Journal on Mathematics Education
Volume 13, No. 3, 2022, pp. 531-548

Indonesian students' perceptions towards AI-based learning in mathematics

Robert Harry Soesanto*, Kurnia Putri Sepdikasari Dirgantoro, Neng Priyanti

Pelita Harapan University, Tangerang, Indonesia
*Correspondence: robert.soesanto@uph.edu

Received: 31 October 2022 | Revised: 29 November 2022 | Accepted: 30 November 2022 | Published Online: 1 December 2022

Abstract

The pandemic has indeed provided students and teachers worldwide with the experience of technology-infused teaching. Even though the pandemic is almost over, the utilization of technology in mathematics education is still needed and inseparable. Relying on cross-sectional design and phenomenological approach, this research investigates senior high school students' perceptions towards AI-based learning, particularly about their understanding and suggestions towards AI-based learning in mathematics in the context of post-pandemic. The participants of the study were 107 students coming from several islands in Indonesia, ranging from grade 10-12, with an age interval of 15-18 years old. The instruments used were the questionaries with open-ended questions in Microsoft forms distributed to mathematics teachers in several WhatsApp groups. The data were then analyzed through a multistage descriptive and pattern coding process. The findings showed that students need to be facilitated with AI, which can display understandable visualization and provide guidance to solve mathematical problems. It is expected that the present study's findings offer researchers in Indonesia and abroad to disseminate and/or implement AI learning in the form of Intelligent Tutoring Systems.

Keywords: AI-Based Learning, Mathematics, Post-Pandemic Era, Senior High School Context

How to Cite: Soesanto, R. H., Dirgantoro, K. P. S., & Priyanti, N. (2022). Indonesian students' perceptions towards AI-based learning in mathematics. *Journal on Mathematics Education, 13*(3), 531-548. http://doi.org/10.22342/jme.v13i3.pp531-548

During the pandemic, teachers and students have been struggling to implement the emergency remote learning. Such conditions forced teachers to adopt the technologically infused teaching as a new teaching habit. Like teachers, students also tried to adopt and adapt with the newly implemented 'technologically infused' learning. This emergency has led to not only the development and adaptation variety of learning strategies but also occurrence of learning difficulties that urgently need to be solved (Bakker & Wagner, 2020; Soesanto & Dirgantoro, 2021b). For example, self-access learning which is commonly developed to maximize the impact of distance learning reduces students' dependence on teachers, and thus increases collaboration between students (Al Ghazali, 2020). However, during the pandemic it may not be working effectively due to some reasons such as lack of digital literacy skills (Irfan et al., 2020; Schleicher, 2020), absence of compatible devices (Serhan, 2020; Soesanto & Dirgantoro, 2021c), as well as stability of internet connection particularly those in geographically challenging area (Adedoyin & Soykan, 2020; Komsiyah, 2021).

In addition, the pandemic condition has also gradually contributed to the existence of software applications and learning media. The educational demand specifically leads to the development of

several learning applications. For instance, zoom as a video conferencing tool has been the most popular and hence on top of other applications with similar functions (Boerngen & Rickard, 2021; Fuady et al., 2021; Nisa et al., 2021). As for the learning media, several findings have suggested some familiar brands such as Kahoot (Mideros, 2020), Flipgrid (Lowenthal & Moore, 2020; Randall, 2022), and Edmodo (Sefriani et al., 2021) to ensure students' active participation.

In the context of Mathematics education, the unprecedented condition brings forth significant pedagogical impacts as educational stakeholders are forced to adopt technologically infused pedagogical strategies. The most popular learning application GeoGebra, for instance, has been found to positively contribute to students' motivation, performance, and interest in learning mathematics (Alabdulaziz, 2021; Nzaramyimana et al., 2021; Rachmavita, 2020). Furthermore, this software application has a variety of features and has been viewed as having the ability to maximize students' engagements. In fact, several research studies have found that GeoGebra when integrated with flipped learning model improved students' self-regulated learning (Ishartono et al., 2022) and critical thinking skills (Andriani et al., 2022) during emergency remote learning. In context of learning in remote areas and among students with low-socio-economic status, the simple application called WhatsApp has been adopted as learning media which further assisted the process of mathematics learning (Raynal & Light, 2021; Wong, 2020; Wulandari & Mandasari, 2021). Moreover, the presence of technology platforms in supporting mathematics education has shown positive impacts as reducing anxiety (Delima & Cahyawati, 2021; Soesanto & Dirgantoro, 2021a; Varghese, 2020), improving students' learning (Kalogeropoulos et al., 2021), and improving students' motivation for learning (Randall, 2022; Seidu & Owusu-boateng, 2022). Besides, Information and Communications Technology (ICT) innovation used in mathematics education has grown rapidly, and thus affected the percentage of mobile devices usage among teachers and students (Alabdulaziz, 2021; Gaol & Hutagalung, 2020; Rachmavita, 2020).

The pandemic trend has shown a sharp decline, it is therefore safe to say that the world is entering the post pandemic era (Ilmi & Praptana, 2022; Bhatt et al., 2022; Haslam, 2021). This post-pandemic era which allows learning to be done face to face instead of through online platforms has been long waited by Indonesian students (Soesanto & Dirgantoro, 2021c). Given the fluctuated covid-trend, learning delivery done through face-to-face may seem unlikely, leaving online learning to be the only option of learning delivery mode. Therefore, the role of technology needs to be maintained to permeate into the learning process.

The integration of technology into mathematics learning is not limited only to the use of gamification or Math application which is primarily one-way but also to the utilization of AI. Tracing back the history, the first important project of AI in relation to educational technology in mathematics education started in the early 1970s which contributed to provide concepts, methods, and tools for the design of flexible computer-based systems and relevant for teaching and learning purposes (Balacheff, 1993). For instance, if students need information to solve mathematical problems, or need guidance to understand a mathematical concept, students can utilize the fast search engine used to identify a variety of texts and multimedia resources (Gadanidis, 2017).

The contribution of AI in mathematics education has, of course, opened potentials, benefits, and challenges in educational practices. In terms of potential and benefits, several research studies have argued that AI based learning assisted students in solving complex mathematical assignments (Kong et al., 2021). Project done by Knill et al. (2004) established a robot Sofia used in Calculus, which was designed with the ability to understand definitions of a variety of mathematical terminologies (e.g., glossary of encyclopedia), to solve simple mathematical problems according to template that has been

designed, and to interact with Computer Algebra System to solve simple calculus problems. However, one of the weaknesses of the Bot lies in its ability to interact, particularly in its function to stimulate teachers' intelligence to give direction, tailored feedback, and support to each student during the learning process (Hwang & Tu, 2021).

The roles of AI in education have experienced paradigm shifts. Ouyang and Jiao (2021) propose three characteristics of paradigm: AI-directed (learner as recipient), AI-supported (learner as collaborator), and AI-empowered (learner as leader). These paradigms are contextualized in such a way to address educational and learning issues in various ways, leading to the development of AI based mathematics learning which is the optimalization of ITS (Intelligent Tutoring System) model (Chen et al., 2020; Cruz-Jesus et al., 2020; Hwang & Tu, 2021; Pappas & Drigas, 2016). AI design for mathematics learning is developed in the form of ITS imitating a human tutor. This model is expected to be able to provide feedback based on students' mistakes, provide directions and tips for each topic, and step-by-step strategies to solve problems and sample exercises (Pappas & Drigas, 2016). Several designs of ITS have been found through several projects such as 4MALITY and Aplusix. 4MALITY is a web-based mathematic tutoring system used to coach students with a variety of problem-solving strategies (Razzaq et al., 2011). Aplusix, on the other hand, makes it possible for students to solve mathematical problems step by step, to receive feedback directly from tutors, and if necessary, functions as a guidance to reach the end solution (Rodrigo et al., 2008). According to their studies, Aplusix has generally better effects on users than the simulation game. Another study states that there is ITS development for solving linear equation using example-tracing tutors (Waalkens et al., 2013). A variety of features are embedded into the intelligent tutor such as solved examples, explanations, feedback messages, next step hints, as well as instructions at the start of each problem set. Through these projects, the development of AI in mathematics education brings forth benefits to students in a way that helps them to solve complex and challenging mathematical problems (Hwang & Tu, 2021).

In the context of mathematics education in Indonesia, few studies have investigated the infusion of AI in enhancing students' mathematical competence. Hermawan (2022) explored the utilization of AI in a form of ITS using the model of Cognitive Tutor Authoring Tools (CTAT). However, the topic was limited to only one small topic - the rules of filling slot in the field of probability. Another study conducted by King et al. (2021) has also implemented CTAT but limited to a simple web-based application that allows teachers to upload modules to be learned by students. In other words, the adaptation of AI-based learning in mathematics education in Indonesia is still lacking. As mentioned previously, mathematics learning in Indonesia during the pandemic has been dominated by the utilization of applications such as learning application GeoGebra (Gaol & Hutagalung, 2020; Ishartono et al., 2022; Sugandi & Bernard, 2020), gamification Kahoot (Apsari et al., 2020; Fatmi et al., 2021; Kusmaharti & Yustitia, 2020; Muhazir & Retnawati, 2020), and video conferencing Zoom (Daniatun et al., 2021; Kustiyani et al., 2021; Monica & Fitriawati, 2020; Nisa et al., 2021).

The dearth of research and literatures on the implementation of AI in mathematics education in Indonesia, and the trend where the learning platforms used in Indonesia are dominated by general learning application served as the background of this research. This research therefore aims to answer these questions: 1) how do students perceive AI in relation to its forms and function? 2) what do students think about mathematical topics that could be used and embedded in the AI-based learning? This preliminary study situates students as the focus of the research as students are current and future users of AI. Thus, mapping students' needs particularly in the form of mathematical topics that provide opportunities for AI to be applied is a necessity. In other words, if students' needs regarding AI are clear,

then teachers can properly prepare what will be performed in the future. As preparing the AI based learning in mathematics is indeed time consuming, the clarity in mapping mathematical topics will therefore lead to effective and efficient AI infusion in mathematics learning. The two proposed research questions are expected to provide opportunities for researchers in Indonesia and overseas to design AI projects creatively and innovatively and/or concepts of AI-based learning. Furthermore, this research is conducted as a response to the study by Bakker et al. (2021) about future themes of mathematics education context one of which focusses on the development of mathematics learning by using technology.

METHODS

Participants

This research involved 107 senior high school students as respondents, ranging from 15-18 years old. The participants were spread across several islands in Indonesia. The demographic is displayed on Table 1.

Table 1. Participants' demographic (N = 107)

		N	Percentage
Gender	Male	56	52.33%
	Female	51	47.67%
School grade level	First year (grade 10)	30	28.03%
	Second year (grade 11)	26	24.30%
	Third year (grade 12)	51	47.67%
Islands (participants' origin)	Sumatera	27	25.23%
	Java	59	55.14%
	Kalimantan	6	5.61%
	Sulawesi	10	9.35%
	Maluku	5	4.67%

The sample of respondents chosen is based on the findings of systematic review of Hwang and Tu (2021) which states that there has been little research done in AI based learning in mathematics senior high school in Southeast Asia, and Indonesia includes in it. They also argue that most of the research in AI is done in elementary school and higher education, which might have been because the nuances of learning in elementary school generally accept new learning approaches, while higher education is also a convenient selection since most of the authors were researchers in universities. Therefore, this current study aims to fill in this gap.

Research Design and Instrument

This survey research uses cross-sectional design with the phenomenological approach because it involves students from different islands in Indonesia in one period to find a phenomenon that is students' perception and suggestions towards AI based learning in mathematics in the context of post pandemic era. Instruments used for this study are questions compiled in a form of Microsoft form questionnaire. Question items developed are divided into two categories: category 1 (questions about respondents'

demography) and category 2 (core questions about respondents' perception towards and their suggestion about the implementation of AI based learning in mathematics). In addition, the first category asks about students' gender, grade, and domicile, while the second category asks about: (1) What do you know about Artificial Intelligence (AI) technology, particularly in the context of mathematics learning? Explain it in detail; (2) Give at least one example of a mathematics topic that you think could be infused with the help of AI technology; and (3) Figure out your imagination regarding the application of AI to a math topic that was previously mentioned. Write down in detail about your thoughts. The questionnaire was then administered by distributing the link to high school teachers who would then forward the link to their respective students. Students were required to spend at least 30 minutes to fill in the questionnaire. Besides that, the researchers provided the opportunity for high school teachers to inform their students to also distribute the link to other high school students.

Data Collection and Analysis

Within the allocated time of three weeks, there were 107 student respondents who managed to fill in the questionnaire. The students were given the Microsoft Forms link which contained the questionnaire. The result was downloaded and exported into Excel Workbook and then analyzed. The open-ended questions were then analyzed using a multistage process of descriptive and pattern coding (Saldana, 2016). The analysis process was performed by finding the pattern and jotting down the theme which emerged frequently based on students' reports in the questionnaire. The result of coding is displayed in themes supported by the testimonies as the answers given by respondents. In addition, the taxonomy and table were presented in this study results as supplementary files to summarize the themes emerged and to ease the readers to look at the findings briefly.

RESULTS AND DISCUSSION

To provide the big picture, the researchers purposefully provided questions that allow respondents to choose whether AI can be used in mathematics education in Indonesia. The result shows that 83,18% respondents state that the current post pandemic era makes room for the implementation of AI in mathematics. Furthermore, the findings will be elaborated more down below.

Students' Perceptions on the Forms and Capabilities of AI

Through the data analysis, it was found that there were two big themes; understanding of AI from the aspect of form (as the first theme) and capability (as the second theme) which appear and are reflected in participants' responses. Each theme has pattern of answers like others.

For the first theme, there were several patterns of responses that occurred quite frequently. The first pattern is that students understand that AI's form is robotic whose function is to imitate humans. They view AI robots like a smart machine that can detect something. For instance, a student exemplified AI using a vacuum cleaner that can detect dust and small dirty particles at home. Another views AI as like Robot that can transform into something else due to its complex embedded coding. In other words, students understand that AI is like Robot which is created to do something to make life easier.

Another pattern of response that occurred quite frequently is related to students' understanding about the form of AI. Students defined AI as a computer system. Functionally, the pattern of answers given is still like the opinion given previously that is there are complicated codes implanted inside the robot that enable the computerized system to function as instructed. The computerized systems mentioned by respondents are GPS or Google Maps that can help to locate geographical positions inside a building.

In addition, on the theme of AI form, AI is viewed as a simulation of intelligence modelled into a machine. The machine model is programmed to imitate the human thought process. In terms of function, it is not far different from previous pattern of answers that is to assist human activities to ensure effective management of time and energy. With the new advancement of the new features, the AI is more capable of solving problems. Generally, those are the testimonies from respondents:

- *AI is one form of technology that is currently needed in our daily lives. For example, robots vacuum cleaners which can move to detect dust and dirty small particles. Another example is when we get lost, there is also AI that is GPS, or what we use Google maps that is accessible through our smartphone.*
- *(AI) is a technology that is used to operate something like Robot who can develop itself and move automatically.*
- *AI is like a system of robots with advanced technology. AI has its intelligence that is like human's*
- *I think, Artificial Intelligent (AI) is a machine or a program that is like human beings, be it in terms of working, teaching, etc. AI can solve mathematical problems in a relatively short time, and most of them can solve questions correctly.*
- *Artificial Intelligence is a system of computers created by humans to analyze and do a problem quickly, because there is some sort of coding implanted in it.*

Regarding the AI capabilities, the first dominant pattern is students' understanding of the capabilities of AI in providing information needed. Several statements support this pattern particularly in relation to mathematics education, that is to help students to find mathematical formula needed to solve a particular mathematical problem. Generally, a statement about capabilities of AI that can be used to interpret mathematical symbols on certain topics such as topics of inequality, sets and angles in Geometry is also found. The theme on other AI capabilities has also been reported through the pattern of answers such as AI could give guidance, tips, and tricks to help students to solve mathematical problems. There was also a report that AI can support learning in terms of giving feedback to students, for example giving revisions and verbal feedback when students' work is not correct. Another specific example is also reported by one respondent who views AI as having potential to help solve mathematical problems related to numbers.

Another report that has supported the pattern of answers on capabilities of AI is that students understand that AI can be a medium for effective and fun mathematics learning. This cannot be separated from respondents' understanding that view AI as a system where a variety of codes are implanted in it. Several arguments are stated by respondents, for example Google maps that can be used to support mathematics learning on the topic of counting distances. There are also some participants who explained about some terminologies like C, C++, Python, JavaScript, or even AI which is also understood as having the ability such as that of NPC (Non-Player Character) in a game. This, of course, will be beneficial if students can enjoy learning mathematics like they are playing games through the capabilities of AI. Down below are several arguments that support such pattern of answers:

- *What I know about Artificial intelligent is that it is an intelligence program which is technologically connected to a server or a machine. This AI technology is specific to solve mathematical problems, in general it is related to human's intelligence. For example, learning, solving problems and introduction of pattern.*

- *I know that AI is a system of computers developed by human beings to do practical work. Di mathematics learning, AI can be used to search for information such as formula, translating symbol of inequality or other geometry terminologies. Oh yes, AI technology can also provide correction if there is an error or mistake in doing mathematical problem, so that (we) know how to solve it rightly.*
- *AI can do anything as long as instructed. The way to instruct is to use code such as C, C++, Java, Python, JavaScript, and AI is actually can be utilized as a learning media for mathematics.*
- *AI can be seen in our daily lives. For example, google assistant and Siri. In mathematics education, AI can also be used such as the dictionary consisting of a variety of mathematical terminologies.*

As a summary, Figure 1 displays the taxonomy such as key words produced by respondents as findings related to students' understanding of AI

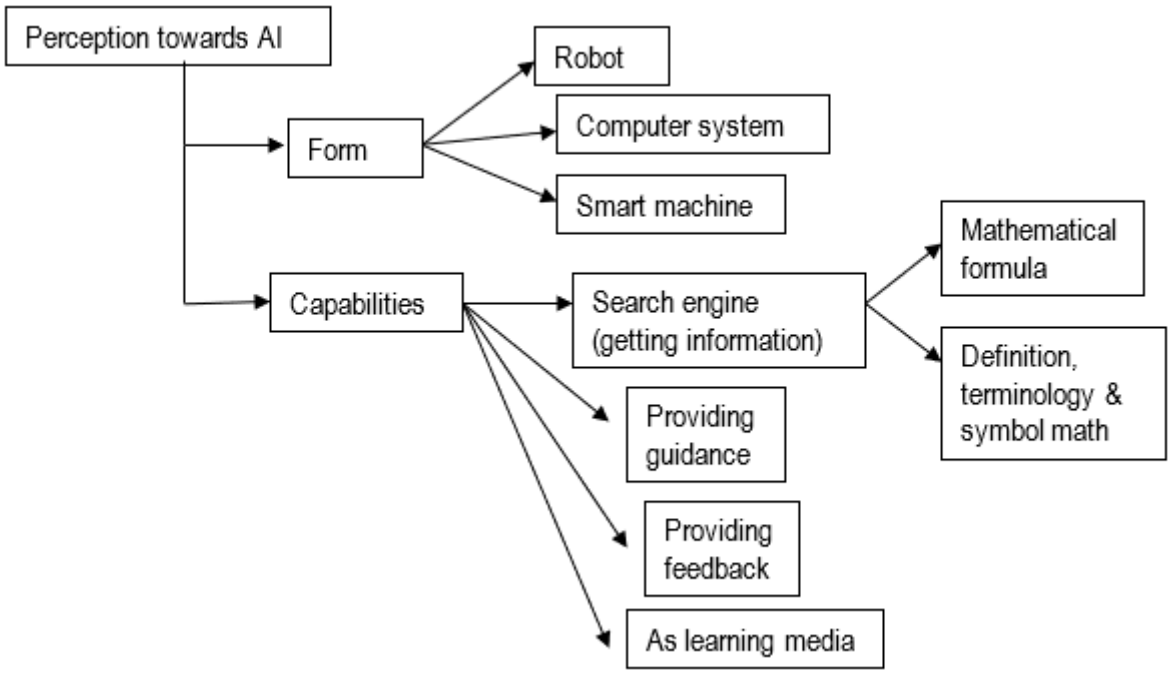

Figure 1. Taxonomy of students' perception towards mathematics AI-based learning

Students' Suggestions about AI-based Learning in Mathematics Post-Pandemic

The context of students' suggestions in giving stimulus to researchers to dig deeper the ideas and insights about what topics of mathematics that they think would be potential to be infused in AI as well as the imaginary on how such is implemented in the post pandemic era. On the question that asks about the implementation of AI, there are a lot of responses from students. The researchers classified those into 6 clusters - Number, Algebra, Geometry, Trigonometry, Calculus, as well as Statistic and Probability. The topic that is most frequently suggested by students is the topic of algebra. This also includes students' recommendation on other advanced mathematics topics that can make use of the concept of algebra in it such as linear program and functions. When it comes to the topic of function, there is this pattern of answer that goes more specific to three themes that is Exponential, Quadratic, and Linear Function. This includes students suggested ideas that AI can assist the process of analyzing graphic from a function

Another pattern that has also become the popular theme is Geometry where students stated about

topics two and three-dimensional shape. Another suggestion is also a specific topic in Geometry that has its potential to be supported by the technology of AI - learning about proof of Pythagoras Theorem. Moreover, the topic about numbers, especially about number operation is also stated as can be taught using the AI. As for the information, the scope of number operation that becomes students' answers revolve around addition, subtraction, multiplication, division, square and square root, where they are related to the arithmetic problems that include the elements of number operation in it. In addition, topic trigonometry has also been in students' mind that can be taught using the technology of AI in which the responses given are more focused on the use of AI as database to store a collection of formulas and identities of trigonometry as well as to provide directions for questions related to trigonometry.

For the calculus category, there were two themes that came out as result and/or students' responses. Most of the arguments state that the theme of limit, differentiation, and integral are suitable for the utilization of AI as learning media. Lastly, the pattern of answers is also focused on the theme of statistic and probability as the potential mathematical topics to be taught using AI. The respondents, however, did not specify what chapters in statistic that they think are suitable. Besides that, it was also found that 4.67% (N = 5) of students do not know which mathematical topics suitable to be taught using AI based learning. To make it easier to read, Table 2 displays taxonomy of the suggested topics:

Table 2. Potential topics for AI based learning

Cluster	Topic	Highlights
Algebra	Linear Program	Optimum value
	Functions	Linear, quadratic, and exponential function
Geometry	Pythagoras	Pythagoras Theorem of proofing and calculation
	Two-dimensional shape	Calculation of perimeter and area
	Three-dimensional shape	Spatial visualization, calculation of volume and distance between two points, points-line, and two lines
Numbers	Basic operations & arithmetic	Addition, subtraction, multiplication, division, square, and square root
Trigonometry	Trigonometry	Formula and Trigonometric Identity for proofing needs
Calculus	Limit	Continuity and graph
	Differentiation & Integral	Graph function for calculating curve area and volumes of the solids generated by revolving the regions bounded by the curves and lines
Statistics & Probability	Statistics & Probability	Visualization as statistic interpretation (graph, diagram, histogram) and visualization for probability word problem

Moreover, insights that represent students' suggestions on how AI can be implemented in mathematics education in Indonesia during the post pandemic era, were described in detail through this section. There are a few patterns of answers that appear quite frequently thus can serve as a theme. The first dominant theme is activating the roles of AI as intelligent tutor. There are lot of mathematics topics in senior high schools that can be explored using the roles of AI as smart tutor. For that, students feel the need of AI to help them with some mathematical problems. To be more specific, students expect AI can provide systematic explanation, guidance or another way of math formula can be used as an alternative in solving questions. In a more imaginative way, there are also reports about the suggestions of AI in a form of robot or application that can produce sound, write, and can be set up to produce male or female voice. Students even expect AI to recognize their voice when they read out difficult questions and then AI can respond back by giving assistance in terms of analysis or hints from the questions read out.

Another testimony that supports this idea is that students expect the AI to not only provide guidance, but also feedback on students' mistakes as feedback serves as an evaluative tool from where students can improve academically. In addition, students also expect AI to provide similar problem exercises where students can be trained to avoid the same mistakes. They expect feedback to be given step by step. To be more specific, they expect the AI to provide step by step process in solving problems so that students are motivated to keep up to the next steps. Due to the language barrier issues, students suggest for AI's instruction to be understood in Indonesian so that it will be easier to be utilized. Regarding the context, below are some reports that support this theme.

- *I want AI to be able to decide the right mathematical formula from one problem. Other than that, I hope AI can also provide detailed explanation, key answers, or faster ways to solve mathematical problems.*
- *Students 'have' AI that can help them in solving mathematics assignments. For example, when I find it hard to do a question, I will record my voice by reading out the questions while the AI is activated. Then, AI will analyze the question and can talk back and write back virtually. If I am still confused, AI will then re-explain slowly and in detail. The language and voice and volume can be adjusted – male or female voice.*
- *Students have the AI that can help them do their mathematics assignments.*
- *When there is a problem related to Algebra, AI knows how to solve it, the way to explain it in detail to students and give similar examples.*
- *Maybe AI can understand questions or materials asked without language barriers. Other than that, AI can also explain how to solve and can respond to students' questions. If there is still something that students do not understand, AI will not provide the answers, but teach them first with systematic and easy to understand instruction.*

The next highlight on students' insights towards AI capabilities in supporting mathematics learning is its ability in giving optimal visualization that supports understanding concepts of mathematical topics. The results that support this theme is that most students write that they imagine AI as a software application that can provide visual graphic or three-dimensional shape accurately. Regarding this, respondents provide examples of relevant topics such as equation in functions topic as well as space geometry, where the two topics are quite dominant to be discussed in Indonesian

senior high school. Students also admit that their spatial ability is lacking so that they need AI to help them visualize pictures to give them effect and thus help them understand some concepts. Clear visualization is also stated in several arguments that mention that clear visualization helps students when dealing with complex geometry problem. For instance, when they must find the distance between two points or between point and line inside the cube, this 3D visualization is very necessary. Through AI that can provide clear visualization, students can understand mathematical problems given so that the process of problem solving can be done effectively.

Other than that, another theme appeared as pattern of answers that is the roles of AI as an application that can understand screenshot of pictures taken, which will later generate steps of doing such mathematical problem. Such AI role is reflected in several topics such as Algebra, exponential function, and statistics. On the topic of Algebra, students expect the assistance of AI in helping them understand the screenshots of, for example, word problems, thus generating steps and/or guidance to solve the problem. On the topic of Exponential functions, students expect similar assistance as that of on the topic of Algebra, that is to provide steps and/or guidance. The same goes with statistics, the only difference is the fact that students have an idea that AI can provide diagrams and interpretation of statistics of screenshots. To support such themes, below are arguments from respondents.

- *From my imagination that I want is maybe AI as modern and sophisticated calculator so that it can calculate not only numerical operations but also other operations. But, also, to provide graphs and other interpretations.*
- *Regarding space geometry, to solve a geometry problem, we are expected to visualize a picture. With the help of AI, it is expected that it can help to visualize the picture well, making it easier to solve the issue. An AI in the form of software application can visualize or predict a two-dimension figure or geometry as instructed. For example, cube with the O as mid-point of AB segment connected to P which lies at the center of CD.*
- *Maybe there is a machine that can be used to assist mathematics learning – Algebra. More or less like photomath application, but if the photomath cannot detect math story problems. So, if it can in Algebra…can detect math story problems.*
- *We can screenshot the questions using specialized Math applications, for example photomath. After taking pictures of such questions, the steps in solving the problem will automatically come out. If still confused with the steps, this application can help explain with voice like the Google (assistant) voice.*

Post pandemic era does not yet seem to free us from the use of technology. The pandemic should have taught students to understand the important roles of technology that infuse a variety of topics to improve class engagement (Galoyan et al., 2021). To be more specific, for senior high school, this understanding is lacking. Several studies argue that the implementation of Math application is centered around primary education (King et al., 2021; Pramana et al., 2021; Rachmavita, 2020) and higher education (Fuady et al., 2021; Syarif et al., 2021). There are studies of the implementation of math application in secondary level, however, it is more to junior high school level (Adnan & Anwar, 2020; Nida et al., 2020; Sumardi et al., 2021). This indication provides the opportunity and encouragement for Mathematics teachers at secondary schools to utilize technology AI more optimally in this era.

According to the findings described, many participants' technological suggestions of AI seemed to have been covered in different types of learning application. For example, AI role expected by participants on the topic of Geometry that can display visualization of three-dimensional shape particularly for students with the lack of spatial ability has been covered by GeoGebra or Desmos. The findings, however, indicate that teachers have not yet optimally used the applications.

Another theme that emerged regarding the AI role in mathematics education is the tendency of students to expect AI technology to function as smart tutor or ITS (Hermawan, 2022). Outside of Indonesia, there a lot of studies that develop and intentionally use ITS (Cruz-Jesus et al., 2020; Razzaq et al., 2011; Waalkens et al., 2013). ITS model is an AI that could provide feedback to students by providing directions, tips and strategies to solve mathematical problems (Hwang & Tu, 2021; Pappas & Drigas, 2016). On the other hand, the roles of AI to provide visualization of graphic when students learn about functions in senior high school, can be accommodated by the roles of Computer Algebra System (CAS) which is also available in the application of Desmos.

In terms of AI forms, students' understanding revolves around robots, smart machines and computer system which has the capabilities to provide guidance and directions in solving mathematical problems and can also be used as learning media. This seems to indicate that students are not yet familiar with math applications which can be used to facilitate such needs. Several studies underlined some factors which tend to cause that issue, namely: mathematics teachers' lack of digital literacy (Al Ghazali, 2020; Seidu & Owusu-boateng, 2022), socio-economic factors (Soesanto & Dirgantoro, 2021c), and geographical issues that are related to the advancement of infrastructure (Agustina & Suharya, 2021; Rahiem, 2021). Therefore, the findings of the current research suggest the needs for socialization and enrichments to teachers to minimize such gap, and of course to see and consider the context of Indonesia as an archipelago with different levels of digital literacy and socio-economic.

CONCLUSION

The findings can be viewed as an opportunity for researchers and practitioners to consider the importance of technology in mathematics education. This aligns with the fact that Indonesia has been facing various issues in relation to technology infusion during learning process. Therefore, socialization in forms of webinar or enrichment for teachers is contextually relevant, and thus vital to be conducted by experts and other researchers. Our study finds the dominant theme for students' expectation, which is AI can provide systematic explanation, feedback, guidance, or another way of math formula that can be used as an alternative in solving questions. In addition, some mathematics topics that might be infused by AI technology are proposed by students. Referring on the findings, it is expected that educators in Indonesia are tangibly pushed to utilize the model of ITS in mathematics and attempt to fulfill the students' suggestions related to mathematics topics which can potentially be developed with AI. The list of mathematics topics compiled from participants' responses can serve as reference for other researchers in Indonesia and outside of Indonesia to introduce AI with the ITS model. Other findings on the implementation of AI are also expected to broaden perceptions and insights. In the end, the technologically infused mathematics learning in Indonesia should be intentionally introduced and used widely.

Acknowledgments

The authors would like to thank all senior high school principals and Teachers College (Pelita Harapan University) alumnae as teachers in some Indonesian schools for providing their time in supporting this research.

Declarations

Author Contribution	:	RHS: Conceptualization, Writing - Original Draft, Editing and Visualization KPSD: Validation, Review Formal Analysis, and Methodology Writing - Review & Editing, Formal analysis, and Methodology NP: Proofreading, Editing Language Issue (Semantics, Grammar, Punctuation, Dangling Modifier)
Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	No additional information is available for this paper.

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