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AI-powered Personalization for Learning and Human-Robot Interaction: A Case Study with Pre-Service Teachers from Indonesia

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Abstract

The rapid advancement of Artificial Intelligence in Education (AIEd) presents unprecedented opportunities to improve learner engagement through personalized instruction and human-robot social interaction (HRSI). However, AI implementation in pre-service teacher education in Indonesia remains limited and underexplored. This study investigated the impact of AI-powered personalization on learning outcomes and social interactions among Indonesian pre-service teachers. Employing a mixed-methods design, the study involved 20 participants using the virtual AI tutor "Cicibot" to support personalized and collaborative learning. Quantitative data were collected via structured questionnaires and analyzed using Pearson correlation, while qualitative insights were obtained from semi-structured interviews. Findings revealed a significant and positive correlation between AI-driven personalization, learner engagement, and social interaction, highlighting the effectiveness of AI tools in fostering meaningful collaboration. This study provides practical implications for AI integration in educational settings, offering insights for future policy and curriculum development in technologically emergent regions.

Keywords: AI-powered personalization, human-robot interaction (HRI), pre-service teachers, personalized learning and collaborative learning, Indonesia

Improving people's quality of life through digital transformation has become a significant driver of growth and development. The emergence of computing science, the expansion of various sectors, and the rapid shift to e-science have resulted from developments in digital technology and easy access to large amounts of data. In response to the rise of intelligent computing, computer literacy and enhanced computing skills have become key competencies that drive technological progress, particularly in manufacturing (Muthmainnah et al., 2025). The availability of affordable computing power and vast amounts of data has fueled the advancement of machine learning.

Artificial neural networks have attracted interest from both the commercial and academic sectors as a result of digital technology. Today, a wide range of applications, including translation, image analysis, self-driving cars, automated customer service, fraud detection, process control, synthetic art, and service robots, utilize neural AI and machine learning techniques (Bibri et al., 2024; Ekin et al., 2025; Khang et al., 2023). By integrating communication technology with virtual reality, artificial intelligence is revolutionizing all aspects of socio-economic life. The introduction of AI into the classroom impacts all facets of learning, cognition, and societal progress (Harishree & Jayapal, 2024). Despite this, a major problem persists: many schools still fail to recognize the importance of using technology in teaching, which has significantly delayed the implementation of AI and prevented it from receiving adequate attention. However, digital transformation has significantly impacted the field of education. Across the globe, secondary and higher education institutions have been profoundly influenced by this revolution in terms of the technology they use in the classroom (Salha, Mousa, & Khayat, 2025; Wang et al., 2025). This has also sparked curiosity and enthusiasm for AIEd, or artificial intelligence in education, among academics and practitioners of contemporary pedagogy.

In the contemporary landscape of education, the rapid advancement of artificial intelligence in education (AIEd) is presenting unprecedented opportunities for enhancing learner engagement via personalized instruction and human-robot social interaction (HRSI). However, in many developing countries like Indonesia, numerous obstacles hinder the improvement of education quality. A primary issue is the uneven adoption of digital technology in the classroom, stemming from teachers' low technology adoption rates and a lack of knowledge on effectively teaching and training students. As a result of a combination of factors, promoting sustainable societal growth through AI requires coordinated efforts from various institutions (Al Yakin et al., 2025). For example, a global lack of consistent university policies has implications for how effectively and logically students learn (Chiu, Ahmad, & Çoban, 2025; Mouta, Torrecilla-Sánchez, & Pinto-Llorente, 2025). Although AI can increase student access to education, foster a collaborative environment, improve 21st-century skills, create an engaging and enjoyable classroom atmosphere, and boost motivation, its implementation remains a challenge compared to its potential benefits (Harishree & Jayapal, 2024).

In light of these challenges, significant research has been conducted on the development of personalized learning through the application of AI in the modern educational environment. Rasjid et al. (2023) and Aktaş (2025) found that students learned more and were more focused when collaborating with classmates. To motivate and enhance learning, students who learn best in groups encourage each other to ask questions, provide explanations, share opinions and justifications, explain and reflect on their knowledge, and express their reasoning. According to Spitzig and Renner (2025), these benefits necessitate active, well-functioning learning teams. Simply placing students in groups and assigning tasks does not guarantee effective peer learning. While some peer groups interact with little difficulty, others struggle to balance leading, following, understanding, and encouraging one another. When a group project fails, it undermines the value of collaboration for learning and, worse, the value of the learning process itself (Howley, Dyson, & Baek, 2025). Furthermore, according to Stamatios (2024), students not exposed to an integrated work environment or who have not participated in team projects do not acquire the necessary social skills to operate effectively in teams.

Moreover, traditional lecture-oriented schools often fail to teach these skills. Effective teachers, however, equip their students with the knowledge and abilities to understand the material and work together effectively in groups. Just as students in traditional classrooms rely on their teacher's direction and support, students learning through technology also need it online (Hanstedt, 2024). The lack of proficiency in social interactions is a common complaint among educational academics and technologists working on computer-supported collaborative learning problem-solving learning (CSCL) systems (Ioannou & Gravel, 2024; Sun et al., 2025). They understand that for students to master these skills, they need practice, encouragement, and direction. Although much research has examined small group collaboration, there is no comparable experience in the use of technology-supported small groups (Marchand & Hilper, 2024; Qadri et al., 2025).

This study aims to fill a knowledge gap by investigating the types of technological assistance necessary for effective social interactions in group learning environments. The research analyzes peer group interactions within intelligent collaborative learning systems to encourage productive social engagement. The investigation sought to determine which aspects of social interaction are most helpful in facilitating productive group learning with AI applications. In line with this, Glaistar et al. (2024) discuss the impact of collaborative learning in general, but more specifically, they reflect this approach by arguing about the impact of categories of interaction. A comprehensive collaborative learning model can be constructed based on these interaction categories (Glaister et al., 2024), allowing for the dissection and characterization of the actions of productive learning teams using a computer (Kaliisa et al., 2025).

In a novel approach, this study distinguishes itself by specifically focusing on the dynamics of AI-powered personalization in an Indonesian higher education setting. While other research has examined AI's influence on individualized learning, this study explicitly investigates how virtual robots can improve learning outcomes and manage student-teacher interactions. Combining AI-driven adaptive learning with human-robot social interaction offers a novel approach to promoting engagement and cooperative learning (Hutson et al., 2022). The study also presents an AI-based tutor, providing a new perspective on how artificial intelligence can be used for educational development by tracking student achievement, personalizing feedback, and facilitating group discussions. The empirical data presented in this paper addresses a research gap by demonstrating the clear benefits and challenges of AI implementation in authentic classroom environments.

Human-robot social interaction (HRSI) learning systems can employ strategies to foster effective interactions within each collaborative learning category (Ekström, Pareto & Ljungblad, 2025). HRSI is capable of selecting the most suitable approach through the analysis of group discussions and activities by embodying models that outline the components of effective personalized AI learning and supporting strategies (Kim, 2024). This article examines AI-powered personalization as a means to enhance learning and discusses how to construct systems that can analyze and facilitate learning interactions with AI. This study addresses several significant gaps in the current literature (Hassan, 2022). A major omission is the incorporation of non-human entities, such as digital feedback systems and AI algorithms, into classroom instruction. Existing research often views digital technologies as objective facilitators, largely ignoring their dynamic role in shaping educational experiences. Furthermore, unexamined ethical consequences, such as algorithmic bias and data privacy concerns, arise from decentralizing the human perspective. Therefore, this study aims to answer how AI personalization affects social interaction dynamics among Indonesian pre-service teachers.

Methodology

Research Design

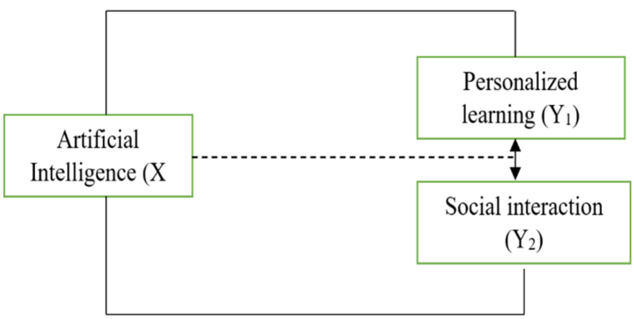
This study employed a mixed-methods approach (Poth, 2023) to examine how AI-powered personalized learning experiences affect student engagement and human-robot social interactions in the classroom. This approach combines quantitative and qualitative research methods to ensure a comprehensive understanding of the phenomenon (Creswell, 2017). This methodology allows for a multi-faceted view of AI-powered learning outcomes, enabling the statistical analysis of learning trends and an in-depth exploration of student experiences, as shown in Figure 1.

Quantitative Methodology

The quantitative component utilized a correlational design to examine the relationship between three core variables: personalization (X), personalized learning (Y_1), and social interaction (Y_2). Pearson correlation was chosen for its suitability in measuring linear associations within the small sample. This design investigated the relationship between pre-service teachers' engagement with AI-powered personalized learning and their social interactions with robots in a classroom setting.

Figure 1

Research Design



Quantitative Methodology

Qualitative data were collected through semi-structured interviews conducted over several sessions from March 7 through 11, 2024. Ten open-ended questions were used to explore participants' perceptions of AI's impact on their learning experiences, including motivation, feedback reception, and collaborative engagement.

Data Source

The study's population consisted of 186 pre-service teachers enrolled in the teacher professional education program at Universitas Al Asyariah Mandar, Indonesia, during the 2023-2024 academic year. A purposive sampling technique was used to select a sample of 20 pre-service teachers for the study. All respondents were middle and high school teachers without prior exposure to artificial intelligence. The participants between 23 and 29 years old were 45% female and 55% male. They expressed enthusiasm and agreed to participate in learning with AI technology.

While a sample size of 20 participants may appear limited to traditional quantitative analysis, it is considered acceptable for specific research designs, especially pilot studies, quasi-experiments, and repeated-measures designs. As Johanson and Brooks (2010) noted, a sample size of approximately 20–

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30 participants can be sufficient for preliminary or exploratory studies to evaluate feasibility, refine procedures, or identify potential effect sizes. This is particularly relevant in experimental studies with a between-subjects design, as inter-subject variability is minimized, which increases statistical power even with a smaller sample (Lakens, 2013). Moreover, small sample sizes can still yield meaningful insights when interventions are tightly controlled and measurements are precise, provided that the assumptions of statistical tests are met and effect sizes are reported to interpret practical significance (Field, 2024).

Research Procedure

This study's findings are limited in relevance to other cultural and educational environments due to its exclusive focus on Indonesian teacher candidates. Several factors influenced the decision to conduct the study in Indonesia. First, the country offers a unique case study because of its diverse educational landscape. Second, the increasing national interest in AI-based education provides an ideal environment to study AI's impact on learning. Finally, the choice was guided by logistical and resource limitations. The Cici bot was selected for its Indonesian language features. After downloading, pre-service teachers were instructed to pay close attention to the application's user instructions, as shown in Figure 2. Researchers observed the interaction process for 14 weeks, from September 2023 to January 2024, which allowed them to reliably measure the knowledge gains of the prospective teachers. No one commented on or criticized the Cici bot during the observation period.

Figure 2

Personalized and Human Robot Social Interaction (HRSI) in action

Research Instrument

A questionnaire was designed to measure pre-service teachers' impressions of the robots, including verbal and nonverbal measures of closeness. This was done using a 5-point Likert scale, as shown in Table 1. Additionally, observations were conducted to record the behavior and interactions of the participants during the learning process with the virtual robots.

Table 1

Likert Scale

Category	Score
Very good	5
Good	4
Moderate	3
Low	2
Very Low	1

Table 2

Reliability Statistics

Cronbach's Alpha	N of Items
0.916	20

As shown in Table 2, the reliability statistics demonstrate a Cronbach's Alpha value of 0.916 of the 20 survey items. This value indicates that the instrument used to measure students' opinions on AI-integrated sociology education has strong internal consistency. A Cronbach's Alpha score above 0.90 is generally considered highly reliable in educational and social science research, suggesting that all questionnaire items are well-aligned and consistently measure the underlying constructs, such as personalized learning and social interaction in an AI-mediated environment.

Data Analysis

Data analysis was performed using IBM SPSS version 26 after converting the collected data into a more manageable format. Pearson correlation tests were employed in the quantitative phase to assess linear relationships between variables. Scores were classified based on the predefined Likert scale, and reliability checks were conducted across all instruments. A P-P (Probability-Probability) plot normality test confirmed that the data for personalized learning and social interaction were normally distributed. In the qualitative phase, data were analyzed using a thematic approach, coding responses into categories such as motivation, engagement, content comprehension, peer interaction, and feedback effectiveness. Finally, insights from both phases were triangulated to ensure consistency and enrich the overall interpretation.

Scope and Limitation

The study is limited in geographic and demographic scope, focusing exclusively on Indonesian pre-service teachers at a single institution. The small sample size (n=20) restricts the generalizability of the findings, though it is sufficient for qualitative saturation. Since it was conducted over one academic semester, the study could not capture the long-term impacts of AI personalization. Additionally, the AI tool (Cici bot) is language- and context-specific, which may further limit its applicability in other educational or cultural settings.

Ethical Considerations

Participation in the study was voluntary, and informed consent was obtained from all participants. Participants were also made aware of their right to withdraw at any time without penalty. Anonymity and confidentiality were upheld throughout data collection and reporting. All data were stored securely and used exclusively for academic research. The AI application did not collect sensitive personal data, and all interactions with the system occurred via institutionally approved platforms. The research adhered to the ethical standards outlined by the university and conformed to best practices in educational research.

Results and Discussion

The results of this study are presented using descriptive statistics to provide a comprehensive overview of participants' perceptions regarding the usability and effectiveness of the AI-powered robot tutor during one-on-one learning sessions. Table 3, which includes 10 items, describes participants' beliefs and attitudes toward the AI-powered robot tutors.

Table 3

AI Cici Bot in Learning (X)

Statements	N	Min	Max	Mean	Std. Deviation
How comfortable do you feel interacting with the Cici AI bot during learning sessions?	20	3.00	5.00	4.2500	.71635
Do you believe that the Cici AI bot enhances your personalized learning experience?	20	3.00	5.00	4.1500	.74516
How effective is the Cici AI bot in adapting learning materials to your individual needs and learning pace?	20	3.00	5.00	4.3500	.67082
To what extent does the Cici AI bot stimulate social interactions and discussions with your classmates?	20	3.00	5.00	4.2000	.76777
Do you find the feedback provided by the Cici AI bot helpful in improving your learning performance?	20	3.00	5.00	4.3000	.73270
How satisfied are you with the ease of use and user interface of the Cici AI bot?	20	3.00	5.00	3.9000	.78807
Do you feel that using the Cici AI bot increases your motivation to learn?	20	3.00	5.00	4.2000	.76777
How confident are you in the security and privacy of your personal data when interacting with the Cici AI bot?	20	3.00	5.00	4.3500	.74516
Would you like to continue using the Cici AI bot in your learning process in the future?	20	3.00	5.00	4.5500	.68633
Do you think the Cici AI bot contributes to a more effective and enjoyable learning environment?	**20**	**3.00**	**5.00**	**4.5000**	**.76089**
Valid N (listwise)	**20**				

As shown in Table 3, most participants provided positive feedback on the Cici AI bot, with an average score of 4.0 or higher across most items. The participants indicated that certain factors made the bot useful and engaging for learning. These findings suggest that AI-driven teaching tools can enhance personalized learning, intrinsic motivation, and social interaction in the classroom.

Table 4

Descriptive Statistics of Personalized Learning Survey

(Y_1)	N	Min	Max	Mean	Std. Deviation
What is your comfort level with interacting with the robot tutor during learning sessions?	20	3.00	5.00	4.4500	.60481
I feel AI-infused tutor robots can enhance the personalized learning experience.	20	3.00	5.00	4.3000	.73270
I believe Robot Tutor is effective in adapting learning methods to suit learning styles in the 21st century.	20	3.00	5.00	4.4500	.68633
I am satisfied with the personal feedback provided by the robot tutor.	20	3.00	5.00	4.2500	.63867
I believe the tutor robot can understand my individual needs in the learning process (answering questions and providing ideas and concepts).	20	3.00	5.00	4.2000	.61559
I am sure there is a personalization effect provided by the robot tutor on my understanding of the learning material.	20	3.00	5.00	4.2000	.83351
I believe that interaction with the robot tutor stimulates social discussions between students during learning sessions.	20	3.00	5.00	4.2000	.76777
I am motivated by the personalization provided by the robot tutor.	20	3.00	5.00	4.0000	.85840
I believe personalized AI learning can enhance meaningful EFL learning experiences.	20	3.00	5.00	4.3500	.58714
In my opinion, new technologies, such as artificial intelligence, contribute to a more effective EFL language learning environment.	**20**	**2.00**	**5.00**	**4.0500**	**.82558**
Valid N (listwise)	**20**				

Based on the survey results in Table 4, the data show that participants' perceptions of the robot tutor's engagement were generally positive across several domains, including comfort, efficacy, happiness, motivation, and impact on social interactions during learning sessions.

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Table 5

Descriptive Statistics of Social Interaction Survey

(Y_2)	N	Min	Max	Mean	Std. Deviation
I feel involved in social interactions with fellow classmates caused by the robot tutor (discussing with classmates about the robot tutor's answers).	20	2.00	5.00	3.9000	.91191
2. I believe the robot tutor's ability to help me overcome learning difficulties (e.g., material, making questions, answering questions, and information)	20	3.00	5.00	4.2000	.76777
Tutor Robot can understand your preferences regarding learning style.	20	3.00	5.00	4.1500	.74516
I am sure that the security of personal data is guaranteed during my interaction with Tutor Robot.	20	3.00	5.00	4.2500	.71635
A robot tutor facilitates collaborative learning between students (classmates).	20	3.00	5.00	4.1000	.78807
I am actively involved in learning activities guided by the help of a robot tutor.	20	3.00	5.00	4.2000	.69585
What is the level of adaptability of the tutor robot in responding to your changing learning needs?	20	3.00	5.00	4.1500	.67082
How much does Robot Tutor's level of personalization aid in the development of your social skills?	20	3.00	5.00	4.1500	.67082
What is your level of satisfaction with the Robot Tutor user interface?	20	3.00	5.00	4.1500	.74516
What is your level of readiness to continue using a robot tutor in your learning process?	**20**	**3.00**	**5.00**	**4.5000**	**.60698**
Valid N (listwise)	**20**				

Table 5 presents data on 10 variables related to how participants perceived the robot tutor's assistance in interactions. The mean scores, ranging from 3.90 to 4.50, indicate a generally positive attitude across several dimensions, such as their participation in social interactions, the robot tutor's assistance in overcoming learning challenges, its responsiveness to evolving learning needs, and improving their social skills.

The correlation statistics are presented in Table 6. The results, at the 0.01 level of significance (2-tailed), indicate a strong linear relationship between the three variables. The Pearson correlation coefficient between personalization (X) and personalized learning (Y_1) was 0.983, indicating a very substantial positive correlation. Similarly, the Pearson coefficient between personalization (X) and social interaction (Y_2) was 0.879, and the Pearson coefficient between personalized learning (Y_1) and social interaction (Y_2) was 0.870. Both of these also indicate a significant positive correlation.

Table 6

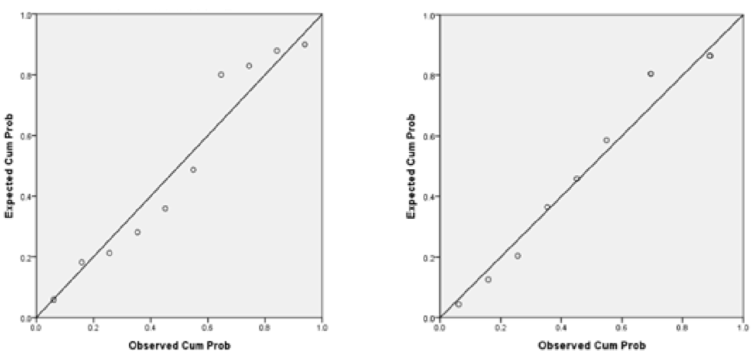
Pearson Correlation

		X	Y_1	Y_2
X	Pearson Correlation	1	.983**	.879**
	Sig. (2-tailed)		.000	.000
	N	20	20	20
Y_1	Pearson Correlation	.983**	1	.870**
	Sig. (2-tailed)	.000		.000
	N	20	20	20
Y_2	Pearson Correlation	.879**	.870**	1
	Sig. (2-tailed)	.000	.000	
	N	20	20	20

*Note: ** Correlation is significant at the 0.01 level (2-tailed).*

Figure 3

P-P Plot of Personalized and Social Interaction



As shown in the P-P plot in Figure 3, the data for both social interaction and personalized learning are normally distributed. The diagram juxtaposes the observed cumulative distribution with the expected cumulative distribution of the normal distribution. The points on the P-P plot align with the diagonal line, confirming that the personalized learning and social interaction variables approximately follow a normal distribution.

Overall, the quantitative survey results revealed high mean scores across all AI personalization and HRSI items, with average responses ranging from 4.00 to 4.55 on a 5-point Likert scale. Table 6, for instance, demonstrates a strong positive correlation between personalized learning and social interaction (r=.870, p<.01). Similarly, a strong positive correlation was found between AI personalization and social interaction (r=.879, p<.01). These correlations indicate interconnected growth in both cognitive and social domains through AI-assisted instruction.

The qualitative analysis further supported these findings. Participants described how AI-driven tools facilitated better content comprehension, boosted motivation, and encouraged peer discussion. Most participants expressed enthusiasm for the real-time feedback and tailored learning paths, indicating a positive overall perception of AI as a collaborative educational agent.

Additionally, the semi-structured interviews strengthened the data obtained about the dynamics of AI-powered personalization for enhanced learning and human-robot social interaction in education. The following presents a summary of the interview findings and insights from the respondents.

Question 1: How has your learning experience been impacted by personalization powered by AI? *(Extracts 1-6 from interviews conducted on March 7, 2024)*

A participant reported, "AI made my learning experience more meaningful by providing personalized content that matched my learning pace and preferences" (Extract 1). The participant felt more invested and inspired since AI-driven feedback had helped them spot and fix misconceptions faster (Extract 1).

Another found that after using AI-powered learning, the participant felt more self-reliant in their study time management abilities (Extract 2). The participant also observed how AI-driven suggestions had helped improve self-regulated learning by highlighting weak spots and bolstering strong ones (Extract 2). On the other hand, the participant occasionally mentioned how frustrating it was when AI misunderstood their requirements (Extract 2).

AI system's interactive material kept the participant interested, which in turn improved the participant's excitement for learning (Extract 3). The immediate response was constructive, allowing the participant to rapidly enhance his comprehension (Extract 3). However, the participant found that AI was not always up to par when providing in-depth, context-specific answers that a human educator could (Extract 3).

A different participant highlighted how AI improved the organization and focus of learning (Extract 4). This participant emphasized how the system's progress tracking capabilities kept them motivated and on task (Extract 4). A major obstacle was getting used to the AI's response style, since it occasionally gave general explanations instead of ones tailored to the current situation (Extract 5).

One participant expressed concern, "One major problem was that AI solutions were not very adaptable" (Extract 6). The participant found that AI occasionally restates earlier responses rather than provides fresh information in response to follow-up queries. A more fruitful discussion about learning was, thus, hindered (Extract 6). Another participant felt AI was ineffective in helping her build her critical thinking skills since it failed to give relevant instances or go beyond predetermined patterns (Extract 7).

Question 2: During your interactions with the AI tutor, what difficulties did you face? *(Extracts 8 and 9 from interviews conducted on March 7, 2024)*

Participants outlined several difficulties with the AI instructor, including not comprehending context, giving the same answers repeatedly, and being unable to handle open-ended questions flexibly (Extracts 8 and 9). Explanations were not always clear to all students, especially when dealing with complicated ideas that need logical reasoning, like those of a human (Extracts 8 and 9). Also, the learning flow was interrupted occasionally due to technological issues that hindered interactions (Extracts 8 and 9). To overcome these obstacles, AI has to be more adaptable and have stronger natural language processing capabilities to better assist personalized learning (Extracts 8 and 9).

Question 3: To what extent did the AI chatbot aid in your comprehension of the material?
(Extracts 2, 3, and 10 from interviews conducted on March 9, 2024)

The AI chatbot helped participants grasp complex concepts by providing detailed explanations and supplementary examples as needed (Extract 10). However, the participant noted that it [AI] did not always handle complex questions requiring further in-depth analysis (Extract 10). Similarly, one participant found that AI-assisted explanations were invaluable, letting him review previously murky material and ultimately grasp it (Extract 3). Another showed that AI was good at delivering content but not so great at giving context beyond what you would find in a textbook (Extract 2).

Question 4: How useful was the AI's tailored criticism? For what reasons?
(Extracts 1, 5, and 7 from interviews conducted on March 9, 2024)

One participant explained how AI feedback enhanced their confidence in learning abilities, which allowed to swiftly identify and fix their mistakes (Extract 1). In a related finding, another pointed out that although the AI's comments were useful for pointing out errors, the explanations were occasionally shallow, making it hard to understand complicated subjects without human guidance (Extract 5). Lastly, one participant appreciated the instantaneous aspect of AI feedback, but it [AI] frequently gave general answers instead of specific, personalized insights that may boost critical thinking (Extract 7).

Question 5: Tell me about a time when the AI tutor encouraged you to engage in conversation with someone. *(Extracts 2, 4, 6, 7, and 8 from interviews conducted on March 10, 2024)*

The AI chatbot prompted a participant to initiate discussions with their classmates by suggesting topics for group work to solve problems, and it brought a sense of order and engagement to group learning (Extract 2). For instance, when the participant was nervous about speaking up in class, AI-facilitated activities had made the participant feel more at ease and allowed them to participate more actively in conversations (Extract 4). Although AI encouraged participation, it could also cause students to rely on the chatbot for answers instead of having in-depth talks with their peers (Extract 6). Moreover, AI chatbots improved collaboration by facilitating real-time ideas and creating discussion-based assignments (Extract 8).

Question 6: How does AI customization stack up against more conventional approaches to education? *(Extracts 1, 3, 9, 5, 7, and 10 from interviews conducted on March 10, 2024)*

"AI made learning more flexible, letting my study at my own speed and go back to difficult subjects anytime I needed to" (Extract 9). On the other hand, this participant preferred the more regulated and socially interactive atmosphere of traditional schooling (Extract 9).

Another participant commented, "Artificial Intelligence (AI) excels at covering predetermined material, but it has a hard time encouraging the kind of critical thinking and creative problem-solving that come from engaging in more free-form, human-led discussions" (Extract 7).

Furthermore, one participant explained that AI personalization enhanced learning by adjusting materials based on progress, making it more engaging and dynamic (Extract 3). The participant also felt AI could not match the breadth of knowledge and practical experiences that human educators offer (Extract 3). Likewise, another explicitly noted, "I became more self-reliant in my learning management because of AI, which enables me to establish individual objectives and monitor my development" (Extract 2).

One participant expressed, "Even though AI was great at imparting information, it couldn't compare to human teachers in terms of the personal connection and support they could offer" (Extract 10).

In addition, a participant acknowledged AI's capacity to tailor learning routes was useful (Extract 5). However, this participant occasionally thought preprogrammed AI responses were *shallow and do not encourage critical thinking like in-class talks with a teacher (Extract 5). Another participant highlighted how AI personalization made staying motivated and tracking her learning progress easier than traditional learning methods (Extract 1). Nonetheless, the participant stressed the importance of student-teacher dialogue in helping students grasp more advanced ideas (Extract 1).*

Question 7: While using the AI-driven educational tool, how did you feel?
(Extracts 2, 4, 5, and 6 from interviews conducted on March 11, 2024)

One participant said, "I felt strong and self-reliant, because AI gave me the ability to direct my own learning. Still, there were times when I was irritated because the AI didn't adequately explain complicated ideas" (Extract 2). Another participant mentioned that while initially interested in AI-driven learning, they eventually became disappointed with its robotic replies and incapacity to have meaningful conversations (Extract 6).

Moreover, another participant demonstrated a combination of assurance and doubt: assurance when getting immediate feedback and uncertainty when AI-generated explanations were overly simplistic or missing subtleties (Extract 5). Furthermore, another discussed how AI system had helped her stay organized and motivated by providing effective progress tracking (Extract 4). However, the participant thought AI did not provide the same level of personal support and encouragement as provided by previous classroom experiences (Extract 4).

Question 8: If you could make one change to the AI instructor, what would it be?
(Extracts 2, 3, 4, 8, and 9 from interviews conducted on March 11, 2024)

One participant emphasized the importance of AI responses that are more natural-sounding, believing AI interactions might be more interesting and humanlike by adding emotional intelligence and adaptable conversational skills (Extract 4). Despite AI's success with organized learning, a different participant expressed that it lacked the ability to assist with creative and critical thinking (Extract 9). The participant suggested that AI be programmed to ask more in-depth questions and provide more conversation starters to encourage more in-depth understanding (Extract 9).

One participant explained, "I find ways AI could be made smarter when asked follow-up questions and conversations felt repetitive because AI occasionally repeated the same replies. For AI to dynamically build on prior interactions, incorporating a learning memory function" (Extract 8).

Question 9: Could you tell me how the AI chatbot affected teamwork and conversation?
(Extracts 1, 2, 3, and 7 from interviews conducted on March 11, 2024)

The AI chatbot was essential in promoting teamwork by suggesting conversation starters, posing questions, and boosting user interaction (Extract 3). Students reported group talks were more organized and fruitful thanks to AI-driven interactions (Extract 1). One participant recounted AI being useful for starting conversations since it provides dynamic questions to answer and makes them think about other points of view (Extract 1).

Another participant described how AI encouraged teamwork by posing questions with clear objectives and a set of predetermined answers (Extract 3). In contrast, another participant mentioned that while AI helped with group conversations, there were times when students became too reliant on automatic responses, which reduced their ability to engage in spontaneous debate (Extract 7).

Although AI's capacity to create study problems and provide group assignments enhances engagement in the learning process, the ever-changing nature of human-led conversations necessitates emotional intelligence and adaptable reasoning, which AI cannot match (Extract 2).

Question 10: In your opinion, might future students benefit from learning enabled by AI? For what reasons? *(Extracts 7, 8, and 9 from interviews conducted on March 11, 2024)*

Most students felt that AI-powered learning should be suggested to future students because of its capacity to make learning more personalized, give immediate feedback, and boost engagement (Extracts 7, 8, 9). In addition, one participant noted, "Students who like to learn at their own pace can benefit from AI-powered learning since it lets them go back over lessons and see how far they've come" (Extract 9).

Another participant weighed how AI simplifies and accelerates the learning process, which benefits students with varying learning speeds (Extract 8). Conversely, they thought AI needed more work before it could do jobs requiring creative and critical thinking (Extract 8).

Lastly, one participant stated, "We learnt that AI is great for structured learning, but that it can also make us rely too much on machine answers. More open-ended talks and better support for collaborative learning environments should be priorities for future AI models" (Extract 7).

The findings of this research highlight the enhanced practical significance of personalized learning and social interaction when mediated by artificial intelligence in a classroom setting. The study's results suggest that social learning dynamics became more productive when students were actively involved and engaged. AI-mediated learning outcomes, student engagement, and individual learning experiences were found to be strongly interconnected (Table 5). Pre-service teachers responded positively to the AI-powered Cici bot, expressing confidence that both personal learning and social interaction had increased during the intervention, as evidenced by the survey results in Tables 3, 4, and 5.

The correlation results show a high level of significance ($p<.001$), indicating a strong linear relationship between the variables. This finding suggests that the AI system's adaptability (X) influenced group work outcomes (Y_2) by facilitating more engaging debates and group projects. The data also revealed a strong positive correlation between personalized learning (Y_1) and social interaction (Y_2) with a correlation coefficient of 0.870 ($p<.01$). This strong relationship indicates that better collaborative learning experiences are highly correlated with higher levels of student engagement.

The results indicate that both personalized learning and social interaction increased due to the AI intervention. The mean scores from the survey results (Tables 4 and 5) support the conclusion that AI can improve personalized learning, aligning with the findings of Huang, Lu, and Yang (2023), Wang et al. (2023), and Parra-Valencia & Massey (2023). Similarly, the findings on increased social interaction align with the studies of Hohenstein et al. (2023), Hennig-Thurau et al. (2023), Dos Santos Melicio et al. (2023), and Jin and Youn (2022). Social interaction is a key component of learning in an environment with robots. Mimicking human behavior is a foundational step in studying human-robot social interactions. Robots respond to humans in a natural way, both verbally and nonverbally, based on a predetermined personality.

Based on the interview results, participants generally reported a positive experience, stating that AI-driven personalization increased their engagement and provided more tailored feedback. Many students stated that AI's content personalization capabilities made it easier to understand difficult concepts than more conventional approaches. In contrast to waiting for a human instructor to react, some respondents also found that the AI tutor offered immediate clarification on topics.

However, some issues did emerge from the interviews. Participants noted the chatbot's difficulty in recognizing context and the presence of technological difficulties that occasionally disrupted the learning sessions. In addition, students voiced concerns about AI's lack of emotional intelligence, which led to an impersonal and mechanical relationship. Regarding social interaction, participants found that the AI-powered chatbot encouraged thoughtful group conversations by offering intriguing questions and fun group activities. However, some students found that using the AI made them less comfortable interacting with others, which reduced their participation in direct communication-based group projects, such as discussions and arguments.

This study examined a virtual robot operating on a smartphone, highlighting the dynamics of human-computer interaction in a way that differs from studies of humanoid robots. Unlike humanoids, which have physical forms that mimic human movement and touch, virtual smartphone robots can only communicate with their users through sight and sound. Despite these caveats, the study established that virtual robots could substantially influence participants verbally and nonverbally. Pre-service teachers displayed genuine and spontaneous responses such as laughing and smiling, as if the virtual robot were real (Figure 3). These results support the findings of Ayub et al. (2025) and Bissessar(2023) that virtual robots can help people feel a sense of presence, both individually and with others. This is a crucial component of human-robot interaction (HRI).

Several factors contribute to the ability of virtual robots, accessible via smartphones, to elicit these nonverbal behaviors. First, students may put more effort into the social aspect of the connection when using a familiar smartphone interface, which reduces cognitive load. Second, the virtual robots' adaptable features, such as changing their voice and adapting to their language, made them seem more lifelike and interact more like friends. A sense of belonging and intimacy can be fostered through personalization, even without physical embodiments. The virtual robot's ability to mimic and follow human speech intricacies, such as pauses and intonation, also added to the realism of the encounter. These features are essential for connecting virtual and physical social agents, which enhances the robot's social presence and user engagement.

Virtual robots can foster positive social dynamics in educational settings, as these nonverbal cues indicate participants' emotional engagement and social bonding. However, the study also notes that perfectly simulating human interactions, particularly regarding cultural sensitivity and emotional intelligence, is impossible (Figure 3). In line with Mårell-Olsson et al. (2025), the investigation found that despite their impressive conversational skills, virtual robots still lack the ability to understand nuanced social signals, such as sarcasm or cultural idioms, which are key components of authentic human interactions. Some evidence is that these devices can help students engage in "normal" social interactions. However, a counterargument to the idea that these technologies foster creative thinking is that they can inhibit it, as seen in studies of children playing with passive dolls (Chen et al., 2023).

The learning experiences examined in this research by integrating AI encompassed personal experience, cognitive awareness, bias, opinion, cultural background, and environment, all fundamental elements of the innate human capacity to learn. Each person's learning journey is unique and continues to develop in understanding, perspective, and abilities of mind and body. A major flaw in conventional classroom wisdom is the assumption that every student has the same background, interests, learning goals, or requirements. This obstacle can be overcome by designing learning activities according to student needs, which can be accelerated using AI.

Traditional learning resources often encourage students to follow a predetermined series of learning sequences to improve their academic performance. In contrast, AI learning sequences that focus on developing personalized learning paths consider each student's needs, motivations, interests, behavior patterns, and abilities, as described in Table 3. This approach is similar to the findings of Habibian et al. (2025). The results regarding the learning process with AI integration in this research also consider the unique role of the teacher when implementing personalized learning. In the traditional approach, educators are more involved in making decisions, whereas personalized learning shifts their role to that of a "coordinator" or even a "mentor." Personalized learning considers each student's unique circumstances, including their interests, abilities, and learning styles, as stated by pre-service teachers in the survey (Table 3).

Effective learning environments include social contact, which is believed to help students build knowledge collaboratively, develop their cognitive abilities, and provide emotional support. The dynamics of social interactions change drastically in AI-powered personalized learning systems due to the mediating role of virtual agents and human-robot social interaction systems (HRSI). This study sought to understand the effects of AI-driven personalization on the social interactions of future educators by examining how virtual robots like Cici Bot promote group work and in-depth conversations.

The results showed that virtual robots are excellent at encouraging social interactions by initiating conversations among students, leading group projects, and providing students with feedback based on their specific circumstances (Table 5). During their interactions with the virtual robots, pre-service teachers exhibited more expressive verbal and nonverbal behaviors, including discussing ideas, debating concepts, and smiling and waving to express their feelings. These interactions enhanced collaborative learning dynamics and extended beyond human-robot exchanges to peer-to-peer communication.

By providing adaptive prompts and real-time feedback, this study highlights the ability of AI systems to promote social presence and build cohesive learning communities. However, it also highlighted significant challenges. While virtual robots effectively generate conversations, they still lack human-level social skills such as empathy, humor, and cultural awareness. AI systems may struggle to facilitate true collaboration and strong social relationships due to their limited capacity for emotional intelligence and nonverbal communication. Furthermore, because cultural and environmental factors affect how people interact, AI systems must also be able to adapt to different communication styles and social norms.

Conclusion

This study provides empirical evidence of the transformative role of AI in pre-service teacher education in Indonesia. The findings demonstrate that AI-powered personalization significantly improved learner engagement and fostered collaborative social dynamics. These results suggest that AI can complement human instruction by enabling personalized learning pathways and enhancing classroom interactivity. However, challenges remain in developing emotionally responsive AI tools that accommodate cultural contexts. Future research should investigate the longitudinal impacts and explore the integration of emotional intelligence and culturally adaptive algorithms into AI educational frameworks. This study lays the groundwork for evidence-based policy in AI adaptation for equitable and inclusive learning.

In summary, this study comprehensively examined the dynamics of AI-powered personalization in educational settings, emphasizing its impact on enhancing learning and human-robot social interactions among pre-service teachers. The results suggest that personalized learning environments can enhance student engagement, knowledge retention, and collaborative learning using advanced AI-driven tools, such as the virtual robot Cici. Learners are empowered to follow personalized learning paths that respond to their specific requirements and preferences through adaptive algorithms, tailored content delivery, and contextualized feedback. Furthermore, digital learning communities became more cohesive and collaborative when HRSI technology was integrated, fostering meaningful social interactions.

These findings strongly highlight the importance of inclusive digital policies and adaptable AI systems that combine human-centered pedagogy with more hands-on, personalized learning. This study adds to the growing body of information on AI-mediated education by bridging the gap between theory and reality. The research offers important insights for educators, policymakers, and designers of educational AI. This study argues that AI should be used strategically to enhance personalized learning while maintaining cultural relevance and rich social connections. Future research should explore the integration of emotional intelligence, cross-cultural communication frameworks, and adaptive social interaction tactics to maximize the opportunities provided by AI in education. By adopting a holistic approach to the AI-enabled educational ecosystem, this research paves the way for more inclusive, engaging, and socially interactive learning environments.

Availability of Data and Materials

The dataset generated and analyzed during the current study is not publicly available due to privacy and confidentiality, but is available from the corresponding author upon reasonable request.

Conflict of Interest Statement

We, the authors, declare that there are no competing interests.

AI Disclosure

We declare that this manuscript was prepared without the assistance of artificial intelligence. Hence, the content of this paper is original.

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