

# Three Paradigms for Learning Mathematics with the Aid of Artificial Intelligence: A Phenomenological Study of Prospective Teacher Students

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**Abstract.** The 21st century has seen rapid changes in educational practices, mainly due to technological advancements such as artificial intelligence. Especially in today's digital age, technology is essential in transforming education. One prominent innovation is the use of AI in the context of learning. This research aims to discover prospective teachers' learning processes using AI. In addition, this research seeks to determine the position of AI in learning mathematics for prospective teachers. The participants are Mathematics Education students of Universitas Swadaya Gunung Jati (UGJ) Cirebon. This qualitative study uses phenomenological methods by collecting data from each research subject about experiences regarding the use of AI in solving several math problems. This research provides insight into how prospective teachers can utilize AI technology in the mathematics learning process. In addition, this research is essential because it contributes to the development of technology-based pedagogy, a significant trend in global education today. This research uses data collection methods through observation, interviews, and content. The results of this study are that 3 paradigms from previous research are in line with the theory of 3 paradigms: (1) AI-directed students as recipients, (2) AI-supported students as collaborators, and (3) AI-empowered students as leaders. Most participants in this study were collaborators in these three paradigms.

**Keywords:** AI, Prospective Teachers, and Mathematics Learning.

## I. INTRODUCTION

With the development of computing and information processing techniques, artificial intelligence has been widely applied in educational practices (Artificial Intelligence in Education; AIE), such as intelligent tutoring systems, teaching robots, learning analytics dashboards, adaptive learning systems, human-computer interaction etc. (Chen et al., 2020)

Recent advances and expansions in machine learning have led to more advanced innovative technologies in digital content generation, such as generative artificial intelligence (Hu, 2023). AI or Artificial Intelligence is a simulation of human intelligence programmed into a computer machine to perform specific tasks that usually require intelligence. Humans, such as problem-solving, decision-making, pattern recognition, and natural language. (Steven Umbrello and Ibo van de Poel, 2021). AI is understood as a class of technologies that are autonomous, interactive, adaptive, and capable of performing human-like tasks. It can be used in a variety of fields, including education, healthcare, finance, transportation, and more. In another definition, Whitby defines artificial intelligence as the study of intelligent behavior in humans, animals, and machines and attempts to engineer that behavior into artifacts, such as computers and computer-related technologies. (B. Whitby, 2008.)

The 21st century has seen rapid changes in educational practices, mainly due to technological advances (such as artificial intelligence) (Petersen, 2021). Advances in learning media and technology provide convenience and access for students, increasing their creativity and the ability of educators to process and create learning spaces that are oriented towards the use of technology and digitization of learning. Technology plays an important role in transforming education, especially in today's digital era. Popenici and Kerr (2017) argue that the purpose of technology in education is to

increase knowledge and assist the teaching and learning process. One prominent innovation is the use of AI in the context of learning.

In today's digital era, technology is increasingly widespread and affects various fields of life, including education. One such field is mathematics education. Mathematics education is an important aspect of the education system that plays a crucial role in developing an understanding of mathematical concepts and problem-solving skills. Mathematics is an essential subject in the education curriculum, especially for students majoring in mathematics. Students are prospective teachers (student teachers), so it is appropriate for them to have knowledge, skills, and understanding. A good understanding of mathematics is key in teaching and guiding students. However, it cannot be denied that some prospective teachers face difficulties in understanding certain mathematical concepts. To overcome this problem, technology has become an effective solution. One of the technologies that can be used is AI. Previous research has shown that using technology in learning can positively affect the understanding of concepts and skills. However, little research has explored the role of AI.

The role of AI in the mathematics learning process for prospective teachers is as a tool that can provide explanations and answers to related questions. Math. By using AI, prospective teachers can better understand difficult-to-understand mathematical concepts. Teacher candidates' interactions with AI in mathematics learning can occur in various ways. They can use AI as a tool to ask for explanations of certain mathematical concepts that are difficult to understand. With continuous interaction, teacher candidates can better understand mathematics and improve their skills. In particular, AIEd has provided new opportunities, potential, and challenges for educational innovation. For example, there is a shift to personalized learning, challenges to the role of instructors, and the development of complex educational systems. To address this gap, this position critically reflects on the theoretical, pedagogical, and computational aspects of AIEd by proposing three AIEd paradigms that use AI techniques in different ways to address learning and instructional problems in education. The three paradigms include:

- Directed by AI

In this paradigm, the learner is the receiver. AI represents and directs cognitive learning, while the learner is the recipient of AI's services. In the communication paradigm, individuals are seen as recipients and stimulus providers in the communication process. In this case, individuals act as communicants and communicators with dual stimulus functions as givers and receivers. From this paradigm, it can be concluded that in the context of AI as a support, AI can act as a provider of stimulus or information received by the learner as a receiver. In this case, AI can assist in the communication and learning process by providing information that the learner can understand and process.

- Powered by AI

In this paradigm of the learner as collaborator, AI supports learning while the learner collaborates with AI. In scientific research theory, a paradigm considers AI as an enabler and the learner as a collaborator. This paradigm emphasizes using AI technology as a support tool in the learning process, where the learner acts as a collaborator in utilizing AI to acquire knowledge and skills. This paradigm can be associated with Qualitative and constructivist approaches emphasize the learner's experience and active contribution to learning. In this context, AI can be seen as a support tool that helps learners build their understanding of learning materials through collaborative interaction. This is in line with the constructivist concept that emphasizes the active contribution of learners in constructing their knowledge.

- AI-Powered

In this paradigm, the learner is the leader, AI is used to empower learning, and learners take control of their learning. Human-centered artificial intelligence in education (Yang et al., 2021) is

proposed to approach AI from a human perspective by considering human conditions, expectations, and context. In Paradigm Three, AI helps learners and instructors achieve enhanced intelligence by providing high transparency, accuracy, and effectiveness (Riedl, 2019; Yang et al., 2021). Instructors are equipped with support that can be understood, interpreted, and personalized by AI systems to promote learner-centered learning (Baker et al., 2019; Holmes et al., 2019; Roll & Wylie, 2016). The learner takes on the role of a leader of their learning, managing the risks of automating AI. Decisions and developing better or more efficient learning (Gartner, 2019). Overall, Paradigm Three, as the development trend of AIED, reflects the ultimate goal of the application of AI in education, which is to enhance human intelligence, ability, and potential (Gartner, 2019; Law, 2019).

Human-computer cooperative systems, which integrate advanced AI techniques and human decision-making, can potentially empower AI, the learner, as a leader in Paradigm Three. On the one hand, advanced techniques (e.g., brain-computer interfaces, machine learning, deep learning) have the potential to achieve continuous data collection and analysis to ensure data accuracy, transparency, and interactivity. AI is said to be human-powered if humans use AI to empower AI to execute tasks that could previously only be done by humans. The use of AI, in this case, is intended to give AI the ability to do something that previously could only be done by humans to increase efficiency and capabilities in various fields of life. Some people oppose the widespread development of AI due to concerns about

The replacement of some human professions by AI can also provide benefits in improving human efficiency and capabilities. Therefore, this study aims to find out how prospective teachers learn with AI and how AI is positioned in learning Mathematics for prospective teachers. In this study, students, as prospective teachers, are the participants involved in using AI as a tool to learn mathematics. Through this research, it is hoped that a better understanding of the potential and benefits of using AI in improving mathematics learning can be found, as well as contributing to developing more effective and innovative educational technologies. By looking at the potential of AI in mathematics education, this research can provide a new perspective on the use of technology in education and open up new opportunities for the development of future education.

## II. METHODS

The phenomenological method in qualitative research is one approach that can be used to examine the process of learning mathematics with the help of AI in prospective teachers. Phenomenology is the study of the structure of consciousness experienced from the point of view of the first person or who experiences it directly. The researcher will analyze the experience of the AI-assisted mathematics learning process on prospective teachers by photographing and seeing it naturally and subjectively. In addition, the peculiarity of this phenomenological method is that it involves phenomenological reduction, where the researcher eliminates personal assumptions or interpretations during the research process, thus focusing on subjective experiences. So, the researcher collected data from each research subject about the subject's knowledge regarding the use of AI in solving some math problems and tried to understand the interaction of AI in the mathematics learning process. To support this research, the researcher gave several math problems to discover how the process of learning mathematics uses AI.

The following questions were given to the participants:

1. A tubular tank has a base diameter of 14 meters and a height of 10 meters. The tank is filled to the brim with gasoline. If every centimeter increase in the gasoline level will increase the volume of gas by 2 liters, how many liters of gasoline will be added when the gasoline level rises 30 cm?
2. A function is defined as follows:

$$f(x) = \frac{2x^3 - 5x^2 + 3x - 1}{x^2 - 4}$$

- a) Find the domain of the function
- b) Find all tangent points, asymptotes, and points of intersection with the axes from the function graph.

In this study, researchers conducted in-depth research into how the human brain works when solving math problems. This includes understanding how information is processed, memory works, and creative thinking is involved in finding complex mathematical solutions. Researchers used appropriate observation methods to record and analyze participants' cognitive processes while solving mathematical problems. We also examined participants' processes when using AI to solve problems, such as their steps and how they understood the AI explanations. In addition, the researcher researched the participants' perspectives on AI and its impact on participants. Thus, the researcher gained an in-depth understanding of the participants' learning process when using AI and the position of AI towards participants.

In this study, researchers used data collection methods such as observation, interviews, and content. Observations were made through direct observation or through observing screen recordings used when participants solved problems and interacted with AI. Interviews were conducted by collecting data through questions given to research subjects, which were flexible and depended on the needs of the research. The research content included eight photos (participant documentation and participant answer sheets), nine videos, and three participant voice recordings related to participants' experiences solving math problems using AI.

The data analysis technique from the observation results is that the researcher analyzes the participant's screen recording, which is used to categorize the interaction between the participant and AI; the researcher also identifies the communication pattern, the type of question or command given by the participant to AI, and AI's response to the interaction. Then, the researcher identified the characteristics of participant interactions that emerged during conversations and problem-solving. In this study, the interview contained how the participant interacted when solving mathematics problems and the participant's experience using AI; the researcher analyzed the interview results by identifying specific keywords that appeared consistently to find categories that emerged during the problem-solving process. Then, the researcher proved the analysis results with research content, including photos, screen recording videos, and participant answer sheets.

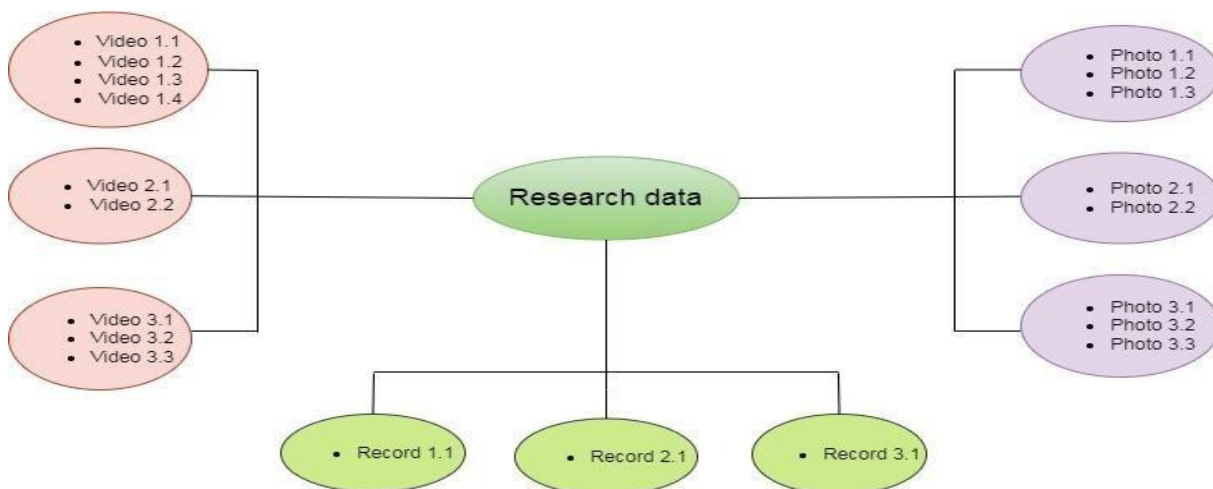


Fig. 1 Research data

### III. RESULTS AND DISCUSSION

All As the theory explained in the introduction states that AIEd has undergone several paradigm shifts, which are characterized by three paradigms in this research position: (1) Directed by AI, with participants as recipients; (2) Supported by AI; participants as collaborators, and (3) Empowered by AI; participants as leaders. Likewise, the researcher used the three paradigm theories from previous research in this study.

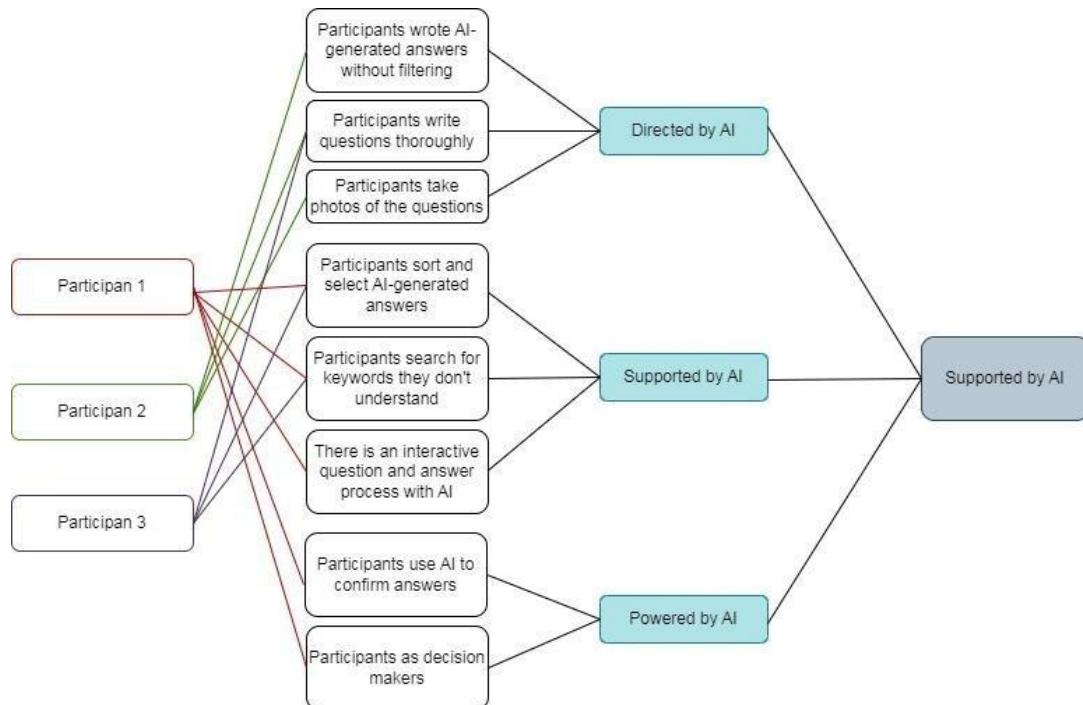


Fig. 2 Data analysis process

The following results found from this research include several points, including:

- **Participants as recipients**  
 In this study, this is evidenced by participants who deliberately look for the same problem by photographing it. When the problem is not found, participants use another AI to find the answer to the given math problem by typing all the questions. That way, participants are in line with the paradigm theory Directed by AI.

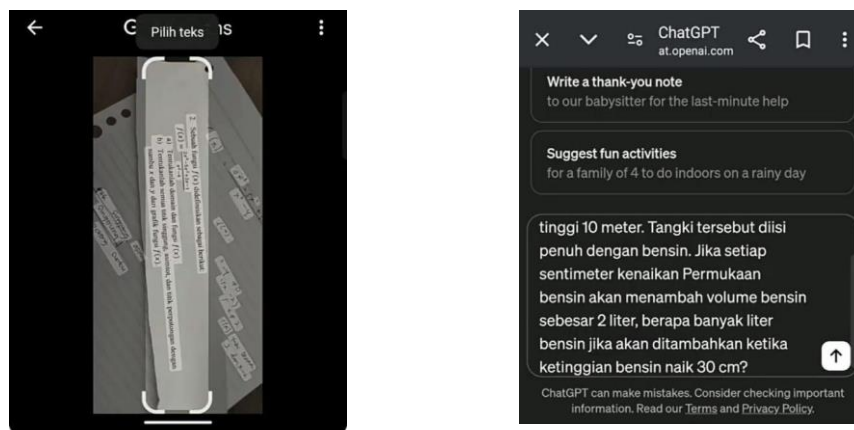


Fig. 3 Proof of participation as a recipient

- Participants as collaborators

In this paradigm, participants are collaborators, and AI is used to support learning while learners work as collaborators with AI. In this study, it is evidenced by activities when participants search for several keywords related to the problem, for example, looking for what asymptotes are. When the keywords they asked were found, the participants asked again how to find the formula for the asymptotes of a rational function. Then, the participants looked for several problems similar to the issues the researcher had given. So, it can be said that AI is said to be a collaborator because these participants work together with AI to solve the problems presented. That way, the participant aligns with the paradigm theory Directed by AI.

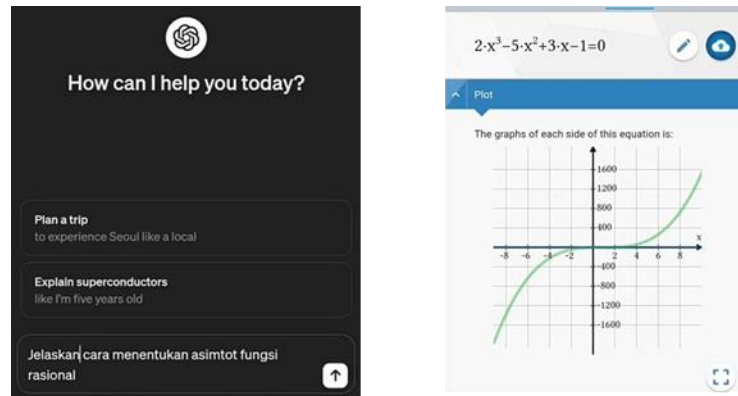


Fig. 4 proof of participation as a collaborator

Thus, this paradigm emphasizes the learner's active role as a collaborator in utilizing AI technology as a supporting tool in the learning process, which is in line with the constructivist approach that emphasizes the active contribution of the learner in constructing their knowledge.

- Participant as Leader

In this paradigm, the learner is the leader, AI is used to empower learning, and learners take control of their learning. This research can be proven by participants' activities when working on problems using AI only to ensure the accuracy of the answers that participants have done manually. Besides that, participants use AI as a reminder and a form of confirmation of the understanding they already know. In addition, it is evidenced by participants when using AI to check a graph of the problem.



Fig. 5 proof of participation as a leader

Thus, this paradigm emphasizes the active role of the learner as a leader in the learning process. Hence, participant interaction is in line with the third paradigm theory, which states that AI is empowered and participants become leaders.

## IV. CONCLUSIONS

The research data illustrates that participants' experiences when solving math problems using AI varied. Some participants revealed that using AI provided convenience and efficiency in solving math problems, especially speed and accuracy. Some participants also saw AI as a collaborator, emphasizing their experience and active contribution to learning. They found AI helpful in understanding complex math concepts. Some participants made manual corrections to the solutions provided by AI, as they felt they were in control of their learning.

Thus, it can be concluded that the learning process using AI in our study is in line with the theory of 3 paradigms, namely (1) Directed by AI, participants as recipients; (2) Supported by AI, participants as collaborators, and (3) Empowered by AI; participants as leaders. From the results of this study, most participants are in line with the second paradigm theory, namely supported by AI; students are collaborators, as evidenced by participants' behavior when solving mathematical problems given by researchers, which is a behavior that shows the paradigm theory.

This research provides insight into how prospective teachers can utilize AI technology in the mathematics learning process. It is also important because it contributes to the development of technology-based pedagogy, which is an important trend in global education today. The researcher advises readers to use AI as a collaborator, but we must remain in control.

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