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The Effect of GeoGebra-Assisted E-Modules on Students' Ability to Solve Problems Mathematically

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Abstract

This research implements a posttest-only control group experimental design to examine the impact of a GeoGebra-integrated e-module on students' mathematical problem-solving abilities. A sample of 68 eighth-grade learners at SMP Negeri 57 Palembang participated in the study, divided into experimental and control groups. The experimental group utilized an interactive e-module featuring GeoGebra software integration, while the control group received conventional instruction. The results showed that students who used the e-module achieved significantly better outcomes in problem recognition, strategy development, implementation of solutions, and outcome assessment. The mean posttest results obtained by the experimental group were higher than those of the control group. A t-test confirmed a statistically significant difference between the two groups. Based on statistical analysis, integrating GeoGebra within a structured digital module demonstrates potential to strengthen students' conceptual understanding, engagement, and problem-solving skills, especially in learning straight-line equations. Furthermore, the approach promotes higher-order thinking and learner autonomy, offering a promising strategy for improving mathematics instruction at the junior high school level.

Keywords: *e-module; GeoGebra; problem-solving; mathematics education*

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INTRODUCTION

Information and communication technology development has significantly influenced the transformation of educational practices, particularly in the digital era. In mathematics education, integrating technology is a powerful driver in creating interactive, visual, and meaningful learning environments (Hassan, 2023; McCarthy et al., 2023). As modern educational paradigms evolve, there has been a growing emphasis on developing students' competencies that align with 21st-century demands, with a particular focus on mathematical problem-solving skills. These skills are essential for fostering logical reasoning, critical thinking, and real-world decision-making (Andini et al., 2023; Gunawan & Putra, 2019).

One of the primary challenges in contemporary mathematics instruction lies in enhancing students' ability to solve mathematical problems effectively. Many students experience difficulties in understanding abstract concepts and applying them to solve non-routine problems that require higher-order thinking skills (Shawan et al., 2021; Tanujaya et al., 2021). These difficulties are often exacerbated by the persistence of conventional instructional methods that prioritize procedural fluency over conceptual understanding, emphasizing teacher-centered delivery rather than promoting active student engagement (Lestari et al., 2023; Nurjanah & Jusniani, 2020)

To address these challenges, it is necessary to implement innovative teaching approaches that harness the potential of digital technology in fostering more profound understanding and promoting greater student autonomy. E-modules, or electronic modules, represent one such approach. These structured and interactive digital learning materials facilitate independent and guided learning experiences (Çelik & Baturay, 2024; Kumbo et al., 2023). When designed effectively, e-modules have the potential to promote learner engagement, support self-paced exploration, and encourage contextualized understanding. However, to maximize their pedagogical potential, e-modules must incorporate interactive and visual components that assist students in developing strong conceptual foundations (Albana & Sujarwo, 2021; Maulana, 2024).

One promising tool for embedding interactivity within e-modules is GeoGebra, a dynamic mathematics software that integrates geometry, algebra, calculus, and data analysis. GeoGebra allows students to construct and manipulate mathematical representations in a dynamic environment, fostering exploratory learning and enhancing visual reasoning (Dyrvold & Bergvall, 2024; Miranda & Nurmitasari, 2022). Numerous studies have confirmed GeoGebra's effectiveness in improving students' conceptual understanding, motivation, and overall mathematics learning outcomes (Muslim et al., 2023; Nadzeri et al., 2023).

Although previous research has explored the benefits of using either e-modules or GeoGebra separately, only a limited number of studies have systematically examined the integration of GeoGebra within e-modules with a specific focus on enhancing mathematical problem-solving abilities. This situation reflects a critical gap in literature. Most existing studies have concentrated on the isolated impacts of digital tools without investigating the potential synergistic effects that could arise from their integration (Dahlia et al., 2024; Thahara et al., 2023; Mohd et al., 2022). Additionally, many of these studies are constrained by methodological limitations, such as small sample sizes, limited experimental rigor, or inadequate adaptation to diverse classroom contexts (Ranta & Zavialova, 2022; Schneider & Rohmann, 2021).

This study seeks to address these gaps by developing and implementing an e-module enriched with integrated GeoGebra features designed to enhance students' mathematical problem-solving abilities. The innovation of this research lies in its comprehensive and pedagogically sound design that combines the affordances of technology, such as dynamic visualizations, with the cognitive requirements of mathematical reasoning (Aprilyani & Hakim, 2020). Rather than merely adding technological elements, the integration is purposefully structured to support all phases of the problem-solving process. This includes understanding the problem, devising a strategy, executing the solution, and reflecting on the results (Jacinto & Carreira, 2021).

In this study, mathematical problem-solving ability is operationally defined as students' capacity to comprehend mathematical tasks, formulate appropriate strategies, execute procedures accurately, and interpret outcomes meaningfully. These cognitive processes are aligned with well-established theoretical frameworks in mathematics education and reflect key performance indicators used in national and international assessments, such as the Program for International Student Assessment (PISA) (Sahidin & Sari, 2022; Satiti & Wulandari, 2021). The GeoGebra-enhanced e-module is designed to support these cognitive steps by providing dynamic visualizations that enable students to explore, conjecture, and visualize abstract mathematical relationships in real time (Dyrvold & Bergvall, 2024).

Accordingly, this study seeks to answer the central research question: How does using a GeoGebra-assisted e-module influence students' ability to solve mathematical problems? The study hypothesizes that students exposed to this technology-integrated instructional approach will demonstrate significantly higher problem-solving performance than those who receive conventional instruction. This hypothesis is supported by previous findings highlighting interactive digital learning tools' motivational and cognitive benefits (Andini et al., 2023; Dyrvold & Bergvall, 2024; Nisa et al., 2024).

This research has two primary objectives. First, it aims to investigate the impact of using GeoGebra-assisted e-modules on students' mathematical problem-solving abilities. Second, it seeks to evaluate the pedagogical feasibility and instructional effectiveness of integrating dynamic digital technologies into secondary school mathematics education. These objectives are pursued through a robust research design combining quantitative and qualitative methodologies to ensure statistical reliability and contextual relevance.

This study contributes to the advancement of mathematics education in several ways. From a theoretical perspective, it expands the literature on technology-mediated learning by demonstrating how digital tools can be holistically embedded into instructional materials, rather than applied as standalone interventions. From a practical standpoint, it provides a replicable model for educators seeking to integrate technology meaningfully into instructional design, thereby promoting student autonomy and deeper conceptual understanding. Furthermore, it responds to increasing demands for innovation in educational policy by aligning with national and international efforts to modernize mathematics curricula (Hasanah, 2023).

In addition, the study adopts a context-sensitive approach by tailoring the intervention to the needs and characteristics of students in authentic classroom settings. This contextual responsiveness addresses common critiques of earlier studies that failed to account for educational diversity (Harahap & Lubis, 2019). By grounding the instructional design in real learning environments, the study enhances its findings' external validity and practical scalability.

In conclusion, this research represents a timely and relevant contribution to mathematics education by leveraging the potential of digital technology. By integrating GeoGebra into an interactive e-module, it proposes a pedagogically grounded and technologically enriched instructional approach aimed at developing students' mathematical problem-solving abilities. The findings of this study are expected to offer valuable insights into improving learning outcomes and guiding best practices for technology integration in mathematics classrooms around the world.

RESEARCH METHODOLOGY

This study employed a quantitative approach using an experimental research method, which is appropriate for investigating causal relationships between variables under controlled conditions. Experimental methods are commonly used in quantitative research to examine the effect of a specific treatment or intervention (Creswell & Creswell, 2023; Sugiyono, 2016). A control group was used as a benchmark for comparison to minimize external influences on the dependent variable (Fraenkel et al., 2019).

The research design adopted in this study was a true experimental design, which allows for high internal validity due to random assignment (Cohen et al., 2018). Specifically, the posttest-only control group design was implemented. In this design, participants are randomly assigned to either an experimental or control group, and only post-intervention outcomes are measured. This design is suitable for avoiding pretest sensitization effects and assessing the treatment's impact (Ary et al., 2010; Sugiyono, 2016).

The sample selection technique employed was cluster random sampling, a type of probability sampling. This method randomly selects intact groups (or clusters) from a population, regardless of individual characteristics within each group (Gall et al., 2003). The population in this study consisted of all eighth-grade students at SMP Negeri 57 Palembang during the 2023/2024 academic year. Two classes were selected as research samples: Class VIII.6 as the experimental group, which received instruction using the GeoGebra-assisted e-module, and Class VIII.1 as the control group, which received conventional instruction. The experimental group consisted of 35 students, while the control group consisted of 33 students.

The independent variable in this study was the GeoGebra-assisted e-module, which was designed to support students' mathematical problem-solving processes through dynamic visualization and interactivity (Dahlia et al., 2024; Handayani et al., 2022). The dependent variable was students' mathematical problem-solving ability, which refers to the students' capacity to understand problems, devise strategies, execute solutions, and interpret results meaningfully (Maslihah et al., 2020; Rohmah et al., 2023).

A mathematical problem-solving test using essay-type items was administered to collect data. The development of the test instrument followed a structured process, including creating a test blueprint, formulating indicators aligned with problem-solving skills, and constructing items (Susetyawati & Nuryani, 2021; Widodo et al., 2021). The instrument assessed various aspects of mathematical problem-solving based on established theoretical frameworks such as Polya's four-step model and OECD PISA problem-solving indicators (Foster, 2023; OECD, 2023). Before its use, the instrument underwent expert validation and item analysis to ensure validity, reliability, and suitability for the research context (J. Creswell & D. Creswell, 2023).

The research was conducted over two weeks, from November 13 to November 25, 2023, at SMP Negeri 57 Palembang. During the intervention, the experimental group engaged with the GeoGebra-assisted e-module, while the control group followed conventional learning methods without digital support (Hohenwarter & Jones, 2007). After the treatment phase, both groups were administered the same posttest to evaluate differences in problem-solving ability.

Data from the posttest were analyzed using appropriate descriptive and inferential statistical techniques to determine the significance of the difference in performance between the two groups (Johnson & Christensen, 2020). Statistical procedures aimed to test the hypothesis that students taught with GeoGebra-assisted e-modules would perform significantly better in solving mathematical problems than those receiving conventional instruction (Ary et al., 2010; Creswell & Plano Clark, 2018).

RESULTS AND DISCUSSION

After the entire series of data collection processes was completed, the results showed that using e-modules based on the Indonesian Realistic Mathematical Approach (PMRI), supported by Augmented Reality (AR) technology, positively impacted students' mathematical problem-solving skills. These findings were obtained through the implementation of research, which is divided into three main stages: preparation, implementation, and closing. Initially, the researcher conducts preliminary observations and coordinates with the mathematics subject teacher to randomly determine the experimental and control classes. Class selection was done using a cluster random sampling technique with the help of the "wheel of names" site. Furthermore, the experimental class received learning treatment with the AR-assisted PMRI e-module for three meetings. In contrast, the control class followed conventional mathematics learning through the lecture method.

During the instructional activities in the experimental group, the PMRI approach was implemented consistently, following its five core principles: engaging students with real-life contexts, utilizing representational models to support mathematical understanding, encouraging learners to construct knowledge actively, connecting mathematical concepts, and fostering interaction among students. The learning context embedded in the e-module revolves around scouting, which was selected due to its familiarity with students and its relevance to straight-line equations. Augmented Reality (AR) was employed to depict scouting-related items, such as tents, flagpoles, and plate racks. These visualizations were designed to support students in comprehending the abstract concept of straight-line equations in a more concrete and meaningful way.

Each session emphasized a distinct subtopic. In the first session, students explored the general form of a straight-line equation by sketching a tent using AR and then deriving the equation from their drawing. The second session addressed determining the equation of a line that passes through a specific point. In this activity, students sketched a flag and identified the corresponding equation. In the third session, students examined constructing a line equation from two distinct points by drawing a plate rack and calculating the equation based on the given coordinates.

During the instructional process, students were directed to apply problem-solving procedures based on Polya's stages, which include identifying the problem, devising a plan, executing the strategy, and reviewing the outcomes. These activities were conducted in groups to promote collaborative discussion, idea sharing, and active presentation of their solutions. Such an approach contributes not only to the development of students' critical thinking but also to fostering a more profound grasp of mathematical concepts.

Upon completing all learning sessions, students took a post-test of five items to evaluate their mathematical capabilities regarding straight-line equation material. Data evaluation indicated that participants in the experimental class demonstrated superior performance compared to their counterparts in the control class. The findings suggest that AR-enhanced PMRI e-modules significantly enhance students' mathematical reasoning capabilities.

This outcome is consistent with earlier studies, which found that the PMRI model has a positive effect on developing students' mathematical problem-solving competencies compared to traditional methods (Harahap & Lubis, 2019). Augmented Reality (AR) into e-modules creates a more engaging and interactive learning atmosphere. AR-based visual representations assist students in linking abstract mathematical ideas with tangible, real-world examples, thereby improving conceptual understanding and knowledge retention (Arifin et al., 2024; Çelik & Baturay, 2024; Jacinto & Carreira, 2021).

Moreover, incorporating a scouting context supports meaningful learning by engaging students emotionally and cognitively throughout the learning process. This is supported by Andini et al. (2023), who found that context-based learning contributes significantly to increasing student involvement and comprehension in mathematics. Similarly, Lestari et al. (2023) emphasized that contextual learning can enhance problem-solving performance, particularly when aligned with students' spatial intelligence.

The synergy between AR technology and the PMRI approach creates a dynamic, student-centered learning environment. Learning that utilizes technology such as AR enables students to interact more directly with the content, potentially leading to deeper conceptual understanding (Albana & Sujarwo, 2021; Çelik & Baturay, 2024). This is further supported by Dahlia et al. (2024), whose findings showed that e-modules designed with dynamic tools like GeoGebra and integrated with discovery learning significantly improved students' problem-solving skills.

The PMRI approach, which emphasizes realistic and relevant daily contexts like scouting, promotes better understanding of mathematical concepts and stimulates students' active participation (Harahap & Lubis, 2019; Lestari et al., 2023). In line with this, AR-based e-modules have been demonstrated to improve engagement and learning outcomes when digital media and game-like features are thoughtfully integrated (Nadzeri et al., 2023; Nisa et al., 2024). The gamified and visually rich learning experience facilitated by AR further boosts students' motivation, making mathematics learning more enjoyable and effective (Albana & Sujarwo, 2021; Gunawan & Putra, 2019).

Overall, implementing a learning strategy that combines PMRI with Augmented Reality (AR) technology and contexts aligned with students' real-life experiences positively influences their mathematical problem-solving capabilities. This instructional model increases student engagement with the material and enhances their comprehension of more advanced mathematical ideas. At the concluding phase of the study, a post-test was administered to evaluate the impact of GeoGebra-integrated e-modules on learners' problem-solving performance concerning straight-line equation topics. The data analysis involved three main steps: testing for normality, assessing homogeneity, and conducting hypothesis testing.

Table 1. Tests of Normality

	Shapiro-Wilk		
	Statistic	**df**	**Sig.**
Experiment (X1)	.943	33	.084
Control (X2)	.936	33	.052

The data distribution assessment examines if the collected information exhibits normal characteristics. The Shapiro-Wilk test was employed in this study, particularly suitable for research with limited participants ($n < 50$), as was the case with the 33 samples analyzed. Referring to the statistical evaluation presented in Table 1, the X1 variable yielded a statistical coefficient of 0.943 with a significance level of 0.084 ($p > 0.05$). In contrast, the X2 variable showed a value of 0.936 with a significance of 0.052 ($p > 0.05$). These findings suggest that both variables satisfy the normality assumption, as indicated by significance levels surpassing 0.05. Consequently, the null hypothesis (H_0) is retained. This outcome confirms that the post-test scores from the experimental group are derived from a normally distributed population. Meeting this assumption allows for applying parametric statistical methods in subsequent analyses.

Table 2. Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
1.071	1	66	.304

An equivalence evaluation was performed to determine if the variations between two groups are similar. This study applied the Levene test to the problem-solving ability data to assess variance equality across groups. As presented in Table 2, the test produced a Levene statistic of 1.071 with degrees of freedom df1 = 1 and df2 = 66, along with a significance measure of 0.304. Since the significance value exceeds 0.05, it can be inferred that the variance difference between the groups is not statistically significant. Thus, the null hypothesis (H_0) is accepted, indicating that the sample groups are homogeneous. This result confirms that the assumption of homogeneity of variance is fulfilled, enabling parametric tests under equal variances for further analysis. Verifying this assumption reinforces the credibility of the comparative analysis conducted on students' problem-solving ability data.

Hypothesis tests were carried out to determine whether the use of GeoGebra-assisted e-modules significantly influenced students' mathematical problem-solving skills. The hypotheses formulated are:

Ho : GeoGebra-assisted e-modules do not mathematically affect students' problem-solving ability in straight line equation material.

Hα : There is an influence of GeoGebra-assisted e-modules that do not mathematically affect students' problem-solving ability in straight line equation material.

Table 3. Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	1.071	.304	6.345	66	.000	25.102	3.956	17.203	33.001
Equal variances not assumed			6.318	63.391	.000	25.102	3.973	17.163	33.041

The comparative analysis revealed a statistically significant difference in problem-solving test scores between the experimental and control groups. The treatment group obtained a mean score of 73.31 (SD = 15.121) from 35 participants, while the control group achieved a mean score of 48.21 (SD = 17.476) from 33 participants. The analysis assumed equal variances based on Levene's statistical outcome ($F = 1.071$; $p = 0.304 > 0.05$), supporting the assumption of distribution homogeneity. The t-test analysis yielded a t-value of 6.345 containing 66 degrees of freedom and a two-tailed significance level of 0.000 ($p < 0.05$). The mean score difference between the two groups was 25.102, with a standard error of 3.956. The 95% confidence interval ranged from 17.203 to 33.001, excluding value zero, thus supporting the evidence of a statistically meaningful difference. These findings suggest that the experimental group outperformed the control group concerning problem-solving scores, with a notable average score gap of approximately 25 points. Based on the results presented in Table 3, where the Sig. (2-tailed) value was below 0.05, it can be inferred that the observed difference is statistically significant and likely attributed to the applied treatment or intervention, rather than random variation.

In addition, students' problem resolution capabilities were examined through Polya's four-step framework, which includes understanding the problem, devising a plan, executing the strategy, and reviewing the solution. Referring to the bar chart (Figure 1), a comparison between the experimental and control groups revealed that, for the majority of questions, students in the experimental class scored higher, particularly during the plan implementation and review phases. This suggests that the instructional approach used in the experimental group supports students in addressing problems in a more structured and systematic manner.

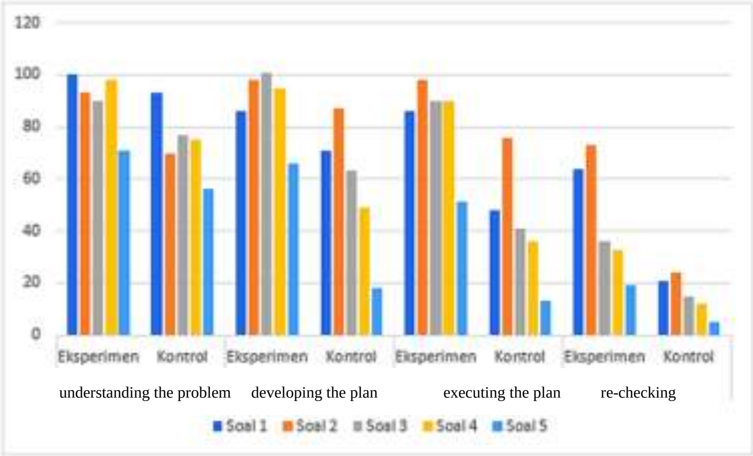


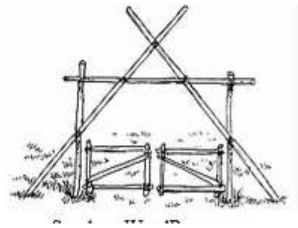
Figure 1. Comparison of Experimental Class and Control Class

This figure illustrates students' average problem-solving scores in mathematics, evaluated based on Polya's stages: understanding the problem, developing a plan, executing the plan, and re-checking, through five questions distributed between the experimental and control groups. The experimental group, which implemented a contextually based or technology-enhanced approach like PMRI, consistently outperformed the control group that followed conventional teaching methods. Both groups showed relatively strong outcomes in the 'understanding the problem' stage, though the experimental group obtained significantly higher marks on Questions 1 and 2. A clearer distinction was evident during the planning phase, where the experimental group sustained scores ranging from 85 to 100. In contrast, the control group experienced a score decline in Questions 4 and 5, with results dropping below 60 on the final question. This indicates that learners in the experimental group were more capable of constructing effective and adaptable strategies for problem-solving.

Throughout the execution phase, the experimental group maintained consistent performance, while the control group showed varying results. Regarding the re-checking phase, both groups recorded their lowest scores, particularly in Question 5, suggesting a general difficulty in revisiting and verifying solutions. Nonetheless, the experimental group still outperformed the control group in this indicator. Overall, the learning strategy employed in the experimental group demonstrated greater efficacy in improving students' problem-solving competence across all four indicators. The decrease in performance on the final two questions, especially in the control group, suggests that these questions were either more cognitively demanding or required thinking skills of a higher order. These skills were not sufficiently developed through conventional teaching approaches.

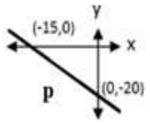
The results of students' answers to post-test questions were analyzed through four stages: understanding the problem, developing a plan, implementing the plan, and re-examining or concluding. The four stages are interrelated (Putra et al., 2018). The following are questions that have a comparison of score results on the problem-solving ability indicator such as in Figure 2.

5.



source: wordprees.com

Look at the picture above, Intan and her friend are assembling the shape of the scout gate in organizing the scout arena. There is a p line on the pioneering pole of the gate, namely:



The perpendicular lines p intersect at point (0,-20). Determine the coordinates of the point where line n intersects the x-axis!

Figure 2. The Problem Number 5

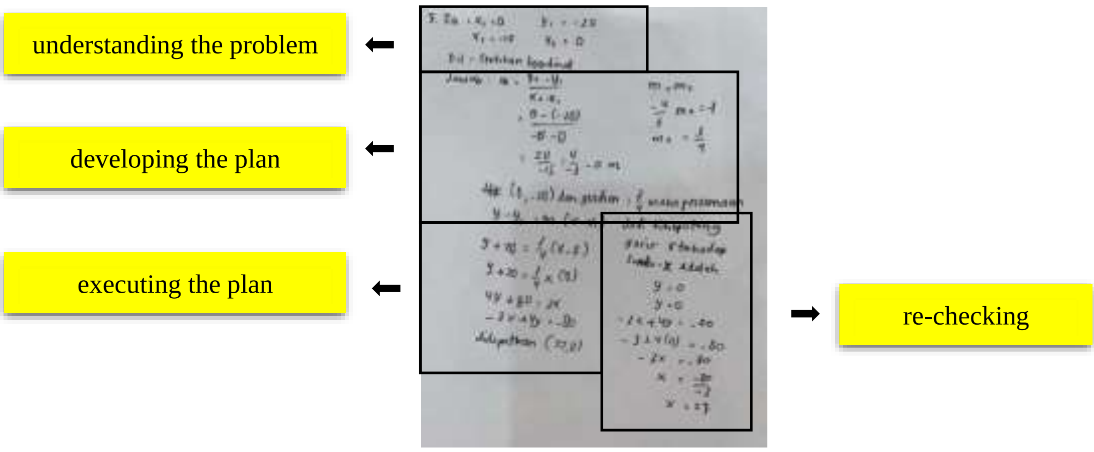


Figure 3. Student's Answers in the Experiment Class

Analysis of question number 5 (Figure 2) revealed notable variations between the participants' answers from the experimental and control classes. Figure 3 shows the answers of students from the experimental class who solved the task with a complete problem-solving structure. Although the information at the stage of understanding the problem is incomplete, students can plan, implement, and conclude results appropriately, resulting in high scores.

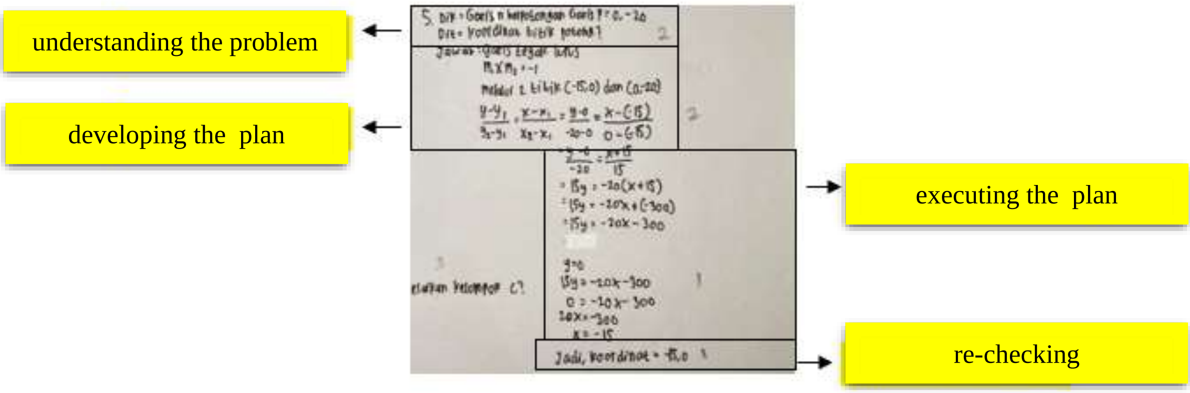


Figure 4. Student's Answers in the Control class

On the other hand, in Figure 4, students from the control class wrote complete problem information while understanding the problem but made mistakes at the implementation and re-examination stage. This shows that even if students understand the problem, they have difficulty solving it thoroughly without a contextual and interactive learning guide like GeoGebra.

The results analysis indicated that implementing e-modules grounded in the Indonesian Realistic Mathematics Approach (PMRI) and digital tools like GeoGebra and Augmented Reality (AR) positively affected mathematical problem-solving capabilities among secondary school learners. These findings align with Arifin and Efriani (2025), who emphasized that the PMRI approach facilitates students in connecting real-world contexts to mathematical problems, making it easier for them to grasp abstract concepts. Polya's proposed systematic strategies were evident in the students' responses, especially in how they planned, executed, and reviewed their problem-solving processes, confirming that such structured approaches are effective (Foster, 2023; Santos-Trigo, 2024).

The enhancement in participants' problem-solving competencies was evident in the assessment outcomes, with the treatment group displaying markedly superior performance compared to their peers in the reference group. This improvement was consistent across all problem-solving indicators, particularly in executing plans and evaluating outcomes. This reflects students' growing understanding of problem-solving procedures and ability to assess their strategies critically. The contrast in the quality of responses between the two groups reinforces the idea that instructional strategies significantly impact learning outcomes. Learning supported by dynamic visualizations, as GeoGebra and AR tools offered, created a more contextual and meaningful environment, helping learners avoid misconceptions and grasp mathematical concepts more concretely (Dahlia et al., 2024; Muslim et al., 2023).

Furthermore, the applied learning model encouraged active student engagement throughout the process. The PMRI approach emphasizes contextual problems, discussion, and exploration, promoting meaningful mathematical communication (Lestari et al., 2023). This aligns with the idea that interactive and contextual learning environments enhance students' motivation and ability to solve problems effectively (Çelik & Baturay, 2024; Handayani et al., 2022). Interactive digital tools support content delivery and expand students' conceptual models and cognitive engagement with mathematical tasks (Jacinto & Carreira, 2021; Nadzeri et al., 2023).

This study affirms the importance of combining realistic mathematics education with technology-enhanced tools to develop students' problem-solving skills. The findings further support the growing body of literature that promotes integrating interactive e-modules into mathematics instruction to create an engaging, effective, and contextually rich learning environment (Albana & Sujarwo, 2021; Miranda & Nurmitasari, 2022).

CONCLUSION AND SUGGESTIONS

The findings demonstrate that utilizing e-modules incorporating the Indonesian Realistic Mathematics Approach (PMRI) enhanced with Augmented Reality (AR) technology yields positive outcomes in developing mathematical problem-solving capabilities among secondary school learners. The elevated performance metrics in problem identification, strategy formulation, implementation procedures, and results interpretation, with notable distinctions between the intervention and comparison groups, evidence this advancement. The synergy between PMRI's contextual framework and AR's interactive visualization capabilities has fostered comprehensive conceptual understanding, heightening learner engagement throughout the educational process. This pedagogical approach facilitates systematic mathematical problem-solving and promotes active knowledge construction through experiential learning opportunities.

However, this study has several weaknesses that must be considered in interpreting the results and developing further research. First, the study was conducted in only one school with a relatively limited number of samples, so generalization of results to a wider population needs to be done carefully. Second, the duration of learning interventions using AR-assisted e-modules is still relatively short, so its impact on long-term retention or knowledge transfer ability cannot be ascertained comprehensively. Third, there are still technical obstacles in implementation, especially related to the proficiency with technological tools from both teachers and students, which can affect the effectiveness of the implementation of AR-based learning. Lastly, the focus of this research is limited to mathematical problem-solving skills. In contrast, other aspects, such as representation, reasoning, and mathematical communication, have not been explored, even though these three are also important parts of mathematical competencies that need to be developed in the context of technological integration.

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