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Mathematical Literacy with Technology-Assisted Scaffolding in Indonesia: Camper and Quitter Students in Solving PISA Problems

Novia Dwi Rahmawati, Wardono, Kristina Wijayanti, Nuriana Rachmani Dewi

Abstract

Background/purpose. This research aims to describe the mathematical literacy of camper and quitter students using technology-assisted scaffolding when solving PISA problems. The Indonesian government has attempted various ways to improve students' mathematical literacy. However, mathematical literacy scores remain low. Mathematical literacy refers to the ability to use and apply mathematical knowledge in a relevant context.

Materials/methods. The subjects of this research were selected using a purposive sampling, taking into account communication skills. Three eighth-grade students from SMP Negeri 2 Jombang Regency served as the research subjects: one was categorized as a camper, and the other as a quitter. The data were collected through a questionnaire and a task-based interview on the space and shape mathematics literacy level-four subject matter. The data were analyzed using Miles and Huberman's conceptual framework, which comprises data reduction, presentation, and conclusion.

Results. The results of this research are as follows: (1) subjects in the camper category met four indicators in completing the initial mathematical literacy test: communication, mathematizing, reasoning, argumentation, and devising strategies for solving problems; and (2) quitter subjects only met one mathematical literacy indicator, namely mathematizing. The alternative scaffolding provided for the campers and quitters included Environmental Provisions, Explaining, Reviewing, Restructuring, and Developing Conceptual Thinking.

Conclusion. The implementation of technology-assisted scaffolding has strong potential to improve conceptual understanding, problem-solving skills, and critical thinking through the gradual support facilitated by digital platforms. While camper students met all four mathematical literacy indicators, quitter students demonstrated proficiency only in the mathematics indicator. Nonetheless, their conceptual understanding improved through the gradual support provided by digital platforms.

1. Introduction

The development of students' mathematical literacy is essential to education (Goos & O'Sullivan, 2023). Similarly, the Organisation for Economic Co-operation and Development (OECD) emphasizes the importance of mathematical literacy in a global context and its impact on individual and societal development (PISA, 2023). In this context, mathematical literacy is defined as an individual's capacity to use and apply mathematical knowledge in relevant contexts (Çakıroğlu et al., 2024; Sujatha & Vinayakan, 2022).

Indonesia's mathematical literacy results remain low (Fauzan et al., 2025; Munadi & Febriyanti, 2020). Indonesia's average score in mathematics is below the international average of 366, positioning the nation at 66th out of 78 participating PISA countries. Within Southeast Asia, Indonesia ranks near the bottom, with only the Philippines scoring lower. These findings suggest that the low performance of Indonesian students in the PISA mathematics assessments is a multifaceted issue affected by several factors, including curriculum alignment, teaching quality, socio-economic status, language obstacles, and limited opportunities to engage in higher-order thinking and problem-solving tasks (Masduki et al., 2020; Sutarni et al., 2024). Consistent with this, mathematical literacy at the deductive level of geometric thinking is more effective for solving geometry problems than the informal and informal-deductive levels (Trimurtini et al., 2023). This study aims to characterize the mathematical literacy and skills of camper and quitter children using technology-supported scaffolding to solve PISA problems. This study employed a qualitative descriptive design.

Some key factors affecting low student literacy in Indonesia include the limited use of contextual approach and non-routine problems in learning (Putri & Zulkardi, 2020), the lack of innovation in learning and assessment design (Zulkardi & Putri, 2020), the absence of clear conceptualization of learner agency (OECD, 2019), and teacher's inadequate capacity to teach mathematical literacy effectively (Risdiyanti et al., 2024). One practical skill for developing mathematical literacy in students with diverse characteristics and needs is teacher noticing. Teacher noticing skills are the act of observing and recognizing significant elements in the learning context, enabling teachers to capture important ideas and good practices during learning (König et al., 2022; Weyers et al., 2024). One effective teacher noticing skill strategy for developing mathematical literacy is scaffolding. Scaffolding is the assistance provided to learners to help them solve problems (Tveitnes et al., 2025). Effective teachers offer scaffolding through various instructional approaches that promote active student engagement. Level 1 (Environment Provisions), Level 2 (Explaining, Reviewing, Restructuring), and Level 3 (Developing Conceptual Thinking). Consistent with the study by Mutia et al. (2023), proper scaffolding supports concept mastery and significantly increases students' creative thinking. Similarly, Santi et al. (2024) state that students with low numeracy skills can benefit from scaffolding, particularly when addressing numeracy problems that are preceded by text and require clarity on what information is known and what is being asked.

Previous studies on mathematics literacy have focused on creating mathematical literacy–rich environments through learning management systems (LMS), classroom spaces, and community settings, with particular emphasis on teacher involvement in directly improving teacher competency (Gustiningsi et al., 2023). In achieving mathematical performance, individuals require not only cognitive abilities but also affective abilities, including the adversity quotient (AQ). AQ influences an individual's attitudes and behaviors when solving mathematical problems (Muhtarom et al., 2021). Research on mathematical literacy from the perspective of AQ highlights the need for highly adaptive scaffolding, which can be integrated with rapidly developing technology, including in education. Various technology-based learning media can support this goal, including the learning management system (LMS) (Rodríguez et al., 2023). Students can learn in school and also study in various places and at any time through a digital learning management system (LMS), which enables flexible learning (Bonilla-Priego et al., 2024). Therefore, this study introduces a novelty by focusing on technology-assisted scaffolding to improve mathematical literacy while incorporating the affective domain of AQ. This study aims to describe students' mathematical literacy in solving PISA-based problems using technology-supported scaffolding.

These findings confirm that Scaffolding with technology assistance is a method that uses technology to help students improve their mathematical literacy systematically, enabling them to understand complex concepts and solve problems independently over time. Technology can provide visual materials, interactive simulations, and collaborative platforms tailored to students' needs, thereby supporting students' understanding of conceptual and procedural skills.

2. Literature Review

2.1. Teacher Noticing

In this study, the teacher's observations serve as scaffolding. Instructor observation is an effective method to help students develop mathematical literacy across diverse traits and needs. Teacher observation, as an act of observing the act and something recognized in the teaching context, allows teachers to identify important ideas and effective instructional practices (Weyers et al., 2024). Scaffolding is one of the most effective teaching strategies for fostering mathematical literacy. It refers to the support provided to students to help them learn how to solve problems. A teacher is considered adequate if they can provide scaffolding as guidance using various teaching strategies that encourage active learning (Mutia et al., 2023). Environmental provisions are included at Level 1; explanation, review, and restructuring are included at Level 2; and conceptual thinking development is included at Level 3. Appropriate scaffolding, supported by instructor observation, is an effective method to help students develop their mathematical literacy across diverse traits and needs. The teacher's observation of the act, as something recognized in the context of teaching, allows the teacher to identify important ideas and good practices in the execution of teaching (Santi et al., 2024).

2.2. Digital Technology

Mathematical literacy is highly adaptable; therefore, it can be integrated with current and continually advancing technologies, including education. One technology-based learning medium that can be used is the learning management system (LMS) (Iqbal et al., 2020; Setiasih et al., 2024). In addition to learning in school, students can also learn at other locations and times through the Learning Management System (LMS), which enables flexible learning (Cavus et al., 2022). One example is the Ledypironing-STEM LMS.

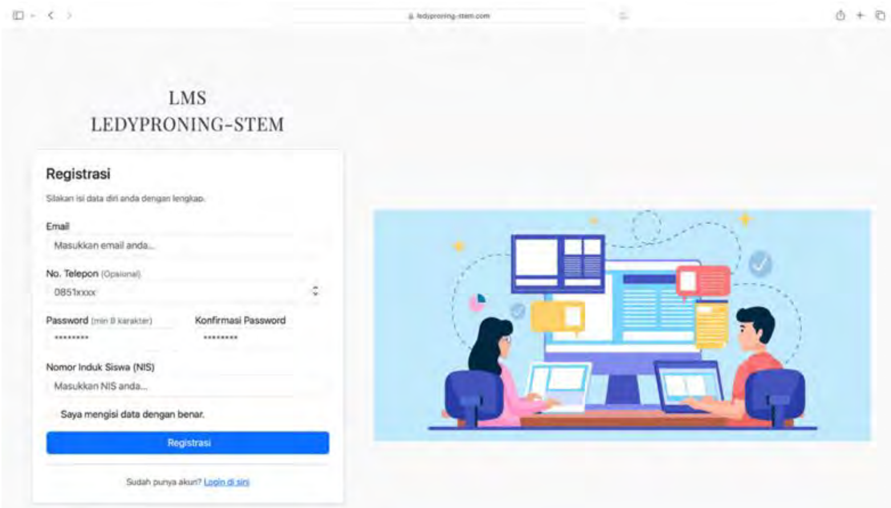

Figure 1. Login Page

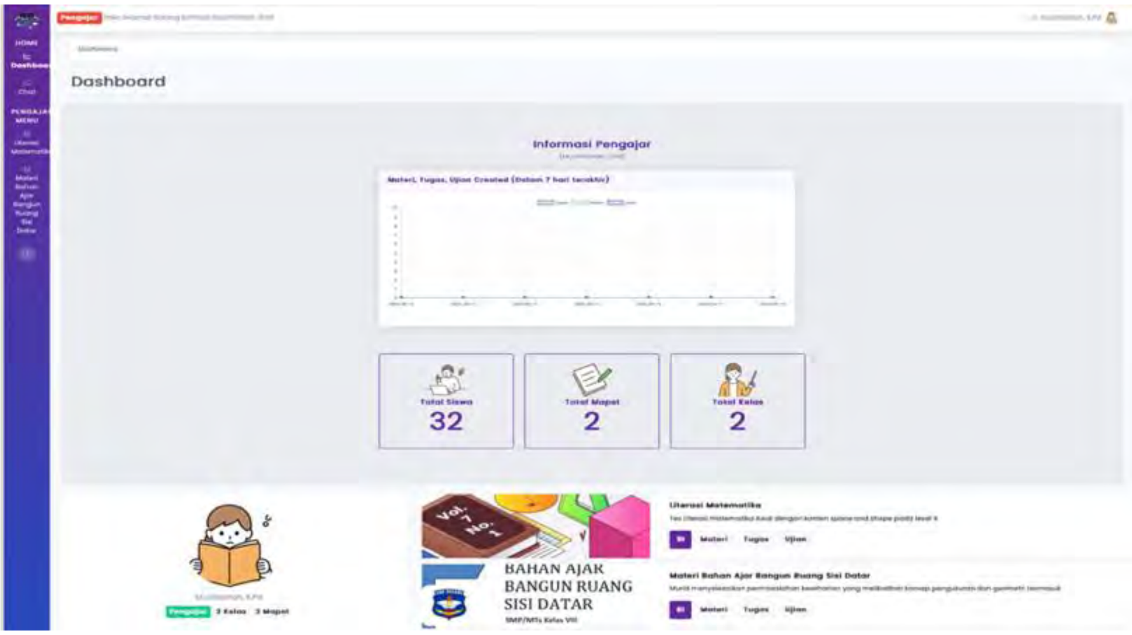

Figure 2. Teacher Dashboard Page

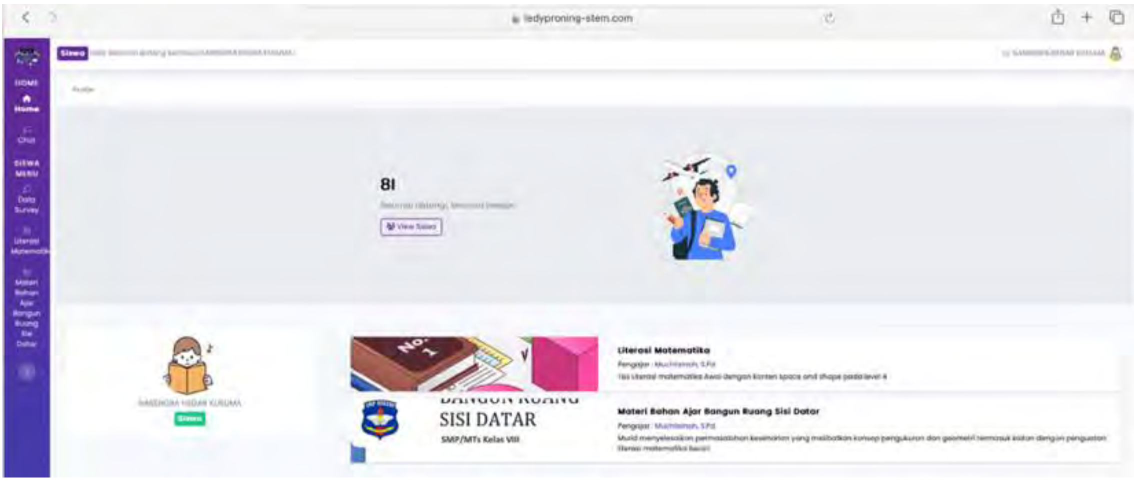

Figure 3. Student Dashboard Page

2.3. Adversity Quotient

Stoltz (2000) explains a new intelligence, namely the intelligence of facing difficulties, and explains how this new intelligence can be improved. The concept emerged from 19 years of research conducted by scientists who reviewed more than 500 references from three scientific fields: cognitive psychology, psychoneuroimmunology, and neurophysiology. They applied the results of these studies to 10 individuals across various contexts worldwide. They ultimately concluded that there is an essential yet previously unrecognized form of intelligence that contributes to an individual's success: the ability to face and overcome difficulties, referred to as the Adversity Quotient (AQ).

Adversity Quotient (AQ) is divided into three categories: Climbers, Campers, and Quitters. Climbers are people who choose to persist and struggle through the challenges that will continue to come their way. Campers, on the other hand, are a group of people who have the will to face existing problems and challenges, but they see their journey as ending. Quitters are people who lack the will to accept the challenges in their lives.

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2.4. Technology-Supported Scaffolding with Adversity Quotient as a Strategy to Improve Teacher Noticing

Some evidence suggests that promising learning outcomes result from implementing technology-supported scaffolding instruction across different studies. The relationship between technology and scaffolding is closely interconnected and mutually supportive. Technology, particularly through the Learning Management System (LMS) or a technology-based learning environment, serves as a platform for implementing various forms of scaffolding more effectively and in an organized manner (Yu et al., 2024). Thus, these findings strengthen the present study's focus on technology-supported scaffolding with the adversity quotient as a strategy to improve teacher noticing. This concept is illustrated in Figure 1, which portrays the connection between technology-supported scaffolding and the development of teacher noticing.

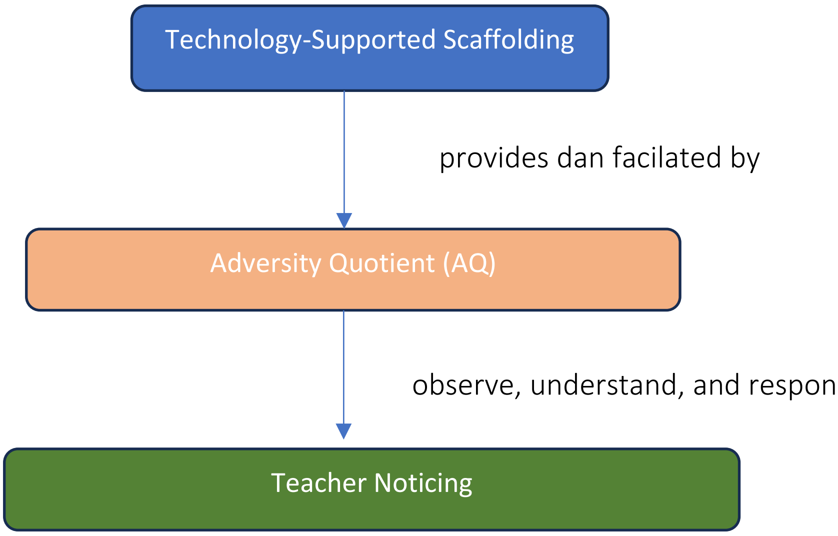


Figure 4. The Connection between Technology-Supported Scaffolding in Enhancing Teacher Noticing

Figure 4 illustrates the flowchart of technology-supported scaffolding instruction using the Adversity Quotient, which helps students understand learning concepts and consequently increases teachers' noticing. Additionally, students are encouraged to enhance their cognitive domain by observing, understanding, and responding to the teacher. Step by step, the technology-supported scaffolding was reduced after students had fully understood the learning material. This indicates that technology-supported scaffolding instruction using the Adversity Quotient can improve teacher noticing and help students develop conceptual and procedural skills.

3. Methodology

3.1. Research Design

This research is a qualitative descriptive study. Qualitative research examines and interprets the meaning of experiences shared by individuals or groups facing social challenges (Creswell & Creswell, 2017). This study aims to characterize the mathematical literacy and skills of camper and quitter students using technology-supported scaffolding to solve PISA problems. This study was qualitative and descriptive in nature.

3.2. Participant

Purposive sampling was used to select the research subjects. Two eighth-grade students from SMP Negeri 2 Jombang regency, one with a camper type and one with a quitter type, participated in this study. Categorization with notice several considerations as follows: (1) Students finish all question test instrument literacy mathematics beginning, (2) Students serve answer with clear writing, (3) Students have good ability in communication and ability express opinions clearly. Furthermore, this study has only two subjects, which limits the generalizability of the findings and is therefore a limitation of the study.

3.3. Research Instrument

This study used two main instruments: an adversity quotient questionnaire and mathematical literacy problems. The adversity quotient questionnaire aims to collect data specifically related to students' adversity quotient. The Adversity Quotient Questionnaire was validated by a team of experts (Stoltz, 2000). The result of this assessment provided initial data for classifying the subjects. In addition to categorizing the adversity quotient, participants' mathematical literacy skills were assessed through mathematical literacy skills problems. This test was validated by three experts, namely three lecturers in mathematics education who teach mathematical literacy problems. Data on the topic of space and shape mathematical literacy at the fourth level were collected using a questionnaire and a task-based interviewing technique.

3.4. Data Analysis Technique

The data were analyzed using Miles and Huberman's paradigm of data reduction, presentation, and conclusion drawing. After the camper and quitter students completed the mathematical literacy tasks, scaffolding was provided when they encountered difficulty solving the problems (Chen & Hou, 2025). This support was expected to help them overcome obstacles experienced during the thinking process. Several examples of the scaffolding procedures used are presentedin Table 1.

Table 1. Scaffolding Activities Carried Out

Scaffolding Components	Activities carried out
Environmental	Give another picture to understand the question
Provisions *Explaining*	Request the student to explain the method and provide directions to understand the question.
Reviewing	Request the student to reflect on the answer given and correct it when wrong.
Restoration	Provide directions so you can answer with the correct plan.
Developing Conceptual Thinking	Request the student combine the work steps previously with logical so that they get the new work steps new

Figure 5 below describes the qualitative research design.

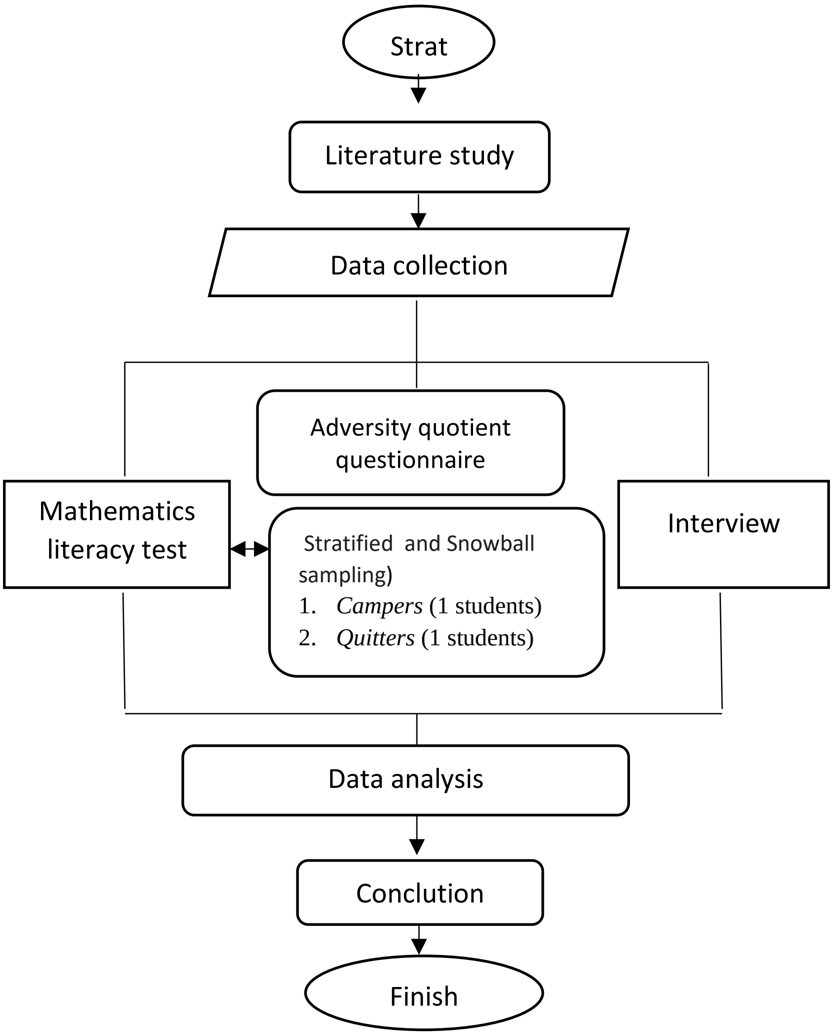


Figure 5. Qualitative Research Design

4. Results

From the results analysis, the filling instrument test adversity quotient, data obtained as in Table 2.

Table 2. Adversity Quotient Level of Grade VIII Students

No.	Adversity quotient level	The number of students
1.	Climber	5
2.	Camper	18
3.	Quitter	7
Number of students		30

In this study, students in the climber category were not included because previous research indicates that climber students are capable of working hard and performing well when solving complex mathematical problems. In contrast, camper and quitter students require technology-assisted scaffolding to solve PISA-oriented mathematical literacy problems (Nur et al., 2022). After selecting two students in the camper and quitter categories, both students were given a level-4 PISA-oriented mathematical literacy test with space and shape content, as shown in Figure 6

Figure 6. Students Working on the Adversity Quotient Test

After completing the Adversity Quotient test, two students, categorized as campers and quitters, took the initial integrated mathematical literacy test via a learning management system (LMS). Further details are presented in Figure 7

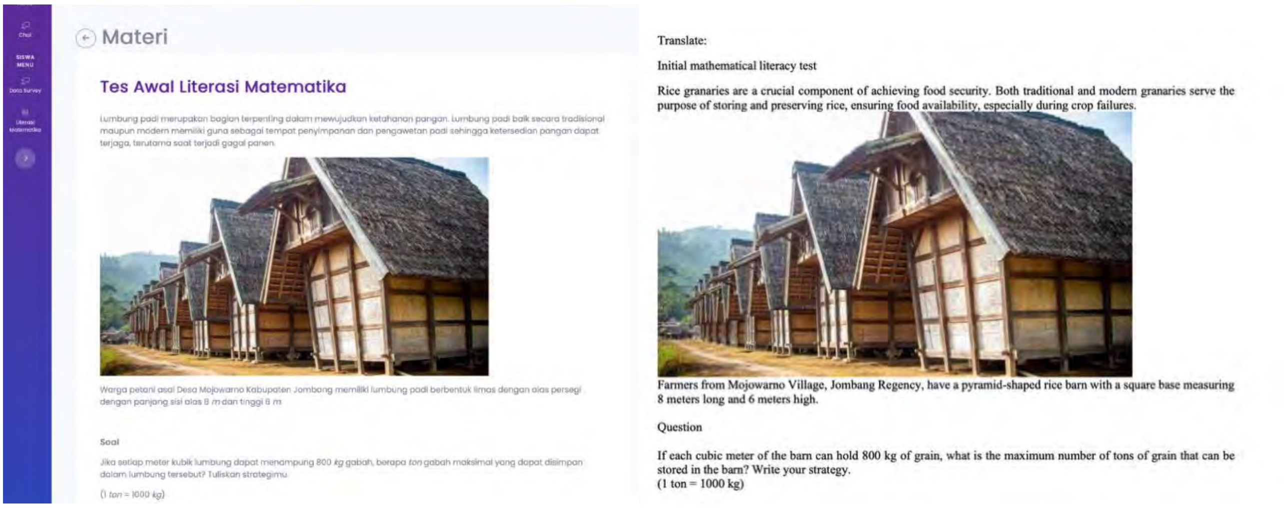
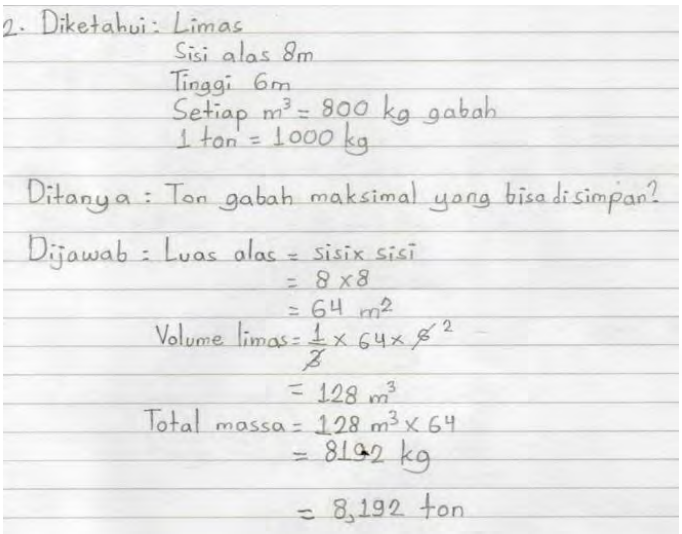


Figure 7. Test Beginning Literacy Mathematics Integrated with Learning Management System

Based on the students' answers in the camper and quitter categories, aligned with the indicators of mathematical literacy ability, the results are as follows.

4.1. Subject AFO

Referring to the results, AFO provides information on formulating the problem, as shown in Figure 8.



Translate

2. Known :
pyramid
base side 8 m
height 6 m
every m^3 = 800 kg grain

Asked : Maximum tons of grain that can be stored?
Answered :
Base area = Side x side
= 8 x 8
= 64 m^2

The volume of pyramid = $\frac{1}{3}$ x 64 x 6
= 192 m^3

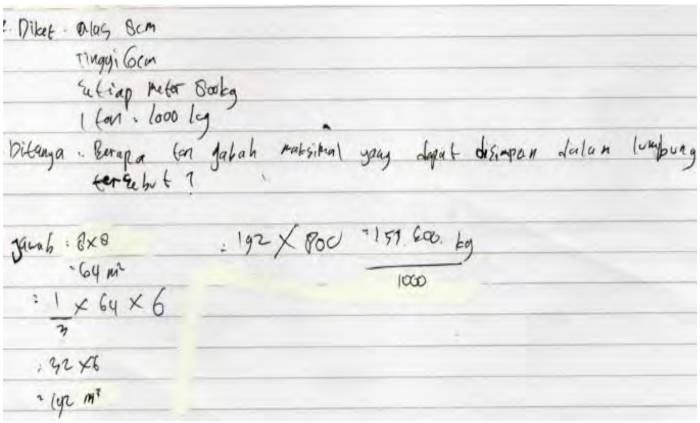
Total mass = 192 x 64
= 8192 kg
= 8,192 ton

Figure 8. Answer Results *Campers* by AFO

Based on Figure 4, the AFO subjects clearly identify and write what is known and what is asked in the problem. The AFO subjects can change the context into a mathematical form. However, in planning the solution, the subject has not yet presented the pyramid with a square base as a diagram. The AFO subject can design strategic plans and implement processes to use mathematics in solving problems. Nevertheless, the AFO subject's use of formal and symbolic operational languages remains incorrect, and they have not used various mathematical tools appropriately in solving the problem.

4.2. Subject NAKP

Referring to the results, NAKP provides information related to formulating the problem, as shown in Figure 9.



Translate

2. Known :
base 8 cm
height 6 cm
every m = 800 kg
1 ton = 1000 kg
Asked : Maximum tons of grain that can be stored?
Answered :
= 8 x 8
= 64 m^2

= $\frac{1}{3}$ x 64 x 6
= 192 m^3

= 192 x 64
= $\frac{153600}{1000}$ kg

Figure 9. Answer Results *Quitters* by NAKP

Based on Figure 5, the NAKP subject does not correctly identify and write what is known and what is asked in the problem. NAKP subjects can change contextual problems into a mathematical form. However, in planning the solution, the subject has not yet presented the pyramid with a square base as a diagram. The NAKP subject is not yet capable of designing strategic plans or implementing processes that use mathematics to solve the problem. The NAKP subject's use of formal and operational language remains incorrect, and they have not used various mathematical tools appropriately in solving the problem.

4.3. Scaffolding

Scaffolding provided for subjects in the camper and quitter category in completing the initial PISA-oriented mathematical literacy problems is presented in Table 3.

Table 3. Scaffolding Provided

No	Adversity Quotient Level	Indicator Literacy Mathematics	Analysis results of literacy and mathematics ability	Scaffolding provided
1	Campers	Communication	Subjects can accurately state and write what is known and what is requested from the problem.	
		Mathematizing	Subjects can change formulation problems from contextual into mathematical form.	
		Representation	The subject in planning the solution to the problem has not yet presented it in the form of a pyramid with a square base.	Request students to explain the method used and give directions to understand the question (Explaining).
		Reasoning and Argument	a. The subject in solving the problem involves all information. b. The subject writes several stages in solving the problem.	
		Devising Strategies for Solving Problems	a. The subject writes some strategies for planning the solution to the problem. b. The subject in planning the solution to the problem involves sufficient mathematical drafts.	
		Using symbolic, formal, and operational	The subject has not yet used formal and operational symbolic language correctly.	a. Request students to reflect on the answer that has been given and corrected when wrong (Reviewing). b. Give directions to enable students to answer with the correct plan and answer (Restructuring).
		Using Mathematical Tools	The subject has not yet used various mathematical tools in solving problems.	Request the student to combine the previous work steps logically to obtain new work steps (Developing Conceptual Thinking)

No	Adversity Quotient Level	Indicator Literacy Mathematics	Analysis results of literacy and mathematics ability	Scaffolding provided
2	Quitters	Communication	The subject has not yet been able to correctly mention and write what is known and what is asked of the problem.	Provide another picture to help understand environmental issues (Provisions).
		Mathematizing	Subjects can change formulation from contextual to mathematical form.	
		Representation	The subject in planning the solution to the problem has not yet presented it in the form of a pyramid with a square base.	Request the student to explain the method used and provide directions to understand the question (Explaining).
		Reasoning and Argument	a. The subject in solving the problem has not yet involved all the information. b. Subject has not yet written several stages in solving the problem.	Request students to reflect on the answer given and corrected (Reviewing).
		Devising Strategies for Solving Problems	a. The subject writes strategies in planning solutions to the problem. b. The subject in planning the solution to the problem involves a sufficient mathematical draft.	Provide directions to help students answer with the correct plan and answer (Restructuring).
		Using symbolic, formal, and operational	The subject has not yet used formal and operational symbolic language correctly.	Provide directions to help students answer with a correct plan and answer (Restructuring).
		Using Mathematical Tools	The subject has not yet used various mathematical tools in solving problems.	Request students to combine the previous work step logically to obtain new work steps (Developing Conceptual Thinking)

Based on Table 3 above, scaffolding was gradually phased out as problem-solving skills improved, thus declaring the teacher's work complete. The scaffolding strategy successfully improved the learning outcomes of both campers and quitters. This is supported by research (Song & Kim, 2021), which found that the scaffolded group showed higher gains in self-regulated learning than the control group.

5. Discussion

According to the analysis findings and the provided scaffolding, the subjects in the camper category met four indicators in finishing the first mathematical literacy test: communication, mathematizing, reasoning and argument, and devising problem-solving strategies. This indicates that mathematical literacy accounted for 57.1% of the total indicators. The alternative scaffolding provided included explaining, reviewing, restructuring, and developing conceptual thinking. This aligns with Stoltz (2000) opinion that individuals in the camper category tend to be easily satisfied with moderate achievement. In other words, this category has a reasonable level of resilience to difficulties, although it is not yet fully optimal (Muhtarom et al., 2021; Nur et al., 2022).

Whereas quitter-type subjects only fulfil one mathematical literacy indicator, namely mathematizing. This means their mathematical literacy score accounts for only 14.9% of the overall indicator. Alternative scaffolding provided includes environmental provisions, explanation, review, restructuring, and development of conceptual thinking. This aligns with Stoltz's opinion that individuals with a quitter type easily lose hope, give up quickly, and lack enthusiasm for achieving success.) and Nur et al. (2022) also report low resilience and the ability to face difficulties. They tend to give up easily when facing challenges or problems, have low motivation to keep trying, and often show pessimistic attitudes toward their ability to solve mathematical problems. Furthermore, motivation and emotion play an important role in the learning process and educational success (Reeve, 2024; Santrock, 2011). A deep understanding of these aspects can help educators create a conducive and motivating learning environment for each student to achieve their best potential.

Findings from this study show that the indicator of using symbolic, formal, and operational expressions has not been used optimally in problem-solving, especially among subjects in the quitter category. This is due to the suboptimal use of formal and operational symbolic language and techniques that involve relevant mathematical understanding and knowledge. To overcome this problem, a solution can be provided through STEM (Cahyono et al., 2025; Deng et al., 2025; Govender, 2025). In STEM literacy, students should have the ability to connect mathematics (science), skills in various technologies (Technology), the ability to construct mathematical designs (engineering), and the ability to analyze and communicate ideas, formulations, and mathematical problem-solving in their applications. For the indicator of using mathematical tools, this is due to the suboptimal use of various tools when completing mathematical problems. To overcome this, technology-based learning models can be implemented (Darmawansah et al., 2023; Divayana et al., 2021; Kerimbayev et al., 2025; Shahzad et al., 2025; Upadhyay et al., 2025). Consistent with this, it is stated that each learning model must have its own general characteristics, including syntax, a social system, reaction principles, supporting systems, and instructional impacts (Joyce & Calhoun, 2024).

This study explores students' mathematical literacy with technology-assisted scaffolding, as observed in the camper and quitter categories when completing PISA questions, which has not yet been researched. Through adaptive digital learning, students can study effectively both inside and outside the classroom, thereby increasing their mathematical literacy. The limitation of this study is that it focused only on subjects in the camper and quitter categories at SMPN 2 Jombang. Further research can explore how technology serves as dynamic scaffolding to improve mathematical literacy by providing structured and adaptive support that helps students understand abstract concepts and solve problems beyond their independent capabilities.

6. Conclusion

This research has successfully explored students' mathematical literacy using technology-assisted scaffolding, as observed in the camper and quitter categories when completing PISA questions. The literacy skills of subjects in the camper category in completing the initial mathematical literacy test met four indicators: communication, mathematizing, reasoning and argumentation, and devising strategies for solving problems. Alternative scaffolding provided included explaining, reviewing, restructuring, and developing conceptual thinking. Meanwhile, subjects in the quitter category fulfil only one mathematical literacy indicator: mathematizing. The alternative scaffolding provided included environmental provisions, explanations, reviews, restructuring, and the development of conceptual thinking.

Through the incremental support provided by digital platforms, technology-assisted scaffolding has great potential to enhance critical thinking, problem-solving abilities, and conceptual understanding.

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Declarations

Author Contributions. N.D.R: Literature review, conceptualization. W: methodology, data analysis. K.W.: review-editing and writing, original manuscript preparation. N.R.D: review-editing and writing, original manuscript preparation. All authors have read and approved the published version of the article

Conflicts of Interest. The authors declare no competing interests

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Ethical Approval. Internal board review approval was obtained from the respective universities of the authors.

Data Availability Statement. The data that support the findings of this study are available from the corresponding author [NDR] upon reasonable request.

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