Jurnal Math Educator Nusantara
Wahana publikasi karya tulis ilmiah di bidang pendidikan matematika
p-issn: 2459-9735 e-issn: 2580-9210
http://ojs.unpkediri.ac.id/index.php/matematika

Enhancing PISA-like Mathematical Literacy through Deep Learning assisted by Mathos AI for Junior High School Students

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Article received : March 28, 2025
Article revised : May 2, 2025,
Article Accepted: May 3, 2025.
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Abstract: Based on PISA, Indonesian students' mathematical literacy skills are very low. This study investigates the effectiveness of Mathos AI-assisted deep learning design in improving PISA-like mathematical literacy among junior high school students. Using design research methodology with validation studies approach. Data were collected through pre-test and post-test, classroom observation, interviews, and analysis of student work. The findings revealed significant improvements in students' mathematical literacy, with positive impacts on their motivation and engagement. The integration of Mathos AI facilitates personalized learning and provides valuable insights into students' learning processes. This study contributes to the growing literature on AI-driven educational interventions, which offer practical implications for improving mathematical literacy in real-world classroom settings. The conclusion of this study is that Mathos AI-assisted deep learning is able to improve PISA-like mathematical literacy skills among junior high school students. The integration of AI-based tools in mathematics education can result in improved learning outcomes and student engagement. Further research is needed to explore the long-term effects of AI-based interventions and develop best practices for their implementation.

Keywords: *Mathematical Literacy, Like-PISA, Deep learning, Mathos AI, Design Research*

INTRODUCTION

In the global and digital era marked by the rapid development of technology and information, mathematical literacy skills play an increasingly crucial role. More than just mastering mathematical concepts and procedures, mathematical literacy empowers individuals to understand, interpret, and use mathematics in a variety of real-life contexts, from financial decision-making to scientific and technological problem-solving (Hernawati et al., 2024; Waluya & Nugroho, 2018; Wesna, 2021). Mathematical literacy, as defined by the Program for International Student Assessment (PISA), is critical to student success in the 21st century (Öz et al., 2024; Thomson et al., 2013). Nevertheless, various studies, including the results of the PISA assessment, have consistently shown significant challenges in students'

CITATION FORMATS: Widada, W., Nugroho, K.U.Z., Masri, M., Anggoro, A.F.D., Herawaty, D., Jumri, R., & Anggoro, S.D.T. (2025). Enhancing PISA-like Mathematical Literacy through Deep Learning assisted by Mathos AI for Junior High School Students. *Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis Ilmiah Di Bidang Pendidikan Matematika*. 11(1), 1-20. https://doi.org/10.29407/jmen.v11i1.25109

mathematical literacy in various countries, including Indonesia (Ingram et al., 2024; O.e.c.d, 2023). Students often struggle to relate mathematical concepts to real-world contexts, solve problems that require critical thinking and reasoning, and communicate their mathematical understanding effectively (Isnaintri & Hepsy, 2023; Nugroho et al., 2023; Rott, 2021). This limitation is a serious concern given the importance of mathematical literacy as an important foundation for further education and participation in knowledge-based societies. Many students struggle to apply mathematical knowledge in a real-world context (Karaca et al., 2023; Lu et al., 2024; Zulkardi et al., 2021).

In this context, the development of mathematical literacy skills that are in line with the characteristics of PISA questions (*like-PISA*) to be very relevant. Questions *like-PISA* Requires students to not only master math content (Garcia et al., 2024; Sepriliani, 2023; Zhu et al., 2025), but also being able to analyze information, formulate problems, use different representations, and evaluate solutions in meaningful contexts (Khine et al., 2024; Payadnya et al., 2023). Therefore, efforts to improve the ability to *like-PISA* junior high school students are an important investment in preparing a competent and adaptive young generation (Hikamudin et al., 2023).

Along with technological advancements, various innovative approaches have emerged to improve the quality of mathematics learning. One of them is the utilization of *Deep Learning*, a branch of artificial intelligence (AI) that allows systems to learn from large amounts of data and identify complex patterns (Liu et al., 2025; Ma et al., 2022; Santos et al., 2023) In the context of mathematics education, *Deep Learning* offers the potential to personalize students' learning experiences, provide adaptive feedback, and identify areas where students are struggling more deeply (Lee et al., 2024; Liu et al., 2021; Widada et al., 2021). This shows that the use of deep learning in mathematics learning will be a solution to overcome the difficulties students learn mathematics.

In an effort to optimize the potential *Deep Learning* to improve math literacy, this study proposes and evaluates the implementation of Mathos AI, an AI-assisted learning system specifically designed to support the development of skills *like-PISA* in junior high school students (Imane et al., 2024; Lee et al., 2024) Mathos AI leverages algorithms *Deep Learning* to present practice questions tailored to the student's individual level of understanding, provide constructive and timely feedback, and monitor learning progress on an ongoing basis (Abukhalaf et al., 2024; Ranjan et al., 2021). Therefore, the application of deep learning assisted by Mathos AI will have a positive impact on mathematical literacy skills, especially PISA-like questions. This is because the integration of artificial intelligence (AI) in education has shown promising results in improving learning outcomes (Feng, 2023). Mathos AI, a platform that leverages deep learning algorithms, offers personalized learning experiences and provides hands-on feedback to students (Svyatkovskiy et al., 2019). This study explores the potential of Mathos AI in improving students' mathematical literacy.

The researcher provides valuable insights into the potential of Deep Learning and AI platforms such as Mathos AI in answering the challenges of mathematics literacy at the junior high school level. Further, this research has the potential to inform the development of more innovative and effective learning strategies and teaching aids in preparing students for the demands of international assessments such as PISA and, more importantly, equipping them with the mathematical skills essential for future success (Humaira & Putri, 2024). Thus, this study aims to investigate the effectiveness of the implementation *Deep Learning* assisted by Mathos AI in improving mathematical literacy *like-PISA* junior high school students. Therefore, it is necessary to develop and evaluate the design of Deep learning learning assisted by Mathos AI.

There is a formulation of the problem investigated in this study, namely: How does the use of Mathos AI affect the improvement of PISA-type mathematics literacy in junior high school students? How effective is Mathos AI in improving PISA-type math literacy in junior high school students?

METHODS

This study applies design research with an approach to *Validation Studies* (Ekawati et al., 2022; Friansah et al., 2024; Plomp & Nieveen, 2013). This approach is particularly relevant to ensure that the interventions developed are truly effective and valid. *Validation studies* is a type of research that aims to test and validate a product, intervention, or theory that has been developed. In the context of design research, this means ensuring that the designed solution actually works according to the set objectives. The main focus is on the empirical evidence that supports claims of effectiveness and validity. **Participants** This study was conducted by 30 randomly selected junior high school students, and mathematics teachers from one of the junior high schools in Rejang Lebong, Indonesia. Data were collected using pretest and postest based on the PISA framework, classroom observation sheets, semi-structured interview protocols, student work analysis rubrics, and questionnaires. This research was conducted in the odd semester of 2024/2025, for eight weeks in September-November 2024.

There are three main stages of the *validation studies approach*, namely preparation and design, teaching experiments, and retrospective analysis.

Preparation and Design

This stage is the foundation of design research with a *validation studies approach*. The focus is on designing robust and scalable interventions. The activities carried out are *needs analysis*, through the identification of specific learning problems, the analysis of student characteristics, the learning context, and the curriculum, and the determination of clear and measurable learning objectives. *Intervention design* involves developing intervention prototypes based on relevant theory and empirical evidence, designing appropriate learning materials, activities, and assessments, and ensuring interventions are aligned with learning objectives. *Development of measurement instruments*, i.e. making or adapting instruments to measure relevant variables (e.g., mathematical literacy tests, motivational questionnaires), ensuring that instruments have high validity and reliability, conducting instrument tests to ensure their clarity and effectiveness. *The research design*, i.e. choosing a quasi-experimental research design, determines the experimental and control groups. Content validity was determined through validation by 5 experts, and was pilot tested with test reliability assessed using Cronbach's alpha, producing a coefficient of α=0.821.

Teaching Experiments

This stage involves the implementation of the intervention in a real learning setting and data collection to assess its effectiveness. The activities carried out are *the implementation of interventions*, namely carrying out interventions in accordance with the design that has been set, ensuring that teachers or facilitators are well trained, and observing the learning process and documenting important events. *Data collection*, namely collecting quantitative data through test scores, and qualitative data through observation and interviews, ensures that data is collected systematically and consistently, and ensures that this data collection process must be carried out as objectively as possible. *Monitoring and adjustments*, i.e. monitoring the learning process periodically, making adjustments if necessary to ensure interventions go as planned, ensuring all changes that occur are recorded and documented.

Here is one of the PISA-like test questions used in the study as an example of an instrument. "In a penguin population, 25% have the genotype AA, 50% Aa, and 25% aa, see Figure 1.

Figure 1. Penguin Population

Calculate the probability that two randomly selected individuals have the same genotype?"

Best Answer: The probability is 0.375 or 37.50%.

The assessment rubric:

Score	Assessment Criteria	Description
2	Precise and Complete Answers	Calculate the probability of selecting two individuals with genotype AA: (0.25) * (0.25) = 0.0625. Calculate the probability of selecting two individuals with genotype Aa: (0.5) * (0.5) = 0.25. Calculate the probability of selecting two individuals with genotype aa: (0.25) * (0.25) = 0.0625. Sum all those probabilities: 0.0625 + 0.25 + 0.0625 = 0.375. Write down the answer clearly and state the probability in decimal or percentage form.
➢ Score 1: If the partial correct answer is to calculate the probabilities for one or two genotypes correctly. Demonstrate an understanding of the concept of probability, but there are errors in the calculation or writing of the answer. Close to the correct result, but there are rounding errors, or small mathematical errors. ➢ Score 0: If the Answer is Wrong or No Answer, i.e. there is no correct calculation. Not showing an understanding of the concept of probability. Not giving answers or giving irrelevant answers.		

Retrospective Analysis

This stage involves data analysis and reflection to assess the effectiveness of the intervention and identify implications for practice. The activities carried out are *data analysis*, namely quantitative data analysis using appropriate statistical techniques, qualitative data analysis using thematic or content analysis, and interpreting the results of data analysis in the context of research questions. *Reflection and interpretation* are reflecting on the research process and results, identifying the strengths and weaknesses of interventions, and drafting discussions of the implications of findings on theory and practice. By following these three stages, design research with *a validation studies approach* produces innovative interventions, which have been proven to be effective and empirically valid.

Data Analysis: Quantitative data is analyzed using inferential statistics, namely t-test and regression analysis. Qualitative data were analyzed using thematic analysis. **Inferential Statistics**: make inferences or conclusions about the population based on a sample of data. With **the t-test analysis technique in covariate analysis**, which is used to compare the averages of two related data groups, i.e. to determine if there is a significant difference between the two averages. **Regression analysis**, which is used to model the relationship between dependent variables and one or more independent variables (predictors). Aims to predict the value of dependent variables based on the value of independent variables. This regression analysis can also be used to see how strong the influence of independent variables is on dependent variables. **Qualitative Data Analysis,** qualitative data is data that is non-numerical in nature: interview transcripts, observation notes, and other documents. **Thematic Analysis**: identifying and analyzing themes or patterns that appear in qualitative data. The steps of the analysis are:

1) Transcription: Converts audio or video data into text.
2) Coding: Assigning labels or codes to relevant data segments.
3) Theme grouping: Identify recurring patterns or themes.
4) Interpretation: Interpret the meaning of the themes identified.

RESULTS AND DISCUSSION

This study provides a picture of the improvement of junior high school students' mathematical literacy through the implementation of Deep Learning learning assisted by Mathos AI. One indicator of its success is a significant increase in students' mathematical literacy skills after following the learning process. In the first stage, the researcher designed an intervention design, namely the Hypothetical Learning Trajectory (HLT). The results of the HLT are in Table 1.

Table 1. Hypothetical Learning Trajectory (HLT) *Mathos AI-Assisted* Deep Learning

Phase	Main Student Activities	Main Objectives	Hypothetical Student Activities
1. Early Introduction and Adaptation	Doing a PISA-based math literacy pre-test. Get to know the basic interface and features of Mathos AI. Following the introduction of deep learning-based learning.	Identify students' initial level of mathematical literacy ability. Build a basic understanding of Mathos AI and deep learning. Adjust the initial difficulty level of learning based on pre-test data.	✓ Students show variations in early math literacy abilities. ✓ Students begin to adapt to Mathos AI's interface and features. ✓ Students show an early interest in new learning approaches.
2. Interactive Exploration with Mathos AI	Work on interactive exercises and tasks customized by Mathos AI. Use visualization and simulation features to understand mathematical concepts. Participate in small group discussions about problem solutions.	Improve understanding of mathematical concepts and procedures. Describe problem-solving and mathematical reasoning skills. Increase student engagement and active participation.	✓ Students show improved understanding of concepts and problem-solving skills. ✓ Students use Mathos AI features actively and effectively. ✓ Students collaborate and share problem-solving strategies.
3. Contextual Applications and Modeling	Working on projects that involve mathematical modeling of real-world problems. Using Mathos AI to analyze data and create mathematical representations. Presenting the results of the project to peers and teachers.	Explain mathematical and representation skills. Improve communication skills and mathematical argumentation. Outline complex and creative problem-solving skills.	✓ Students are able to create mathematical models of contextual problems. ✓ Students use Mathos AI to analyze data and create visualizations. ✓ Students present the project clearly and confidently.
4. Self-Reflection and Evaluation	Work on a reflection task about the learning process and understanding concepts. Doing a PISA-based mathematical literacy post-test. Provide feedback on the learning experience with Mathos AI.	Improve metacognitive awareness and self-evaluation skills. Measuring the improvement of mathematical literacy skills. Evaluate the effectiveness of Mathos AI and learning design.	✓ Students are able to reflect on the learning process and identify areas for improvement. ✓ Students show a significant improvement in post-test scores. ✓ Students provide constructive feedback on Mathos AI.

Phase	Main Student Activities	Main Objectives	Hypothetical Student Activities
5. Transfer and Generalization	Apply mathematical literacy skills in contexts outside the classroom. Using Mathos AI as a self-study tool. Demonstrate an interest in exploring advanced math topics.	Explain the transferability and generalization of mathematical knowledge. Increase independence and motivation to learn mathematics. Building a positive attitude towards technology-based mathematics learning.	✓ Students are able to apply mathematical literacy skills in new situations. ✓ Students use Mathos AI independently to learn math. ✓ Students show interest in learning more about math topics.

The HLT was validated by five experts with valid results and recommended for application in real classroom learning. Various revisions and standardization cycles of the HLT have been carried out to obtain a valid and practical intervention design (validity and practicality tests of the intervention design are not discussed in this paper). The focus of the discussion of the results of this study is (1) The results of the t-test showed a significant difference between the pre- and post-test scores, which indicated an increase in students' mathematical literacy. (2) Regression analysis revealed a positive correlation between the use of Mathos AI and student learning outcomes. (3) Questionnaire responses showed positive perceptions and increased student motivation towards mathematics learning. (4) Thematic analysis of interview and observation data highlighted the effectiveness of personalized learning and contextual problems in increasing student engagement. During the learning process, students carried out activities according to the stages of the learning trajectory. This was confirmed by the results of interviews between the researcher and students.

Based on interviews between Researchers (R) and Students (S), it is presented based on the stages of learning trajectory. This is one of the research subjects who has an increase in mathematical understanding, especially in solving PISA-like literacy problems.

Stage 1: Introduction and Initial Adaptation

In the early stages, Student S showed a process of adaptation to the Mathos AI platform which was new to him. Although he felt a little confused at first, Student S appreciated the attractive interface and helpful initial explanations. The initial difficulty in understanding the more narrative PISA-like question format was normal. The sample questions and discussion features were key in helping Student S overcome confusion and understand the expectations of this type of question. As the following interview excerpt shows.

R: When you were first introduced to Mathos AI, what was your first impression? Was the display easy to understand? How did you adapt to the way Mathos AI presents the material and questions?

S: At first, I was a little confused because it was something new. But in my opinion, the display is quite interesting and not too complicated. There is also a brief explanation on how to use it. I started trying to work on some of the questions given. At first, it might be a bit difficult because the questions are different from the ones I usually get in school, *more like stories. But over time I started to get used to the question format and the way Mathos AI provides feedback after I answer.*

R: Are there any special features of Mathos AI that you think are helpful in the early stages of this adaptation?

S: In my opinion, the feature that provides examples of questions and their explanations is very helpful. So, if I am confused about a type of question, I can first see an example of how to solve it. Then, if I answer wrongly, the explanation is also quite easy to understand.

The interview footage confirmed that students were able to recognize and adapt to walking positively thanks to the interface design of the mathos application. It can be seen from the student's smartphone that the application has installed (see Figure 2).

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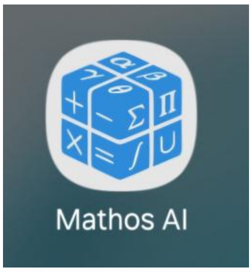


Figure 2. Mathos.ai app on Student Smartphone

Based on the interview and confirmation excerpts, it can be seen that the introduction and adaptation stages went positively thanks to the user-friendly interface design and the availability of supporting resources such as sample questions and discussions. This shows that Mathos AI has managed to provide a fairly intuitive learning environment for students to start interacting with platforms and question types like PISA.

Stage 2: Interactive Exploration with Mathos AI

In Activity 2, students showed active involvement and a sense of challenge in working on PISA-like questions in Mathos AI. The challenges they felt actually triggered their interest in learning. Interaction with the system that provided instant feedback and instructions when answering incorrectly was considered positive. The question adaptation feature based on student ability was also felt by Student S, indicating that the deep learning algorithm in Mathos AI functions to adjust the level of difficulty. This can be seen from the following interview excerpt.

R: After using Mathos AI for some time, how was your experience in working on various types of PISA-like questions presented? Did you feel challenged? How was your interaction with the system when working on the questions?

S: I feel that the questions are indeed more challenging than ordinary questions. Sometimes I have to really think hard and connect several mathematical concepts to be able to answer. But that's what makes me more interested. The interaction is also good, Sir. I can answer immediately, and immediately know whether it's right or wrong. If I'm wrong, there are also instructions, so I can try again or see the discussion. I also like it *because the questions seem to adjust to my abilities. If I'm often right on one topic, the questions become more difficult.*

R: Do you use the feedback feature provided by Mathos AI? What do you think about the quality and benefits of the feedback?

S: Yes, I often see the feedback. In my opinion, the feedback is quite detailed. Not only does it say whether it's right or wrong, but it also explains why my answer is wrong and how to answer it correctly. Sometimes there are also tips or concepts that are relevant to the question. It really helps me to understand my mistakes and learn from them.

Based on the interview snippets, it can be conformed to the use of adaptive applications by students. It can be seen Figure 3.

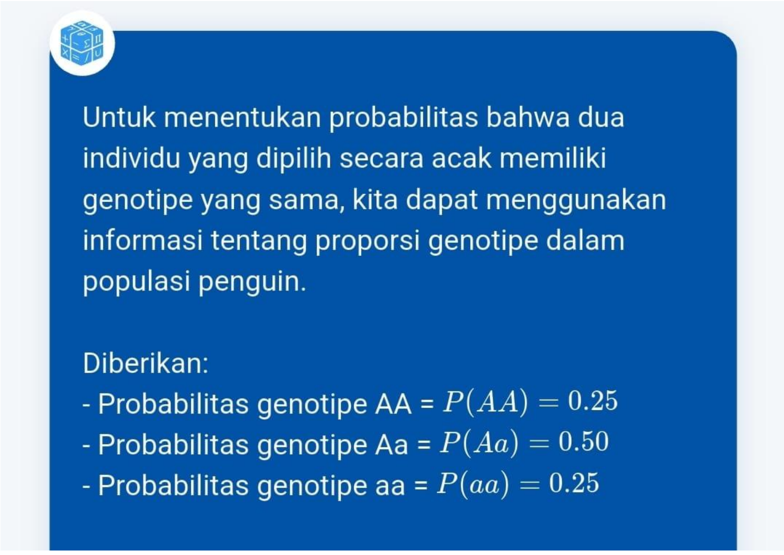


Figure 3. Adaptive applications

Interview footage and Figure 3 show that interaction with Mathos AI successfully stimulates students' thinking through challenging yet adaptive problems. Constructive and timely feedback plays an important role in the learning process and understanding of concepts. This indicates that the deep learning approach is able to create a personal and engaging learning experience.

Stage 3: Contextual Application and Modeling

Activity 3, initially, PISA-like contextual questions were a challenge because Student S tended to focus on the narrative of the questions. However, over time and with continuous practice through Mathos AI, Student S began to get used to identifying relevant information and connecting it to mathematical concepts. The illustration or image feature in the questions also helped visualize the context. Student S began to realize the relevance of mathematics in everyday life through the examples of questions given. The following is an excerpt from his interview.

R: PISA-like questions often involve the application of mathematics in real-world contexts. How was your experience in understanding and solving such questions through Mathos

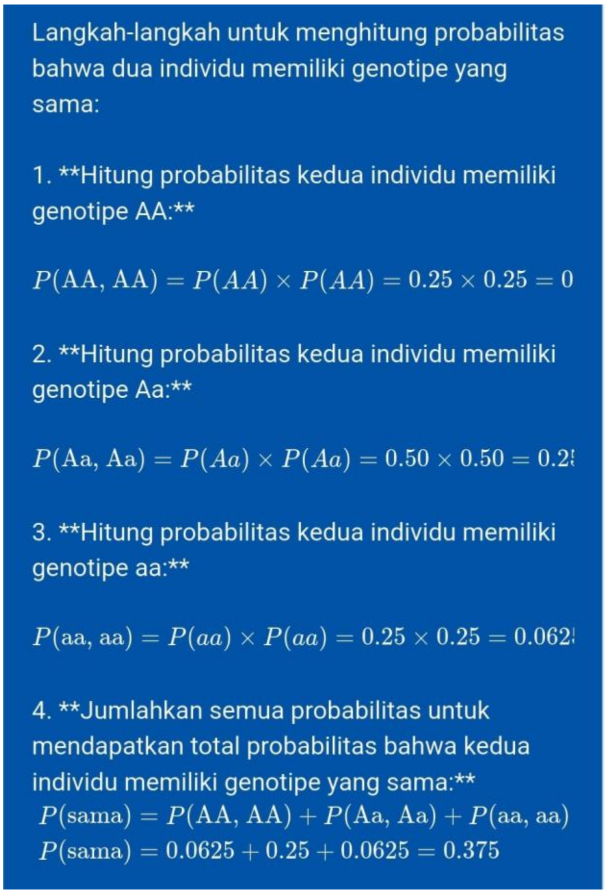
AI? Do you feel that Mathos AI helped you see the connection between mathematics and everyday life?

S: At first, the questions with stories were a bit confusing. I focused on the story rather than the mathematics. But after working on them often, I became more accustomed to identifying important information and how mathematics can be used to solve problems in the story. Mathos AI also sometimes provided illustrations or images that helped me imagine the context of the question. I became more aware that mathematics is not just numbers in a book, but can be used for many things around us.

R: Are there any specific examples of questions that you found very helpful in understanding the contextual application of mathematics?

S: There were several questions about calculating budgets, then about reading graphs and drawing conclusions, and questions about map scales. These questions made me think about what it would be like if I faced similar situations in real life.

Based on the interview snippets, it can be conformed to the use of adaptive applications by students. It can be seen Figure 4.



Langkah-langkah untuk menghitung probabilitas bahwa dua individu memiliki genotipe yang sama:

1. **Hitung probabilitas kedua individu memiliki genotipe AA:**

$P(\mathrm{AA}, \mathrm{AA}) = P(AA) \times P(AA) = 0.25 \times 0.25 = 0$

2. **Hitung probabilitas kedua individu memiliki genotipe Aa:**

$P(\mathrm{Aa}, \mathrm{Aa}) = P(Aa) \times P(Aa) = 0.50 \times 0.50 = 0.2$

3. **Hitung probabilitas kedua individu memiliki genotipe aa:**

$P(\mathrm{aa}, \mathrm{aa}) = P(aa) \times P(aa) = 0.25 \times 0.25 = 0.062$

4. **Jumlahkan semua probabilitas untuk mendapatkan total probabilitas bahwa kedua individu memiliki genotipe yang sama:**

$P(\mathrm{sama}) = P(\mathrm{AA}, \mathrm{AA}) + P(\mathrm{Aa}, \mathrm{Aa}) + P(\mathrm{aa}, \mathrm{aa})$

$P(\mathrm{sama}) = 0.0625 + 0.25 + 0.0625 = 0.375$

Figure 4. Students Get Their Thought Process

Based on the interview excerpt, Mathos AI gradually helps students develop the ability to apply mathematical concepts in real-world contexts. Structured exercises and visual support in problems play a vital role in bridging abstract understanding of mathematics with concrete situations. This is a crucial aspect in improving PISA-like mathematical literacy.

Stage 4: Reflection and Self-Evaluation

At this stage, Student S utilized the learning outcome summary feature to monitor his progress and identify areas for improvement. Awareness of strengths and weaknesses in specific math topics allowed Student S to focus his efforts on relevant areas. The use of Mathos AI also increased Student S's confidence in dealing with non-routine math problems, indicating a positive impact on the affective aspect of learning. As seen from the following interview.

R: Mathos AI may have a feature that allows you to see your learning progress. Have you ever used that feature? How do you reflect on your progress in math literacy after using Mathos AI?

S: Yes, I have seen the summary section of my learning results. There you can see which topics I have mastered and which topics I still need to improve. I can tell, oh, it turns out I am still weak in geometry or algebra, for example. That way, I can focus more on studying and practicing questions in those topics. I feel that there is an increase in my understanding, especially in working on questions that require reasoning and application of concepts.

R: Do you feel more confident in dealing with non-routine math problems or those that are similar to PISA problems after using Mathos AI?

S: Yes, sir. In the past, when I saw a question that was long and had a lot of stories, I immediately felt it was difficult. But now, after getting used to the questions in Mathos AI, I am calmer and more confident that I can do them. I am more focused on understanding the core of the problem rather than just looking at its different forms.

According to the excerpt, the self-evaluation feature in Mathos AI empowers students to take an active role in their learning process. The ability to reflect on progress and identify areas for improvement is an important component in student (=S) learning and improving mathematical literacy. Increased self-confidence is also a positive indicator of the effectiveness of using the platform.

Stage 5: Transfer and Generalization

Activity 5, Student S felt that there was a transfer of knowledge and skills gained from Mathos AI to other learning situations, such as in class and when working on assignments from the teacher. The ability to analyze questions, find relevant information, and try various problem-solving strategies increased. The concrete examples given by Student S show that the learning experience with Mathos AI is not only limited to the platform, but also has an impact on his learning approach in general. Here is the evidence.

R: After studying with Mathos AI, do you feel that there is a change in the way you learn mathematics in class or when doing assignments from teachers? Do you feel that the skills you trained in Mathos AI can be applied to other learning situations?

S: I think it has an impact, sir. Now if the teacher gives a question that is a bit different or requires more thought, I am not too surprised. I try to analyze the question first, find out what is actually being asked, and how the relevant mathematical concepts can be applied. I also become more courageous in trying various ways to solve the question, not *just sticking to one method taught in class. I feel that Mathos AI trains me to think more flexibly and creatively in solving math problems.*

R: Can you give a concrete example of how you apply what you learned from Mathos AI in a learning situation outside of that platform?

S: For example, at that time there was a question on the daily test about interpreting graphs. It became easier for me to understand the meaning of the graph and how to get the information needed to answer the question, because in Mathos AI there are also many practice questions that use graphs. Or, when there is a group assignment to create a project that involves calculating scale, I understand the concept of scale better because I have often practiced questions like that in Mathos AI.

This activity can be confirmed from the results of using Mathos AI as shown in Figure 5.

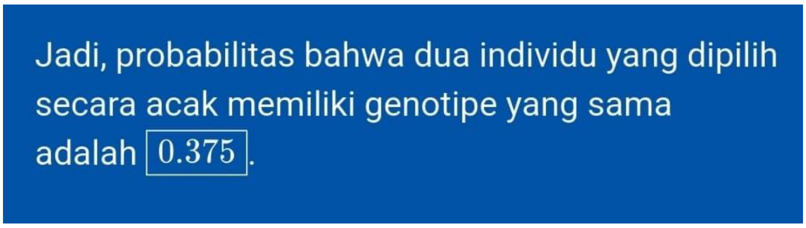


Figure 5. Mathos AI application draws conclusions

Based on the excerpt and Figure 5, the use of Mathos AI contributes to the development of more flexible and creative mathematical thinking skills. The ability to transfer and generalize the knowledge and skills acquired shows that learning with Mathos AI not only improves the ability to work on PISA-like problems, but also strengthens the understanding of mathematics in a deeper and more applicable way. Interviews with R and S provide an overview of how interviews can be conducted to explore students' experiences at each stage of the learning trajectory when using Mathos AI to improve PISA-like mathematical literacy. Thus, the interview with Student S shows that the use of Mathos AI has significant potential in improving PISA-like mathematical literacy in junior high school students. This platform not only helps students adapt to different question formats, but also stimulates critical thinking, improves contextual application skills, encourages self-reflection, and facilitates the transfer of learning to other contexts. Adaptive feedback and self-evaluation features in Mathos AI are important elements that support an effective and personalized learning process for students. Student S's positive experience provides a strong indication that Mathos AI-assisted deep learning can be a promising approach to improving the quality of mathematics learning, particularly in preparing students to face assessment challenges such as PISA and developing mathematical skills relevant to everyday life.

Furthermore, quantitative data was analyzed using inferential statistics, namely the t-test and regression analysis as follows. Hypothesis test of the influence of HLT deep learning and Mathos AI interaction on PISA-like mathematical literacy ability after controlling for the influence of students' initial ability. The hypothetical pairs are Ho: $\alpha\beta_{ij} = 0$; for i = 1, 2 and j = 1, 2; H1: Not Ho. The description is Ho: There is no effect of the interaction of HLT deep learning and Mathos AI on the mathematical literacy ability of PISA-like after controlling for the influence of students' initial ability. H1: There is an effect of the interaction of HLT deep

ISSN 2459-9735 (print), ISSN 2580-9210 (online)

learning and Mathos AI on PISA-like mathematical literacy skills after controlling for the influence of students' initial ability. The statistics used are the Fo(AB) test in the *Tests of Between-Subjects Effects* table. Accept Ho, if the *value of the Tests of Between-Subjects Effects* is Fo(AB) with a p-value > 0.05. Based on the analysis of SPSS-assisted data, Table 2 is shown.

Table 2. *Tests of Between-Subjects Effects*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6,583.640	4	1,645.913	76.820	0.000
AB	68.711	1	68.710	3.207	0.015
Error	2,035.43	95	21.432		

The decision is that based on data analysis (Table 2), obtained Fo(AB) = 3.207 with db(1, 95) and p-value = 0.015<0.05 means that Ho is rejected. Thus, there is an effect of the interaction of HLT deep learning and Mathos AI on the mathematical literacy ability of PISA-like after controlling the influence of students' initial ability.

Furthermore, test-hypotheses about PISA-like math literacy, deep learning and Mathos AI together affect PISA-like math literacy skills. The hypothetical pairs tested are Ho: μ_i = βj = Xs = Xs = 0; H1: Not Ho. The description is Ho: Mathematics literacy skills like PISA, Deep learning and Learning Approach together have no effect on mathematics literacy skills like PISA. H1: Mathematics literacy skills like PISA, Deep learning and Learning Approach together affect mathematics literacy skills like PISA. The statistics used, the Fo (*Corrected Model*) Test in the Tests *of Between-Subjects Effects table*. Accept Ho, if the value *of the Tests of Between-Subjects Effects* is Fo (*Corrected Model*) with a p-value of > 0.05. The results of the analysis (Table 2) were obtained that Fo = 76.82 with db(4, 95) and p-value = 0.00<0.05 means that Ho is rejected. Thus, the mathematics literacy skills like PISA, deep learning, and Mathos AI together affect the mathematics literacy skills like PISA.

For testing on PISA-like math literacy skills, students were taught with Mathos AI-assisted deep learning after controlling for the influence of students' initial abilities. Hypothetical pairs tested Ho: μ_{01} ≤ μ02; H1: μ01 > μ02; The description is that Ho: The students' like-PISA math literacy ability for deep learning is not higher than that of students for deep learning taught with the Conventional Learning Approach after controlling for the influence of PISA-like math literacy ability. H1: The students' PISA-like math literacy ability for deep learning is higher than that of students for deep learning taught with the Conventional Learning Approach after controlling for the influence of PISA-like math literacy ability. The statistics used are t-tests for row B1 in the *Parameter Estimates* table. Accept Ho, if the value t for row B1 in the *Parameter Estimates* table has a p-value > 0.05. Based on data processing using SPSS, parameter estimates are obtained, see Table 1.

Table 1. Parameter Estimates

Parameters	B	Std. Error	t	Sig.
Intercept	32,723	2,781	11,767	.000
B1	23,175	1,016	22,810	.000
X	0,467	0,063	7,413	.000

Dependent Variable: PISA-like mathematical literacy skills

Based on Table 1, the t-test shows that t-count = 22.810 and p-value = 0.000 <0.05 means that Ho is rejected. Thus, students' PISA-like math literacy abilities for Mathos AI-assisted deep learning were higher than students taught with conventional learning approaches after controlling for the influence of their initial abilities.

The results of the data analysis showed a significant increase in students' mathematical literacy scores. This is supported by the results of the t-test comparing the pre-test scores (before the implementation of learning) and post-test scores (after the implementation of learning). The main finding of this study is that there is a statistically significant difference between the pre-test scores and the Post-test scores of students' mathematical literacy. This significant difference indicates that there is a real change in students' mathematical literacy abilities after participating in learning with the Mathos AI-assisted Deep Learning model. Also, the significant difference with a higher Post-test score than the pre-test score clearly shows that the implementation of the Mathos AI-assisted Deep Learning model has succeeded in improving students' mathematical literacy. This increase means that the learning approach applied is effective in developing students' abilities to understand, apply, and interpret mathematics in various real-life contexts, in accordance with the competencies emphasized in PISA. These findings provide empirical evidence regarding the effectiveness of the Deep Learning model combined with Mathos AI in improving junior high school students' mathematical literacy. The implication of the results of this study is that this study supports the application of innovative approaches in mathematics learning, especially those that utilize artificial intelligence (AI) technology such as Mathos AI and deep learning strategies. The results of the study indicate that the combination of Deep Learning and Mathos AI has great potential in improving the quality of mathematics learning, especially in the literacy aspect which is very important for students' future success. Education practitioners, such as teachers and curriculum developers, can consider the application of similar learning models as an alternative to improving students' mathematical literacy.

The results of this study provide an overview that Student S's experience in the initial stage is in line with research findings. That is, the initial stage of adaptation to new technologies is often challenging for users, especially in educational contexts(Mishra & Koehler, 2006). However, intuitive interface design and the availability of supporting resources such as examples and instructions can accelerate the adaptation process (Liu & Wu, 2019). Initial difficulties in understanding the different PISA-like question formats, but were quickly overcome thanks to the example and discussion features provided by Mathos AI. Experience Initial difficulties in understanding the different PISA-like question formats, but were quickly overcome thanks to the example and discussion features provided by Mathos AI. This suggests that user-friendly interface design and support provided by the platform can help students overcome initial barriers to using new technologies for learning. Furthermore, Student S's experience with the feedback provided by Mathos AI is in line with research findings. He appreciated the details and explanations provided by the system, which helped him understand his mistakes and learn from them. Research shows that constructive and timely feedback is an important factor in improving student motivation and understanding (Hattie, 2008). Adaptive learning systems, which can adjust the level of difficulty and provide relevant feedback, can increase student engagement and encourage more learning (Koedinger et al., 1997). Mathos AI's ability to adjust the level of difficulty and provide relevant feedback is also evident in Student S's increased confidence in working on more challenging problems.

Research shows that the ability to apply mathematical concepts in real-world contexts is an important aspect of mathematical literacy (O.e.c.d, 2019). The use of interactive and engaging technology can help students better understand and apply abstract concepts (Kadijević & Vlahović, 2015). Student S's experience in understanding and solving contextual problems through Mathos AI is in line with research findings. She initially found it difficult, but with practice and support from the platform, she began to see the connection between mathematics and everyday life. The use of illustrations and images in Mathos AI also helped Student S visualize the context of the problem, which strengthened her understanding.

The ability to reflect and self-evaluate is an important skill in effective learning (Zimmerman, 2000). Technology that supports reflection and self-evaluation can help students monitor their progress and identify areas for improvement (Hattie, 2008). Student S's experience with the learning outcome summary feature in Mathos AI showed that she was able to reflect on her progress and identify areas for improvement. The ability to monitor progress and identify areas of weakness is an important aspect of Student Sri's ongoing learning.

Transfer of learning, which is the ability to apply knowledge and skills acquired in one context to another, is an important goal of education (Bransford et al., 2000). The use of interactive, student-centered technology can support transfer of learning by creating a more active and meaningful learning environment (Mayer, 2009). Student S's experience in applying what she learned from Mathos AI to other learning situations shows transfer of learning. She was more confident in dealing with non-routine problems and was better able to apply mathematical concepts in a variety of contexts. This suggests that the use of Mathos AI not only improves students' ability to work on PISA-like problems but also strengthens their understanding of mathematics more generally.

Based on the discussion, the results of this study support the findings of studies that show that the use of interactive and adaptive learning technologies, such as Mathos AI, can have a positive impact on improving students' mathematical literacy. This platform not only helps students understand and apply mathematical concepts, but also increases their motivation, self-confidence, and reflection skills. The ability to transfer and generalize knowledge gained is an important aspect of effective learning, and Mathos AI has been shown to support this process.

Overall, the results of this study strongly indicate that the application of the Mathos AI-assisted Deep Learning model has a positive and significant impact on improving junior high school students' mathematical literacy. The significant t-test results are statistical evidence supporting this claim. This study provides an important contribution to the development of more effective and relevant mathematics learning practices to the demands of the 21st century.

The limitations of the study are that this study has not explored the long-term effects of AI-based interventions (Mathos AI) on students' mathematical literacy. This study has not developed or identified comprehensive best practices for the implementation of Mathos AI or similar AI tools in various educational contexts.

The novelty of this research is that this study shows the potential (novelty lies in the demonstration of potential and specific applications) of the use of Mathos AI with deep learning specifically to improve PISA-like mathematical literacy in junior high school students, as well as its implications for educators and curriculum developers. This is a new contribution in the application of certain AI tools (Mathos AI) for specific mathematics education purposes (PISA-like literacy) at a certain level.

CONCLUSION

This study demonstrates the potential of Mathos AI-assisted deep learning in improving PISA-like mathematical literacy among junior high school students. Integration of AI-based tools in mathematics education can lead to improved learning outcomes and student engagement. Further research is needed to explore the long-term effects of AI-based interventions and develop best practices for their implementation.

The findings of this study have practical implications for mathematics educators and curriculum developers. Integration of Mathos AI and similar AI-based tools can be considered a viable strategy for improving mathematical literacy. Teacher training and professional development programs should focus on equipping educators with the skills to effectively integrate AI tools into their teaching practices.

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