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Enhancing Mathematical Literacy: Evaluating the Effectiveness of the ELPSA Framework in Mathematics Classrooms

Firmansyah B[1], Ega Gradini[2*], Nadiatul Husna[3]
[1]Program Studi Pendidikan Matematika, UIN Alauddin Makassar, Indonesia
[2,3]Program Studi Tadris Matematika, IAIN Takengon, Indonesia
E-mail: ega.gradini@gmail.com
* Corresponding Author

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ABSTRACT

Abstrak, Penelitian ini bertujuan untuk menyelidiki efektivitas Kerangka ELPSA dalam meningkatkan keterampilan literasi matematika siswa kelas tujuh di SMP IT Cendekia Takengon. Penelitian ini menggunakan pendekatan kuantitatif dengan desain eksperimental. Data dikumpulkan melalui tes dan dianalisis menggunakan uji t independen sampel. Temuan menunjukkan peningkatan yang signifikan dalam keterampilan literasi matematika di antara siswa dalam kelompok eksperimental dibandingkan dengan mereka dalam kelompok kontrol. Peningkatan ini terlihat dalam hasil tes N-Gain, yang menunjukkan bahwa 35% siswa dalam kelompok eksperimental mencapai tingkat literasi matematika tinggi, sementara 65% mencapai tingkat sedang, dengan rata-rata Gain sebesar 0,68, yang dikategorikan sebagai sedang. Selain itu, evaluasi pasca-intervensi terhadap keterampilan literasi matematika dalam kelompok eksperimental mengungkapkan bahwa sebelum implementasi ELPSA, literasi matematika siswa menunjukkan konsentrasi pada tingkat kemahiran Pertama, dengan sebagian kecil mencapai tingkat Kedua. Setelah penerapan kerangka ELPSA, pergeseran positif teramati. Jumlah siswa di tingkat pertama berkurang menjadi hanya enam, 16 siswa mencapai tingkat kedua, empat menunjukkan kemahiran tingkat ketiga, enam mencapai tingkat keempat, dan dua siswa mencapai kemahiran tingkat kelima. Namun, tidak ada dari siswa yang mampu mencapai tingkat keenam. Hasil uji hipotesis menunjukkan bahwa hipotesis nol (H0) ditolak, mengkonfirmasi adanya perbedaan yang signifikan dalam peningkatan keterampilan literasi matematika antara siswa yang diajar menggunakan Kerangka ELPSA dan mereka yang diajar menggunakan pendekatan pengajaran konvensional yang digunakan oleh guru-guru sekolah.

Abstract, This study aimed to investigate the effectiveness of the ELPSA Framework in enhancing the mathematical literacy skills of seventh-graders at SMP IT Cendekia Takengon. The research employed a quantitative approach using an experimental design. Data were collected through tests and analyzed using an independent sample t-test. The findings revealed a significant improvement in mathematical literacy skills among students in the experimental group compared to those in the control group. This improvement was evident in the N-Gain test results, indicating that 35% of the students in the experimental group achieved a high level of mathematical literacy, while 65% attained a moderate level, with an average Gain of 0.68, categorized as moderate. Moreover, the post-intervention assessment of mathematical literacy skills in the experimental group revealed that prior to ELPSA implementation, student's mathematical literacy indicated a concentration at First Level proficiency, with a smaller portion reaching Second Level. Following the introduction of the ELPSA framework, a positive shift was observed. The number of students at First Level decreased to only six, 16 students achieved Second Level, four demonstrated Third Level proficiency, six reached fourth

Level, and two students achieved Fifth Level proficiency. However, none of students able to reach the Sixth level. The hypothesis test results indicated that the null hypothesis (H0) was rejected, confirming a significant difference in the improvement of mathematical literacy skills between students taught using the ELPSA Framework and those instructed using conventional teaching approaches employed by the school's teachers.

INTRODUCTION

Mathematical literacy, the ability to interpret, analyze, and apply mathematical concepts to solve problems in various contexts, is an essential skill for individuals to navigate the complexities of modern society. In the realm of mathematics education, enhancing students' mathematical literacy has become a paramount objective. Mathematical literacy proficiency has been a subject of international comparative studies such as the Programme for International Student Assessment (PISA), which is conducted triennially for 15-year-old students. PISA measures mathematical literacy proficiency by presenting mathematical problems that incorporate content, contexts, and competencies (Stacey, 2014; Stacey & Turner, 2014). The mathematical problems presented are real-world situations that provide a context for applying mathematics (Niss, 2014).

PISA 2015 defines mathematical literacy as the capacity of an individual to formulate, apply, and interpret mathematics in diverse contexts (Genc & Erbas, 2019; Jailani, Retnawati, Wulandari, & Djidu, 2020; Steen, Turner, & Burkhardt, 2007; Yore, Pimm, & Tuan, 2007). This encompasses mathematical reasoning and the utilization of mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena or events. This includes mathematical reasoning and the use of mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena or events. It also requires individuals to recognize the role of mathematics in their life and to make well-founded judgments and decisions. It necessitates individuals to recognize the role of mathematics in life and to make sound judgments and decisions as required by a constructive and reflective citizen.

Many researchers differentiate between mathematical literacy and numeracy (Dockrell & Teubal, 2007; Grotlüschen, Desjardins, & Liu, 2020; Jablonka, 2015; Tariq, Qualter, Roberts, Appleby, & Barnes, 2013) while some consider it same (Lange, 2005; Pugalee, 1999, 2001; Stacey, 2015). Mathematical literacy is the ability to reason mathematically in a variety of contexts equipped with the necessary mathematical knowledge and skills (De Lange, 2003; Kilpatrick, 2001; Lange, 2005; Stacey, 2014). Then, mathematical literacy proficiency is of paramount importance as it not only equips individuals with an awareness and comprehension of mathematics' role in the real world, but it also serves as a yardstick to gauge the quality of education, as measured through the Programme for International Student Assessment (PISA) initiated by the OECD (Gradini, Firmansyah, & Saputra, 2021; Gradini & Firmansyah, 2020).

Indonesia's average PISA mathematics scores have exhibited a downward trend from 2015 to 2022. In 2015, the average score was 386 points, placing Indonesia at 54th out of 72 countries. This score was 490 points lower than the OECD average. By 2018, the average score had declined to 379 points, resulting in a drop to 62nd out of 79 countries. The gap between Indonesia's score and the OECD average remained significant at 489 points. In 2022, the average score continued to decline, reaching 366 points, placing Indonesia at 70th out of 81 countries. The gap with the OECD average narrowed slightly to 472 points. While Indonesia's average score has declined, its global ranking has shown a marginal improvement from 2018 to 2022. Regional disparities in mathematics performance persist across Indonesia. The analysis reveals significant variations in average scores between different provinces and regions. These disparities highlight the uneven distribution of educational resources and opportunities across the country.

The observed decline in Indonesia's PISA mathematics scores from 2015 to 2022 raises concerns about the quality of mathematics education in the country. The COVID-19 pandemic likely played a role in the 2022 score decline, as school closures and disruptions to teaching and learning impacted students' progress. However, the downward trend observed prior to the pandemic suggests deeper systemic issues that need to be addressed. Despite the overall decline in scores, the marginal improvement in global ranking from 2018 to 2022 offers a glimmer of hope. This improvement may be attributed to ongoing efforts to improve education quality, such as teacher training initiatives and curriculum reforms. However, the persistent regional disparities underscore the need for targeted interventions to ensure equitable access to quality mathematics education for all Indonesian students.

The ELPSA Framework, an acronym for Experience, Language, Pictorial, Symbolic, and Application, presents a structured approach to fostering mathematical literacy in students (Adams et al., 2023; Lowrie, Logan, Harris, & Hegarty, 2018; Lowrie & Patahuddin, 2015). In Experience (E), students engage with real-world experiences or manipulatives to build a foundation for the new concept. In Language (L), students discuss the mathematical ideas in their own words, clarifying their understanding. In Pictorial (P), visual representations like diagrams, graphs, or models are used to solidify the concept. Furthermore, in Symbolic (S), mathematical symbols and notation are introduced alongside the pictorial representations. Lastly, Application (A), students apply the learned concepts to solve real-world problems or connect them to other mathematical ideas.

The ELPSA Framework is a powerful tool for designing math lessons that improve student's mathematical literacy. By encountering concepts through various representations (concrete, pictorial, symbolic), students develop a richer understanding that goes beyond memorization (Adams et al., 2023; Adams, 2020; Boaler & Greeno, 2000; Grabinger & Dunlap, 1995; Spiro, Feltovich, Jacobson, & Coulson, 2012). Researchs find that by discussing math in words helps students clarify their thinking and express mathematical ideas effectively (Carpenter, Franke, & Levi, 2003; Chapin, O'Connor, & Anderson, 2009; Dreyfus, 1991; Franke et al., 2007). Some studies also unveiled the real-world connections by applying math to solve problems builds confidence and demonstrates the relevance of mathematics in everyday life (Boaler, 2022; Bransford & Donovan, 2005; Franke et al., 2007; Watson & Mason, 2006).

We did preliminary research to measured mathematical literacy of seventh-graders at SMP IT Cendekia Takengon. The measurement is identifying a shortcoming in mathematical literacy skills. The analysis revealed several significant deficiencies in the mathematical literacy of SMP IT Cendekia Takengon seventh-graders. These deficiencies can be summarized into the following key areas, namely: (1) Students struggled to apply mathematical concepts to real-world contexts, as evidenced by their inability to solve problems presented in everyday scenarios; (2) Students exhibited difficulties in constructing solutions due to a lack of conceptual understanding and the inability to connect mathematical concepts to real-world contexts, (3) Students' lack of exposure to contextualized math problems hindered their ability to comprehend and solve such problems, (4) Students faced difficulties understanding mathematical symbols, particularly in algebra, where a large number of symbols are used; (5) The initial introduction of mathematical concepts through symbols and formulas often created barriers to understanding for students; and (6) The teacher-centered approach and the lack of connections between mathematical concepts and everyday life limited students' appreciation of mathematics' practical applications.

There is a lack specific research on ELPSA directly connected to mathematical literacy. However, numerous researchs show the relevant finding on mathematical literacy dimension, for example constructivism and collaborative learning (Lowrie & Patahuddin, 2015; Sari & Wijaya, 2017; Shadiq, 2017), and multiple representations (Johar & Hajar, 2016; Juliangkary & Pujilestari, 2020; Lowrie, Logan, Harris, et al., 2018; Lowrie, Logan, & Patahuddin, 2018). ELPSA draws from constructivism, where students build knowledge through experiences and interactions. This approach encourages active participation and grappling with ideas, which is crucial for problem-solving and reasoning in mathematics. Furthermore, the core aspect of ELPSA as multifaceted approach helps students develop a deeper understanding of mathematical concepts, which is essential for critical thinking and applying math in different contexts. The Application stage in ELPSA pushes students to use the learned concepts in practical situations. This strengthens problem-solving skills and demonstrates the relevance of math in daily life, both aspects that contribute to mathematical literacy.

Despite numerous research finding suggesting strong potential, it's important to note that research directly measuring the impact of ELPSA on fostering mathematical literacy might be limited. However, the framework's core principles align well with established practices for developing mathematical literacy skills. To address this gap, this study delves into the effectiveness of the ELPSA Framework in enhancing the mathematical literacy skills of seventh-graders at SMP IT Cendekia Takengon. The study's novelty lies in its direct measurement of ELPSA's impact on this specific age group within the context of an Islamic Junior School in Indonesia. The findings can provide valuable insights into the real-world application of ELPSA for promoting mathematical literacy.

METHOD

This quantitative experimental study investigates the effectiveness of the ELPSA Framework in improving students' mathematical literacy skills. A True Experiment design with pre-test and post-test control groups was chosen to assess the intervention's impact. This design allows for the isolation of the ELPSA Framework's influence on student learning, as external factors can not be fully controlled. The study was conducted in a seventh-grade class at SMP IT Cendekia Takengon. Purposive sampling ensured a diverse group of participants (n = 68, 34 for each group) under 15 years old with equal gender representation and varied socio-economic and geographic backgrounds, reflecting the target population for PISA's mathematical literacy assessment (13-15 years old).

The research followed a three-step process. First, the research design, assessment tools (mathematical literacy test), and learning materials integrating the ELPSA Framework were developed. Subsequently, a pre-test measured students' baseline mathematical literacy in both groups. The experimental group then received instruction incorporating the ELPSA Framework, while the control group received standard instruction. Finally, a post-test assessed all participants' final mathematical literacy levels.

Both pre-test and post-test consist of six problems, each designed to assess a distinct level of mathematical literacy. The first problem, entitled "The Building," evaluates students' level 1 competencies in the content domain of Change and Relationship situated within a personal context. The second item, "Floor Plan", assesses students' level 2 mathematical literacy in Change and Relationship within a societal/public context. The third item, "Following a Competition", evaluates students' level 3 mathematical literacy in Change and Relationship within a societal/public context. The fourth item, "Football Field", measures students' level 4 mathematical literacy in the content domain of Space and Shape applied within a personal context. The fifth item, "The Garden", assesses students' level 5 abilities in Space and Shape within a personal context. Additionally, the sixth item, "The Carpenter," measures students' level 6 abilities in Space and Shape, but within an occupational context.

Statistical inference will be employed to analyze the pre-test and post-test data, specifically to identify any significant differences in mathematical literacy between the experimental and control groups. This analysis will determine the effectiveness of the ELPSA Framework in enhancing students' mathematical literacy skills.

This study assessed the core components of mathematical literacy, reflecting the ability to apply mathematical knowledge and skills in a variety of contexts. The assessment of these competencies provides a comprehensive evaluation of students' mathematical literacy, as follow: (1) Communication; (2) Mathematising; (3) Representation; (4) Reasoning and Argument; (5) Devising strategies for solving problems, (6) Using symbols, formal and technical languages, and operation, and (7) Using mathematical tools. The assessment of mathematical literacy often utilizes proficiency levels, as exemplified by the PISA framework. Within the context of this research, the concept of "literacy level" aligns with the mathematical proficiency levels established by PISA.

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Table 1. The Mathematics Proficiency of PISA (Stacey & Turner, 2015)

Level	Mathematics Proficiency
First Level	Answer questions within a familiar context where all relevant information is provided and the questions are clearly stated. Identify information and apply common procedures based on clear instructions. Perform an action in response to a given stimulus.
Second Level	Focusing on straightforward situations that can be understood directly. Gathering key details from a single source and using a single format to represent them. Applying basic rules, formulas, or established procedures to solve problems with whole numbers. Interpreting the answers literally, without hidden meaning.
Third Level	This capability involves following well-defined procedures, even those with branching choices, and making sound interpretations from information to build basic models or choose problem-solving strategies. It also includes understanding and using different representations of data from various sources, reasoning directly from them, and demonstrating some ability to handle percentages, fractions, decimals, and proportional relationships. Overall, this level focuses on fundamental interpretation, reasoning, and applying basic mathematical concepts.
Fourth Level	This skillset involves tackling complex, real-world situations with clear models, even when limitations exist or assumptions need to be made. It requires selecting and combining different representations, including symbols, and directly linking them back to real-world aspects. While reasoning might be limited, some insightful thinking is used in straightforward contexts. This allows for constructing and communicating explanations and arguments based on interpretations, justifications, and the actions taken.
Fifth Level	This level tackles complex situations by building and manipulating models. It involves identifying limitations (constraints) and making clear assumptions upfront. Here, individuals strategically select, compare, and choose the best problem-solving approach for these complex models. They utilize a broad range of well-developed thinking and reasoning skills, along with various linked representations like symbols and formulas, to analyze the situations. This includes the ability to draw insights from the models. Finally, this level encourages individuals to start reflecting on their work, formulating the interpretation and reasoning, and effectively communicating them.
Sixth Level	Conceptualizing, generalizing, and applying knowledge gained from in-depth investigations and complex problem models. Students can utilize this knowledge in unfamiliar situations, seamlessly linking and switching between diverse information sources and representations. They leverage their deep understanding and mastery of symbolic and formal math to craft innovative approaches for entirely new problems. This level fosters critical reflection, where students not only formulate their interpretations and reasoning but also precisely communicate them alongside their actions and reflections. They can explain why these were chosen and how they relate to the original situation.

RESULT AND DISCUSSION

In this study, we hypothesize that the implementation of the ELPSA can effectively improve students' mathematical literacy. To test this hypothesis, we conducted an experimental research design to compare the mathematical literacy scores of students in an experimental group that received ELPSA instruction to those of a control group that did not receive the intervention. The results of this comparative analysis are presented in the following table.

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Table 2. Mathematical Literacy Scores of Experimental and Control Groups

Independent Samples Test										
		Levene's Test for Equalit of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
n-gain	Equal variances assumed	1.503	.225	10.064	66	.000	.234	.0232	.187	.280
	Equal variances not assumed			10.064	62.157	.000	.234	.0232	.187	.280

Levene's test deploy to checks for equal variances in the scores between the two groups. The significance value (Sig.) is 0.225, which is greater than 0.05 (common significance level). Therefore, we assume equal variances between the groups. Then t-test used to determine the difference in means between the groups. Then, t-value is 10.064, indicating a potentially large difference in means. The sig. (2-tailed) is 0.000 (less than 0.05), which is statistically significant. This means we reject the null hypothesis (that there is no difference between the means) and conclude there is a statistically significant difference in mathematical literacy scores between the groups. Furthermore, the mean difference is 0.234. This suggests students in the ELPSA group scored an average of 0.234 points higher on the test. Meanwhile, the confidence interval is range between 0.187 and 0.280 represents the 95% confidence interval for the true mean difference between the groups. We can be 95% confident that the real difference in population means falls within this range.

The findings provide strong evidence that students who received ELPSA instruction scored significantly higher on the mathematical literacy test compared to those who did not receive the intervention. However, it is important to consider the effect size, e.g. how big the difference is, alongside statistical significance.

Subsequently, we assessed the mathematical literacy levels of experimental group to determine the impact of the ELPSA program. The following table presents the results of this assessment, which investigated the changes in literacy levels following the program's implementation.

Table 3. Improvement in mathematics literacy level

	Mathematical Literacy Level					
	First Level	Second Level	Third Level	Fourth Level	Fifth Level	Sixth Level
Pre-test	25	9	0	0	0	0
Post-test	6	16	4	6	2	0

After the implementation of ELPSA, students' mathematical literacy level improved. Prior to ELPSA implementation, student performance in Indonesia, as measured by the PISA (Programme for International Student Assessment) report (Kamaliyah, Zulkardi, & Darmawijoyo, 2013; Stacey, 2011), indicated a concentration at First Level proficiency, with a smaller portion reaching Second Level. Following the introduction of the ELPSA framework, a positive shift was observed. The number of students at First Level decreased to only six, 16 students achieved Second Level, four demonstrated Third Level proficiency, six reached fourth Level, and two students achieved Fifth Level proficiency. However, none of students able to reach the Sixth level. These findings suggest that the ELPSA program may contribute to advancements in mathematical literacy.

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Table 4. Findings of each mathematical literacy level

Mathematical Literacy Level	Finding
Level 1	Students demonstrate competence in tackling problems set in recognizable and broad contexts when given complete information. Their capabilities are reflected in their ability to recognize relevant data, understand algebraic methods, and correctly identify variables, coefficients, and constants in Algebraic Forms. This progress can be credited to the implementation of Pictorial (P) and Symbolic (S) components, which enhance students' visual-spatial capabilities and enable them to convert conceptual understanding into symbolic representations.
Level 2	Students exhibited notable enhancement in their mathematical problem interpretation and analysis skills. They successfully extracted pertinent information, recognized suitable algebraic techniques, and substantiated their solutions with clear reasoning. When describing route applications, students articulated their understanding in their own words, stating for instance that "the two routes differ because their algebraic expressions are distinct" and "the routes vary in length or distance, as evidenced by the different quantities of x and y variables in routes a and b." These improvements can be linked to the ELPSA framework's effectiveness, which encourages dynamic learning through real-world context engagement (Experience), facilitates deeper comprehension by connecting mathematical principles with linguistic expression (Language), and empowers students to implement their knowledge through effective problem-solving opportunities (Application).
Level 3	Following the implementation of ELPSA, four students attained this level of mathematical literacy. This achievement illustrates how the ELPSA instructional approach incorporating Experience (E), Symbols (S), and Application (A), cultivated students' abilities to recognize problems, examine information critically, formulate solutions, and assess results. In their problem-solving process, students first documented the given information prior to analysis. They then converted this information into symbolic notation to develop solutions. Upon completing their solution process, students concluded by evaluating the outcomes and articulating them as final statements.
Level 4	Students employ a strategic approach to utilizing various representational forms, such as symbols and equations, to comprehend the scenarios under examination. They have initiated reflective practices regarding their work, through which they formulate and express their interpretations and cognitive processes. This demonstrates their advanced ability to move between different mathematical representations while developing metacognitive skills that allow them to articulate their reasoning and analytical approaches.
Level 5	Students demonstrated proficiency in constructing and manipulating models for intricate scenarios, recognizing key issues, and formulating relevant assumptions. They exhibited competence in judiciously choosing, contrasting, and assessing problem-solving approaches for sophisticated model-based challenges. The research revealed that these students employed strategic methods utilizing comprehensive thinking and reasoning patterns, while effectively linking symbolic representations and formal elements to contextual understanding. Furthermore, they displayed the capacity for self-reflection on their mathematical processes and clearly communicated their interpretations with well-articulated justifications for their approaches and conclusions.
Level 6	No students were able to achieve this level.

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Students Mathematical Literacy on First Level

This study indicated that before using ELPSA, 25 students were only able to achieve First Level. After using ELPSA, this number decrease to six students. This demonstrates a significant improvement in mathematical literacy skills at First Level for the experimental class that used ELPSA.

First Level mathematical literacy is assessed using The Building problem. This problem explores the concepts of change and relationship within a personal context, drawing upon students' personal experiences or those of individuals close to them. Students are tasked with determining the algebraic representation of the relationship, identifying the coefficients, terms, and constant by utilizing all available information.

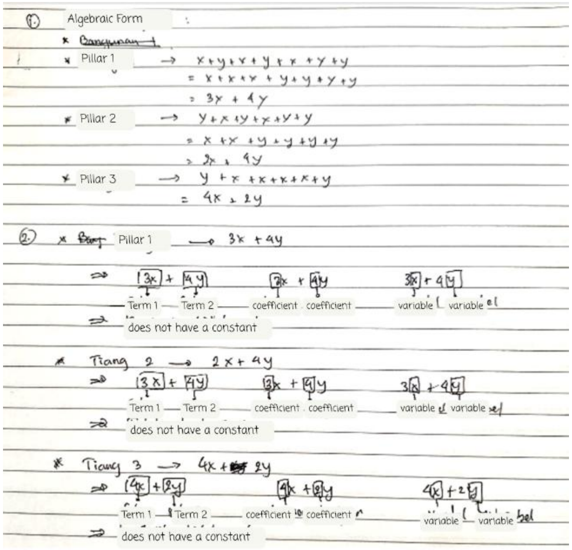

Figure 1. Student proficiency in solving The Building problem

Figure 1 illustrates that students at this level have attained the ability to address questions with familiar and general contexts where all pertinent information. This is evidenced by their proficiency in identifying information, comprehending algebraic procedures, and naming variables, coefficients, and constants within the topic of Algebraic Forms. This achievement is attributed to the Pictorial (P) and Symbolic (S) elements that foster students' visual and spatial abilities, empowering them to translate their understanding into symbols.

This finding supported by numerous studies that implied level one students can comprehend and respond to questions that pertain to familiar contexts, provided all information is presented in a clear and unambiguous manner (Genc & Erbas, 2019; Manfreda Kolar & Hodnik, 2021; Tarim & Tarku, 2022). Additionally, they possess the ability to describe information in accordance with explicit instructions (Tarim & Tarku, 2022).

Students Mathematical Literacy on Second Level

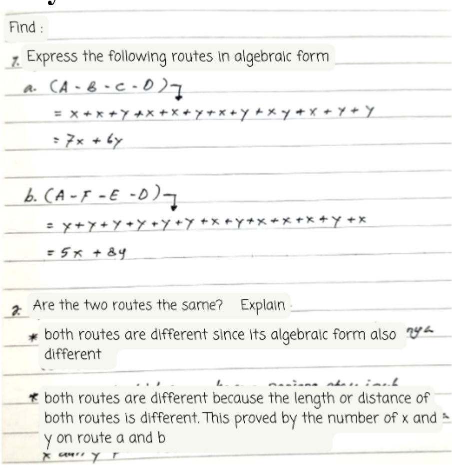

Figure 2. Students Prociency on solving Floor Plan problem

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Problem 2 was designed to assess all the aforementioned competencies of second-level mathematical literacy. The task presented students with a real-world scenario that required them to interpret the situation, extract relevant information, employ a single representation method, apply basic algorithms and formulas, and justify their solutions. Sixteen students were at the second-level proficiency, from nine students.

This study found that students demonstrated significant improvement in their ability to interpret and analyze mathematical problems. They effectively selected relevant information, identified appropriate algebraic procedures, and provided justifications for their solutions and answers. Figure 3 showed that students able to write the application of route using their own language, for example, "*kedua rute tidak sama karena bentuk aljabarnya berbeda* (both routes are different since its algebraic form also different)", and "*kedua rute tidak sama karena panjang atau jauh dari kedua rute berbeda. Itu terbukti dari banyaknya x dan y pada rute a dan b* (both routes are different because the length or distance of both routes is different. This proved by the number of *x* and *y* on route *a* and *b*)". This finding can be attributed to the ELPSA framework since it facilitates active learning by engaging students in real-world scenarios (Experience). It promotes meaningful understanding by fostering connections between mathematical concepts and language (Language). Finally, ELPSA enables students to apply their knowledge by providing opportunities to solve problems effectively (Application). These findings align with existing research which suggests that instructional frameworks promoting active learning and application have a more positive impact on students' mathematical skills (Grabinger & Dunlap, 1995; Jamaludin & Osman, 2014; Theobald et al., 2020) compared to conventional teaching models (Mayasari, Natsir, & Zulfiah, 2022).

Students Mathematical Literacy on Third Level

The third level of mathematical literacy was assessed using problem 3. Following Competition. As shown table 3, prior to implementing ELPSA, seven students in the experimental class had only attained third level. However, after implementing ELPSA, four students able to reach this mathematical literacy level. This demonstrates that the ELPSA instruction that utilized Experience (E), Symbols (S), and Application (A) fostering students to entails identifying problems, analyzing information, generating solutions, and evaluating outcomes.

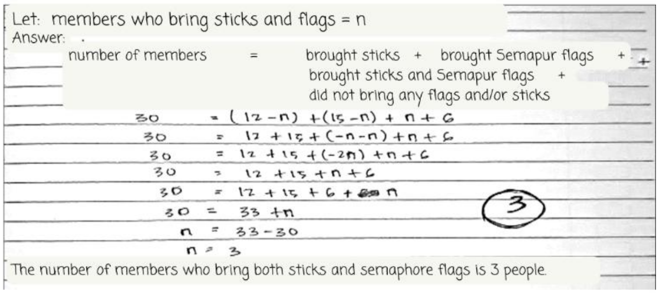

Figure 3. Student's mathematical proficiency on solving problem 3

Figure 3 showed that student entails identifying problems and analyzing information given from the problem. Students written down the informations before analyzing them. Furthermore, student generating solutions by his/her own languange, such as, "*jumlah anggota = membawa tongkat + membawa bendera Semapur + membawa tongkat dan bendera Semapur + tidak membawa keduanya* (number of members = brought sticks + brought Semapur flags + brought sticks and Semapur flags + did not bring any flags and/or sticks)". Then, students change it into symbolic form to generating soltions. At the end of solution, student evaluating problem outcomes by restating it as a conclusion.

The findings align strongly with Polya's four-step problem-solving model, which emphasizes understanding the problem before attempting a solution. According to Polya, effective problem-solving requires students to first comprehend the problem by documenting given information, then devise a plan by converting information to symbolic notation, and finally look back to evaluate outcomes. This directly supports the observed process where "students first documented the given information prior to analysis, then converted this information into symbolic notation to develop solutions, and concluded by evaluating outcomes" (Polya, 2014).

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Students Mathematical Literacy on Fourth Level

Fourth Level was assessed using the soccer field problems. Table 3 shows there were six students who could reach fourth level after being taught using ELPSA. The greatest improvement was seen in fourth level, where the number of students increased from 0 to 6 students at this level. This level challenges students to build models for intricate scenarios. These models involve recognizing limitations and making clear any underlying beliefs. By outlining these assumptions, students choose, compare, and assess the best approaches to solve complex math problems linked to the models. Additionally, they are expected to leverage their well-honed thinking and reasoning skills in a strategic way.

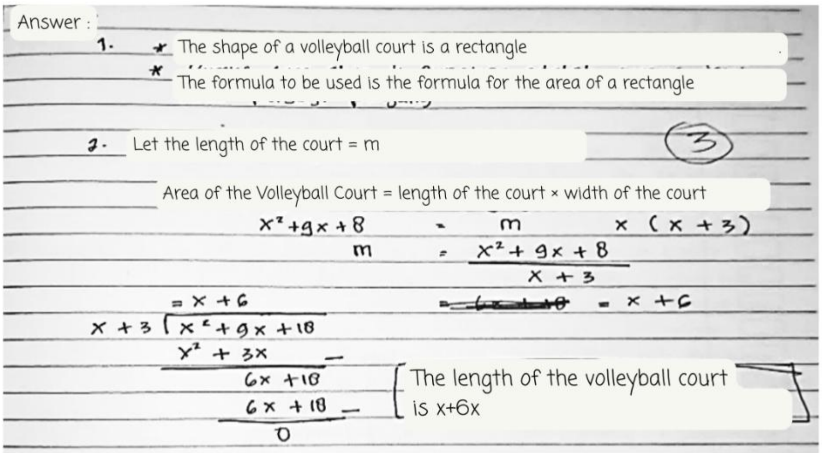

Figure 4. Student's mathematical proficiency on solving problem 4

Figure 4 showed that students strategically use different forms of representation, including symbols and equations, to understand the situations they are studying. They began reflecting on their work, where they develop and communicate their interpretations and thought processes. The finding showed that after ELPSA implementation, students develop critical thinking by analyzing real-world models. They interpret various representations (diagrams, equations, etc.) to understand the situation, connect the model elements to reality, and solve problems using their existing skills. They communicate their reasoning and actions to demonstrate their understanding.

This research strongly supports the finding that students benefit from using multiple representations in developing metacognitive skills. The study found that "the REAL learning model with multiple representations plays an important role in developing students' metacognition and problem-solving abilities" (Distrik & Saregar, 2022). Students who engaged with various representational forms demonstrated enhanced ability to reflect on their work and articulate their reasoning processes, directly aligning with the observed strategic approach to utilizing symbols and equations.

Students Mathematical Literacy on Fifth Level

The Fifth Level proficiency was assessed using The Garden problem. Prior to ELPSA implementation, none of the students achieved this level. However, after ELPSA instruction, 6 students successfully attained Fifth Level. This level demands proficiency in model development and application for complex situations. Students must identify problems, make assumptions, and strategically select, compare, and evaluate problem-solving approaches. They should demonstrate broad-based reasoning and effectively connect symbolic representations with relevant knowledge. Additionally, reflection and communication of interpretations and justifications are crucial.

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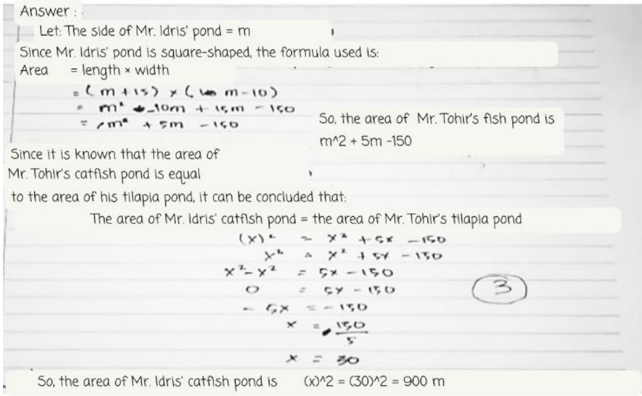

Figure 5. Student's mathematical proficiency on solving problem 5

Figure 5 showed that students able to develop and work with models for complex situations, identify problems, and make assumptions. Subsequently, they are performed appropriately select, compare, and evaluate problem-solving strategies related to complex model-related problems. In this study, students are also show that they work strategically using broad-based thinking and reasoning, and appropriately connect symbolic representations and formal characteristics to situation-related knowledge. Additionally, they also be able to reflect on their work and articulate and communicate their interpretations and justifications. This finding is in align with numerous studies that found students's mathematical reasoning impacts mathematical literacy (Adams et al., 2023; Brown, 2016; Franke et al., 2007; Walshaw & Anthony, 2008).

Students Mathematical Literacy on Sixth Level

This study assessed Level 6 mathematical proficiency using "The Carpenter" problem. However, none of the students attained this level. Level 6 proficiency necessitates the ability to conceptualize, generalize, and apply information gleaned from analysis and modeling of complex situations. Students must demonstrate above-average knowledge, flexibly connect and represent information from diverse sources, and exhibit advanced mathematical thinking and reasoning. They are expected to leverage their knowledge and understanding of mathematical symbols and operations to develop novel strategies for tackling new situations. Additionally, students at this level must engage in reflective practice, articulating and communicating their actions accurately while drawing connections to findings, interpretations, opinions, and real-world relevance.

Significant Improvements in Mathematical Literacy

Our research demonstrates substantial improvements in students' mathematical literacy following the implementation of the ELPSA framework. Initial assessment revealed concerning deficiencies, with 73.5% of students functioning merely at the first literacy level and the remaining 26.5% reaching only the second level. Prior to intervention, students predominantly followed basic instructions mechanistically, exhibiting minimal capacity to interpret information or apply mathematical concepts appropriately in contextual situations.

Post-implementation data revealed a marked redistribution across higher proficiency levels, with 5.8% of students achieving the fifth level, which is a significant advancement from the pre-implementation baseline. This transformation provides compelling evidence that the ELPSA framework effectively facilitates students' development from rudimentary recognition of simple problems to sophisticated mathematical capabilities. Students demonstrated newfound abilities to construct and manipulate models of complex situations, solve sophisticated mathematical problems, conduct evaluations of mathematical approaches, and communicate mathematical reasoning with precision and clarity.

These improvements align with established cognitive development theories, particularly Vygotsky's social constructivism and Bruner's representational theory. As Treder argues, the progression from concrete experience to visual representation to mathematical symbolism constitutes a critical pathway for comprehending abstract concepts (Żądło-Treder, 2021). The ELPSA approach succeeds precisely because it facilitates active learning through peer collaboration and encourages independent exploration (Amalia, Johar, & Ikhsan, 2020; Nissa, Sanapiah, & Yuntawati, 2019).

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Futhermore, Walshaw's assertion that direct experience through social interaction helps students build deeper mathematical understanding (Walshaw & Anthony, 2008) is strongly supported by our findings.

Critical Limitations and Future Directions

Despite these encouraging results, the absence of students achieving Level six proficiency indicates significant limitations in our ELPSA framework implementation. This finding suggests that developing the highest levels of mathematical literacy requires extended implementation periods and exposure to diverse contextual problems. Students require sustained opportunities to encounter novel problems, engage in reflective thinking, and practice applying and communicating their mathematical knowledge across varied situations.

Research by Orozco & Pasia and Melawati et al. confirms that consistent engagement with diverse real-world mathematical contexts substantially enhances higher-order reasoning and critical thinking capabilities (Melawati, Rochmiyati, & Nurhanurawati, 2022; Orozco & Pasia, 2021). These advanced cognitive processes are precisely what students need to master the complex mathematical challenges measured by PISA's Level 6 standards (Anggraeni, Abdulhak, & Rusman, 2019). Our implementation, while effective for intermediate levels, did not sufficiently develop these highest-order skills.

Our research encountered several methodological limitations that warrant acknowledgment. First, the relatively brief implementation period of the ELPSA framework prevents us from drawing conclusions about its long-term impact on students' mathematical literacy development. Second, the limited range of contextual problems presented to students likely restricted their opportunities to develop adaptability when confronting unfamiliar problems and engaging in high-level thinking processes. Furthermore, our study did not comprehensively investigate other potentially influential factors affecting mathematical literacy development, including teacher effectiveness, students' prior academic achievement, learning motivation, and additional contextual variables that might moderate the framework's effectiveness.

CONCLUSION

In addressing the primary objective of investigating the ELPSA Framework's effectiveness in improving students' mathematical literacy skills, our study provides substantial evidence of positive impact across multiple literacy levels. The statistically significant improvements in the experimental group, coupled with the clear progression through proficiency levels, demonstrate that the ELPSA Framework is indeed effective for developing mathematical literacy. However, this fulfillment is substantial rather than complete. While we demonstrated significant improvements through Level Five, the framework's inability to elevate students to Level Six proficiency indicates that further refinements are necessary to achieve comprehensive mathematical literacy development. Future research should address the identified limitations through extended implementation periods, more diverse contextual problems, and investigation of additional influential factors to fully realize the potential of the ELPSA framework.

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PROFILE

Firmansyah B, born on November 11th 1988, is a Lecturer in Mathematics Education at UIN Alauddin Makassar. He holds degrees of undergraduate (2010) and postgraduate (2013) in Mathematics Education from Makassar State University, and his research interests lie in exploring how technology can improve mathematics learning and education.

Ega Gradini, born on January 26th 1985, is a Lecturer in Mathematics Education at IAIN Takengon, with a background in Mathematics Education from Syiah Kuala University (2006) and a postgraduate degree in Teaching of Mathematics from Universiti Sains Malaysia (2010). Her research interests focus on developing students' mathematical abilities through Higher Order Thinking Skills, Mathematical Literacy, and Mathematical Concept exploration.

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Nadiatul Husna, having graduated with a degree in Mathematics Education from IAIN Takengon (2022), transitioned from student to teacher and now inspires young minds in mathematics at SDIT Az Zahra Takengon.

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