2025) demonstrates that the integration of generative AI in mathematics education can boost teachers' creativity in designing innovative learning media while significantly increasing student engagement during the learning process. This community engagement program aims to enhance the digital literacy competence of teachers and students in utilizing Artificial Intelligence (AI) as an innovative and adaptive mathematics learning medium. Additionally, the initiative seeks to improve students' mathematical problem-solving skills through the deployment of AI technologies capable of providing conceptual visualization, step-by-step problem-solving analysis, and real-time feedback. Through this training and mentoring, teachers are expected to develop creative AI-based mathematics instructional models, while students are anticipated to foster critical, analytical, and autonomous thinking skills in resolving mathematical problems. (Ramadhani *et al.*, 2025) explain that the integration of AI in mathematics education can assist students in developing reflective thinking skills and improving the effectiveness of complex problem-solving. Meanwhile, (Kumbo *et al.*, 2023) state that AI contributes substantially to reinforcing digital literacy and student readiness to face 21st-century educational challenges. Furthermore, this program is designed to support the implementation of technology-based education in the digital era, while simultaneously establishing a culture of ethical, responsible, and quality-oriented AI utilization. Consequently, this community engagement initiative is expected to provide a tangible contribution to strengthening the quality of mathematics education and preparing the younger generation for the challenges of Industrial Revolution 4.0 and Society 5.0. (Heinsfeld *et al.*, 2025) emphasize that the utilization of AI in education must be directed toward developing digital competence, creativity, and critical thinking skills to enable learners to adapt to continuous global changes. This program is expected to yield significant benefits for various stakeholders. For teachers, it enhances digital pedagogical competence and the ability to integrate Artificial Intelligence (AI) into mathematics instruction. For students, it fosters digital literacy, critical thinking, creativity, and mathematical problem-solving skills. For the institution, it supports technology-based educational transformation and reinforces a culture of pedagogical innovation. Furthermore, this initiative serves as a model of best practice for utilizing Artificial Intelligence in mathematics education, which can be replicated in other schools to contribute to the advancement of national educational quality.

METHODS

This community engagement initiative employed a comprehensive methodology comprising socialization, training sessions, practical workshops, mentoring, and evaluation to enhance the capacity of teachers and students in utilizing Artificial Intelligence (AI) for mathematics education. This multi-stage method was selected to ensure that participants transitioned from theoretical understanding to direct implementation within instructional activities. A participatory approach was adopted to foster active engagement across all sessions. The program involved 30 participants, consisting of mathematics teachers and vocational high school (SMK) students from the partner institution. Participants were purposively selected based on institutional needs regarding digital literacy enhancement, the reinforcement of educational technology competencies, and readiness to integrate AI into mathematics learning. The initiative was executed through several structured phases designed within a one-day intensive program: Pre-implementation Phase: Conducted prior to the event, this phase involved preliminary observations, a partner needs assessment, coordination with school authorities, and the development of instructional materials and training modules. Socialization and Training Phase: On the day of implementation, the program commenced with socialization regarding the fundamental concepts of AI, digital literacy,

opportunities and challenges of AI in education, and its specific application in mathematics. Subsequently, participants engaged in hands-on training and practical workshops utilizing various AI platforms, including ChatGPT, Gemini AI, Canva AI, and GeoGebra AI, to facilitate instructional media development, Higher Order Thinking Skills (HOTS)-based question design, and the visualization of abstract mathematical concepts. Mentoring and Implementation Phase: Following the training sessions, participants received direct mentoring to implement AI applications for solving mathematical problems and developing interactive learning activities. Evaluation Phase: In the final stage, an evaluation was conducted via pre-tests and post-tests, participant activity observations, and the administration of response questionnaires to measure the increase in participants' comprehension of AI utilization. The evaluation results served as a baseline to assess program effectiveness and to provide follow-up recommendations for the partner school. This community engagement initiative was conducted over a single day in February 2026 at SMK Avicena, Tangerang Regency, serving as the partner school. The site selection was grounded in a needs assessment that highlighted an urgent requirement to enhance the digital competence of teachers and students, alongside optimizing AI integration in mathematics instruction. Through this initiative, it is anticipated that a more innovative, interactive, effective, and adaptive mathematics learning environment will be established, while.

RESULTS AND CONCLUSION

Results

The implementation of this community engagement program, which focused on optimizing the utilization of Artificial Intelligence (AI) in mathematics education, yielded various positive outcomes, particularly in enhancing digital literacy and students' mathematical problem-solving skills. The program was executed through a series of activities comprising socialization, training, hands-on practice, and implementation mentoring for several AI-based platforms, including ChatGPT, Gemini AI, Canva AI, and GeoGebra AI. Data regarding the program's outcomes were gathered through a combination of field observations, interviews, pre-test and post-test measurements, and the administration of questionnaires to the participating mathematics teachers and students. The analysis demonstrated that the program made a tangible contribution to enhancing participants' capacity to leverage AI technology as a more effective and engaging mathematics learning tool. In line with these findings, (Yusuf *et al.*, 2024) state that hands-on, practice-based training effectively enhances teachers' skills in integrating Artificial Intelligence into mathematics instruction. These results indicate that practice-based training methods are significantly more effective than unidirectional, theoretical presentations. Preliminary findings revealed that the digital literacy levels of both teachers and students prior to the program remained relatively limited. Although most teachers had incorporated digital devices into their instruction, their utilization was confined to material presentations and had not yet progressed toward leveraging AI as an instructional instrument. Furthermore, teachers' capacity to design Higher Order Thinking Skills (HOTS) based questions, develop digital media, and implement personalized learning through technology was suboptimal. These conditions indicate that technology-based learning transformation at the partner school still requires more systematic reinforcement. A similar situation was observed among the student group. The majority of learners utilized digital devices primarily for communication and entertainment purposes, whereas the application of technology to support their learning process remained severely constrained. Preliminary survey results indicated that only a small fraction of students were aware of AI's potential to facilitate the understanding of mathematical concepts and to solve mathematical problems autonomously. This deficient academic digital literacy directly hindered students' ability to critically select, interpret, and utilize digital information as an educational resource. In terms of academic performance, the pre-test results revealed that students' mathematical problem-solving skills required substantial improvement. Many students experienced difficulties when encountering tasks that demanded higher-order reasoning, particularly within algebraic and geometric topics. The majority still relied on rote memorization of formulas without understanding the underlying concepts. Furthermore, their capacity to identify critical information, formulate resolution strategies, and construct logical arguments was relatively low. These findings suggest that the existing

instructional process had not fully provided learning experiences that foster active exploration, reasoning, and problem-solving. This initial condition is detailed in Table 1.

Table 1. Pre-test and Post-test Results of Teachers' Digital Competence and Students' Problem-Solving Skills.

Variable	Indicator	Pre-Test	Post-Test	Improvement
Teachers' Competence	Digital Integration of Artificial Intelligence (AI) in Teaching and Learning	45	84	39
	Development of AI-Assisted Higher-Order Thinking Skills (HOTS) Assessment Items	40	82	42
	Development of Digital Learning Media	51	84	33
	Average	45.3	83.4	38.1
Students' Solving Skills	Problem-Problem Identification and Understanding	58	81	23
	Selection of Problem-Solving Strategies	54	79	25
	Problem Resolution and Execution	52	78	26
	Drawing Conclusions	61	82	21
	Average	56.2	80.1	23.9

To assess the program's effectiveness, pre- and post-activity measurements were conducted. The analysis revealed significant improvements in both teachers' digital competence and students' problem-solving abilities. Specifically, the mean score for teachers' digital competence escalated from 45.3 to 83.4 following the training and mentoring sessions. Concurrently, students' average mathematical problem-solving skills advanced from 56.2 to 80.1. These data demonstrate that integrating AI into mathematics education can strengthen digital competence while simultaneously elevating the quality of students' mathematical thinking processes. This aligns with Chiu *et al.*, (2022) who stated that AI can facilitate personalized mathematics learning and enhance students' critical thinking through adaptive feedback mechanisms." This suggests that AI can foster a more personalized learning experience tailored to individual student needs. The successful implementation of the program was further augmented by the active engagement of the partner school. The institution played a pivotal role in providing facilities, coordinating participants, and supporting the entire sequence of activities. While teachers enthusiastically attended every training and practical session, students demonstrated active participation in exploring AI applications for mathematical problem-solving. Ultimately, the synergy between the implementation team and the partner institution served as a critical factor in achieving the program's objectives.

Discussion

The enhancement of teachers' digital competence underscores that practice-based training yields a more effective learning experience compared to a solely conventional, lecture-based approach. Post-intervention, teachers were capable of leveraging ChatGPT and Gemini AI to construct instructional designs, develop AI-driven HOTS items, and provide more structured explanations of mathematical concepts. Moreover, Canva AI facilitated the creation of visually compelling learning media, whereas GeoGebra AI enhanced the visualization of abstract mathematical concepts that were hitherto challenging to grasp. These insights suggest that AI acts as a catalyst to amplify teachers' pedagogical creativity and innovation. Regarding the student perspective, AI integration engendered a more dynamic and interactive learning environment. Throughout the program, students demonstrated heightened engagement in discussions, increased confidence in inquiry, and a more robust capacity to explore alternative problem-solving pathways. The deployment of AI-powered chatbots allowed for instantaneous feedback, making the learning process substantially more personalized and adaptive. Furthermore, the geometric and algebraic visualizations offered by GeoGebra AI effectively scaffolded students' understanding of interconnected mathematical concepts, transitioning them into more concrete terms. The advancement in post-test scores demonstrates that the integration of AI contributes significantly to reinforcing students' mathematical problem-solving abilities. Students acquired not only the final solutions but also a comprehensive understanding of the systematically presented procedural steps. This condition facilitated the development of analytical skills, logical reasoning, and reflective thinking during mathematical problem-solving tasks. Consequently, these findings align with a robust body of literature indicating that AI-driven learning systems effectively support personalized learning environments and elevate

students' critical thinking capacities. When contrasted with conventional pedagogical approaches, AI-supported learning offers significantly higher flexibility and adaptivity. In traditional instruction, students frequently function as passive recipients of information. Conversely, the integration of AI encourages learners to engage in autonomous exploration, receive instantaneous feedback, and grasp complex concepts through diverse visual and interactive representations. Consequently, AI holds substantial potential as an innovative solution to elevate the quality of mathematics education. Nevertheless, the implementation of this program encountered several notable challenges. Limited internet access and the scarcity of digital devices emerged as primary barriers for a segment of the participants. Furthermore, a pronounced variance in technological proficiency was observed among the teachers, thereby requiring more intensive, individualized mentorship for certain participants. Another critical challenge pertains to the ability to construct effective prompts, which is essential for ensuring that AI generates outputs aligned with specific instructional needs. In addition to technical constraints, the ethical dimensions of AI utilization emerged as a critical concern. Some students exhibited a tendency to leverage AI to obtain instantaneous answers without engaging in deep cognitive processing. Consequently, throughout the activities, it was strictly emphasized that AI must be utilized as a cognitive tool to scaffold learning, rather than a substitute for students' own reasoning processes. This approach is paramount to ensure that technological integration remains oriented toward fostering critical thinking, creativity, and self-regulated learning. The mentorship provided throughout the program proved to be a decisive factor in the successful implementation of AI. Through consultation sessions, hands-on practice, reflection, and evaluation, both teachers and students were afforded opportunities to gain a deeper comprehension of AI applications. Furthermore, this supportive process assisted participants in overcoming various technical and pedagogical hurdles encountered during the activities. This aligns with (Syam *et al.*, 2025) who asserted that intensive mentorship is a critical determinant in the successful integration of Artificial Intelligence within mathematics education. These findings underscore that successful AI integration in education depends not merely on the technology itself, but inherently on a sustained and continuous mentorship process. The program yielded several significant outputs, including the enhancement of both teacher and student digital competencies, improved mathematical problem-solving abilities, and the compilation of a training module on AI integration in mathematics education. Additionally, it produced AI-driven instructional media, comprehensive activity documentation, publications in online media, and a scientific article dedicated to community engagement. These deliverables demonstrate that the program's impact extends beyond short-term outcomes, providing tangible resources that can be utilized sustainably by the partner institution. As a follow-up action, the partner school intends to integrate AI applications more broadly across mathematics and other academic disciplines. To ensure the long-term sustainability of the program, the future agenda includes establishing teacher professional learning communities, conducting advanced training sessions, and designing AI-based instructional designs. Consequently, this community engagement program not only enhances participant competencies but also catalyzes sustainable pedagogical innovations that support digital educational transformation in the Society 5.0 era.

CONCLUSION

This community engagement program on the integration of Artificial Intelligence (AI) in mathematics education proved highly effective in enhancing teachers' digital competence and students' mathematical problem-solving abilities. Evaluation results indicated a substantial increase in teachers' average digital competency scores from 45.3 to 83.4, and students' problem-solving proficiency from 56.2 to 80.1, following a series of socialization, workshops, hands-on practice, and mentorship sessions utilizing ChatGPT, Gemini AI, Canva AI, and GeoGebra AI. The implementation of AI not only assisted educators in developing instructional media and Higher-Order Thinking Skills (HOTS) assessments but also empowered students to engage in a more active, interactive, and adaptive learning environment through real-time feedback and concrete conceptual visualizations. The program's success was driven by the active participation of the partner institution, teachers, and students throughout all phases. Despite constraints regarding limited digital infrastructure, variations in technological literacy, and ethical challenges in AI adoption, intensive mentorship emerged as a decisive factor

in driving successful implementation. Beyond immediate skill acquisition, the initiative yielded a training module, AI-driven learning materials, and a scientific manuscript for sustainable utilization. Consequently, integrating AI into mathematics education represents a highly innovative strategy to fortify digital literacy, critical thinking, and problem-solving skills, while simultaneously accelerating digital educational transformation toward the Society 5.0 era.

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