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The effect of STEAM-oriented wayground on motivation and problem-solving in elementary math

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Abstract. The low learning motivation and problem-solving ability of elementary students remain significant challenges in Indonesian mathematics education. This study examines the effect of STEAM-oriented Wayground media on both variables among fourth-grade students on the flat shapes topic. A quantitative quasi-experimental pretest-posttest control group design was employed. The sample consisted of 46 students selected using purposive sampling, divided into an experimental group (n=26) receiving STEAM-oriented Wayground instruction and a control group (n=20) receiving conventional instruction. Instruments included an ARCS-based motivation questionnaire (16 items) and a Polya-based problem-solving test (20 items), both validated and reliable (Cronbach's Alpha 0.86 and 0.89). Data were analyzed using independent t-test and MANOVA. Results showed a significant effect on learning motivation ($t = 10.662$; $p < 0.001$) and problem-solving ability ($t = 12.894$; $p < 0.001$) compared to conventional learning. MANOVA also indicated a significant simultaneous effect ($F = 165.468$; $p < 0.001$; $\eta^2 = 0.885$). The experimental group showed moderate to high improvement (N-Gain motivation = 0.53; N-Gain problem-solving = 0.64). This study recommends integrating interactive digital media with a multidisciplinary approach as an innovative learning alternative in areas with limited resources.

Introduction

Mathematics learning in elementary schools plays a strategic role in developing students' logical reasoning, spatial abilities, and problem-solving competencies (Hendriana et al., 2017). These foundational skills are essential for students to succeed in higher education and everyday life. In the context of the Merdeka Curriculum currently implemented in Indonesia, flat shapes are an essential topic for fourth-grade students because they demand not only conceptual understanding but also geometric visualization skills and the ability to connect mathematical ideas with real-life contexts. Mastery of flat shapes material, including identifying shapes, calculating perimeter and area, and understanding the properties of two-dimensional figures, forms the foundation for learning more complex geometry at higher education levels (Sarama & Clements, 2009).

Despite the importance of this topic, students' numeracy achievement in Indonesia remains low. The 2023 National Assessment results showed that only 38% of fifth-grade students across Indonesia achieved the minimum numeracy competency, indicating that more than half of elementary school students have not mastered basic mathematical concepts, including geometry and measurement (Kemendikbudristek, 2023). Furthermore, the Programme for International Student Assessment (PISA) 2022 results consistently place Indonesia in the lower ranks for mathematical literacy, with Indonesian students struggling particularly on questions requiring higher-order thinking and problem-solving skills (OECD, 2023). This low performance reflects the urgent need for pedagogical innovation in mathematics instruction, particularly in geometry which requires strong visualization and spatial reasoning abilities (Bishop, 2021; Widana & Umam, 2023).

A similar condition was found at SDN 3 Randulawang, where mathematics instruction remained dominated by lecture methods with limited use of digital media; teachers reported barriers including access to devices, lack of training, and concerns about student adaptability. This condition reflects many rural elementary schools in Indonesia, where technology integration in mathematics instruction remains minimal (Widodo et al., 2023; Widana et al., 2024).

As a result of these conventional teaching practices, flat shapes material tends to be perceived as abstract, boring, and less contextual by students. Many students had difficulty distinguishing between various flat shapes, calculating the perimeter and area of combined shapes, and solving story problems related to daily life contexts. This condition was reflected in the odd semester daily test scores for the 2024/2025 academic year, where 64% of fourth-grade students (9 out of 14 students) had not reached the Minimum Mastery Criteria (KKM) set at 70 for geometry material. The class average score was only 62.5, far below the expected standard. This finding is consistent with previous research documenting similar challenges in geometry instruction in Indonesian elementary schools (Fadillah et al., 2021; Widana & Laksitasari, 2023).

On the other hand, the rapid development of digital technology in the 21st century opens significant opportunities for pedagogical transformation in elementary schools. One promising innovation is the use of gamification-based educational platforms, which have been widely adopted in various educational contexts. Gamification in education has been shown to increase student engagement, motivation, and learning outcomes across multiple disciplines (Dicheva et al., 2015). Among various gamification platforms, Wayground is an interactive quiz platform that allows teachers to design digital quizzes equipped with image visualizations, instant feedback features, competitive elements such as leaderboards and avatars, as well as flexible accessibility through various devices (Purba et al., 2022). These features can potentially increase student engagement, active participation, and learning motivation during the teaching and learning process.

Previous research has demonstrated the effectiveness of Wayground in improving various learning outcomes. Mawaddah et al. (2021) proved that using Wayground in elementary mathematics learning significantly increased the average mathematical problem-solving ability of students from 65.19 to 88.08, with an N-Gain in the high category. This finding is reinforced by Afifah & Arnellis (2025) who reported that the integration of Wayground with the STAD cooperative learning model significantly improved both learning activities and mathematics learning outcomes. Similarly, Nur & Yusuf (2026) found a significant positive relationship between the use of Wayground in mathematics learning and students' learning motivation. Waliah et al. (2026) also confirmed that local wisdom-based Wayground media effectively improved fraction problem-solving skills in primary school students.

Despite these positive findings, the use of Wayground in Indonesian elementary schools is generally still limited to being an evaluation tool or conventional exercise platform. Most teachers use Wayground only for summative assessments or drill-based practice questions, without integrating it into a broader pedagogical approach (Supriyanto, 2018). The full potential of Wayground has not yet been optimally explored. The platform's potential would be much greater if integrated into a contextual, multidisciplinary, and holistic learning approach that connects mathematics with other disciplines and real-world applications.

One such promising approach is STEAM (Science, Technology, Engineering, Arts, and Mathematics), which has gained significant attention in elementary education worldwide. The STEAM approach encourages students to think integratively across disciplines, fostering creativity, critical thinking, collaboration, and problem-solving skills simultaneously (Yim et al., 2025; Suryaningsih et al., 2025). In the context of learning flat shapes, the STEAM approach allows students to connect geometry concepts with art through pattern design and cultural exploration, with technology through digital simulations and interactive tools, with simple engineering through designing and constructing objects, with science through understanding the physical properties of shapes such as balance and symmetry, while mathematics remains the core discipline.

Purnamasari et al. (2020) emphasized that STEAM-based learning in early childhood and elementary education successfully develops higher-order thinking skills and prepares students for the challenges of the 21st century. Recent studies have confirmed the effectiveness of STEAM integration in elementary mathematics instruction, particularly in improving student engagement and conceptual understanding (Herro et al., 2023; Sandi, 2021).

The novelty of this research lies in three key elements that have never been studied simultaneously in the context of Indonesian elementary schools on flat shapes material. The first element is the use of Wayground media specifically designed as a STEAM-oriented interactive quiz platform, where each multiple-choice question is deliberately developed to contain explicit elements of Science, Technology, Engineering, Arts, and Mathematics. This integration is not merely adding pictures or contexts to questions but involves a systematic design where each question is mapped to specific STEAM elements aligned with learning objectives.

The second element is the simultaneous measurement of two dependent variables, namely mathematics learning motivation, measured using the ARCS model by Keller (1987) encompassing Attention, Relevance, Confidence, and Satisfaction dimensions, and mathematical problem-solving ability, measured using a four-stage framework Polya (1973) including understanding the problem, devising a plan, carrying out the plan, and looking back. Most previous studies measured only one variable, either motivation or problem-solving, not both simultaneously. The third element is the research context in rural areas with limited digital infrastructure, which has been largely dominated by studies conducted in urban settings with adequate technological resources.

This context is particularly relevant given the Indonesian government's commitment to inclusive technology-based pedagogical transformation (Kemendikbudristek, 2023). Based on the background, problem identification, and research gaps described above, this study addresses three research questions. First, does using STEAM-oriented Wayground media significantly affect fourth-grade elementary school students' motivation to learn mathematics on flat shapes material compared with conventional learning? Second, is there a significant effect of using STEAM-oriented Wayground media on the mathematical problem-solving ability of fourth-grade elementary school students on flat shapes material compared to conventional learning? Third, is there a significant simultaneous effect of using STEAM-oriented Wayground media on both the learning motivation and mathematical problem-solving ability of fourth-grade elementary school students?

Accordingly, this study aims to determine the effect of using STEAM-oriented Wayground media on the mathematics learning motivation of fourth-grade students, to determine the effect of using STEAM-oriented Wayground media on the mathematical problem-solving ability of fourth-grade students, and to analyze the simultaneous effect of using STEAM-oriented Wayground media on the learning motivation and mathematical problem-solving ability of fourth-grade students. The hypotheses proposed in this study are that there is a significant effect of STEAM-oriented Wayground media on students' mathematics learning motivation, that there is a significant effect of STEAM-oriented Wayground media on students' mathematical problem-solving ability, and that there is a significant simultaneous effect of STEAM-oriented Wayground media on both learning motivation and mathematical problem-solving ability.

Method

Research Method and Design

This study employed a quantitative approach with a quasi-experimental design using a pretest-posttest control group pattern. This design was chosen because, in school-based research, researchers cannot fully randomize subjects and must use intact groups, or existing classes, as analysis units (Creswell & Creswell, 2018). The quasi-experimental design allows for the comparison of outcomes between an experimental group receiving the intervention and a control group receiving conventional instruction, while controlling for initial differences through pretest measurements (Fraenkel et al., 2019).

Participants and Sampling Technique

The population of this study was all fourth-grade students of SDN 3 Randulawang and SDN 1 Randulawang, Jati District, Blora Regency, Central Java. The sample was selected using purposive sampling, based on the equivalence of the two schools' characteristics. The selection criteria included equivalent access to digital devices, age range (9–11 years), similar initial mathematics ability (means 68.5 and 67.8), and that students had never used Wayground. These criteria ensured that both groups were relatively equivalent before the treatment (Gall et al., 2015).

The experimental group consisted of 26 fourth-grade students from SDN 3 Randulawang who received learning with STEAM-oriented Wayground media, while the control group consisted of 20 fourth-grade students from SDN 1 Randulawang who received conventional learning. The sample size imbalance (26 vs. 20) resulted from using intact classes and their existing student numbers. To ensure equivalence between groups before treatment, an independent t-test was conducted on pretest scores. The results showed no significant difference between the experimental and control groups in learning motivation ($t = 0.502$; $df = 44$; $p = 0.618$) and problem-solving ability ($t = 0.780$; $df = 44$; $p = 0.440$), confirming that both groups were equivalent before the intervention.

Research Setting and Timeline

The research was conducted at SDN 3 Randulawang, which served as the experimental group, and SDN 1 Randulawang, which served as the control group, both located in Jati District, Blora Regency, Central Java, Indonesia. The research was conducted in the even semester of the 2025/2026 academic year and lasted approximately six weeks. Each learning session lasted 80 minutes and was conducted twice per week for four weeks. The researchers obtained permission to conduct the research from the principals of both schools. The researchers obtained informed consent from parents or guardians of all participating students and assured all participants of confidentiality and their right to withdraw at any time.

Research Procedures

The research procedure was carried out in three stages. The first stage was the pretest, conducted in the first week, in which both groups were given a pretest to measure their initial ability in learning motivation and mathematical problem-solving. The pretest used the ARCS-based motivation questionnaire (16 items) and the Polya-based mathematical problem-solving test (20 items). The pretest served as a baseline to ensure both groups were equivalent before the intervention. The second stage was the treatment, conducted during weeks two to five, in which the experimental group received STEAM-oriented Wayground media instruction for four weeks, while the control group received conventional instruction. The same teacher taught both groups to eliminate teacher-related variables, and both groups received the same instructional time.

The experimental group followed a structured sequence: orientation (10 minutes), STEAM exploration via Wayground (20 minutes), a collaborative project on floor patterns or batik-inspired designs (25 minutes), reflection and a formative quiz (15 minutes), and reinforcement and follow-up (10 minutes). The control group received conventional instruction without digital media, using lectures and practice questions on the blackboard. The third stage was the posttest, conducted in the sixth week, in which both groups were given a posttest with instruments equivalent to the pretest. The posttest measured students' final learning motivation and mathematical problem-solving ability in both groups.

Data Collection Techniques and Research Instruments

This study used tests and questionnaires for data collection. The instruments used were a mathematics problem-solving ability test and a learning motivation questionnaire. The mathematics problem-solving ability test consisted of 20 multiple-choice questions developed based on Polya's (1973) problem-solving stages: understanding the problem, devising a plan, carrying out the plan, and looking back. The test was administered twice, as a pretest and a posttest, with equivalent questions but different numbers. Each correct answer was scored 1, and incorrect answers were scored 0. The maximum score was 20, converted to a scale of 100. Table 1 presents the test blueprint.

Table 1. Grid of Mathematical Problem-Solving Ability Test

Polya's Stage	Indicator	Item Number	Total
Understanding the problem	Identify known and asked information	1, 2, 3, 4, 5	5
Devising a plan	Determine the appropriate formula/strategy	6, 7, 8, 9, 10	5
Carrying out the plan	Perform calculations correctly	11, 12, 13, 14, 15	5
Looking back	Re-examine the results and draw conclusions	16, 17, 18, 19, 20	5
Total			20

The learning motivation questionnaire consisted of 16 statements developed based on Keller (1987) ARCS model, which includes Attention, Relevance, Confidence, and Satisfaction dimensions, with four items for each dimension. The questionnaire used a 1-4 Likert scale, ranging from strongly disagree to strongly agree. The questionnaire was administered to both groups during the pretest and posttest. Total scores ranged from 16 to 64, with higher scores indicating higher learning motivation. Table 2 presents the questionnaire blueprint.

Table 2. Grid of Learning Motivation Questionnaire (ARCS Model)

Dimension	Indicator	Item Number	Total
Attention	Students' interest in learning; curiosity	1, 2, 3, 4	4
Relevance	Connection to daily life and experiences	5, 6, 7, 8	4

Dimension	Indicator	Item Number	Total
Confidence	Self-confidence in learning; belief in success	9, 10, 11, 12	4
Satisfaction	Satisfaction with learning outcomes	13, 14, 15, 16	4
Total			16

Instrument Validity and Reliability

The instruments were validated in two stages. First, expert validation was conducted by two experts, namely a mathematics education lecturer and a fourth-grade elementary school teacher, covering content validity, construct validity, and language validity using a Likert scale of 1 to 4. The validation results showed that all instruments were highly valid, with average scores above 3.80. Second, empirical validity testing was conducted with 20 students outside the research sample: 10 students from SDN 2 Randulawang and 10 students from SDN 4 Randulawang who had similar characteristics but were not part of the study.

The Corrected Item-Total Correlation (CITC) was used as the validity criterion, with a minimum acceptable threshold of 0.30. The results showed that all items were valid with correlation coefficients above the critical r-table. Reliability was measured using Cronbach's Alpha coefficient. The reliability test results showed that the problem-solving ability test had a Cronbach's Alpha of 0.89, while the learning motivation questionnaire had a Cronbach's Alpha of 0.86. Both values exceeded the minimum reliability threshold of 0.70, indicating high reliability for both instruments.

Product Specifications

The table presents the specifications of the Wayground media developed in this study.

Table 3. Product Specifications of STEAM-Oriented Wayground Media

Aspect	Specification
Platform	Web-based application (accessible via browser on mobile phones, tablets, or computers)
Access	Via wayground.id with a unique quiz code
Features	Drag and drop, graphing tool, scratchpad, instant feedback, leaderboard, avatar customization, live session mode
Content	30 multiple-choice questions on flat shapes with STEAM elements
STEAM Integration	Science (natural phenomena), Technology (digital tools), Engineering (design problems), Arts (local culture), Mathematics (core geometry)
Mode	Live session (to save bandwidth in rural areas)
Offline Backup	Printed worksheets prepared in case of network disruptions

Data Analysis Techniques

Data were analyzed using descriptive and inferential statistics in SPSS version 26.0. The analysis was conducted in several stages. Prerequisite tests included normality and homogeneity tests. We tested normality using the Shapiro-Wilk test, with the criterion that data are considered normal if the significance value is greater than or equal to 0.05. We tested homogeneity of variances using Levene's test, with the criterion that data are homogeneous if the significance value is greater than or equal to 0.05.

Hypothesis testing used an independent-samples t-test to test the mean difference in learning motivation and problem-solving ability between the experimental and control groups. The test was conducted at a significance level of $\alpha = 0.05$, with H_0 rejected if the significance value (2-tailed) was less than 0.05. Multivariate Analysis of Variance (MANOVA) was used to test the simultaneous effect of STEAM-oriented Wayground media on both learning motivation and mathematical problem-solving ability, also at $\alpha = 0.05$.

Supporting analysis used the Normalized Gain Score (N-Gain) to determine the level of improvement from pretest to posttest, with the formula N-Gain = (Posttest Score - Pretest Score) / (Maximum Score - Pretest Score). The N-Gain criteria are high if $g \geqslant 0.70$, medium if $0.30 \leqslant g < 0.70$, and low if $g < 0.30$. All statistical tests were conducted at a 95% confidence level, and the results were interpreted with reference to the established criteria.

Results and Discussion

Prerequisite Test Results

Before conducting hypothesis testing, prerequisite tests were performed to ensure the validity of the statistical analysis. The Shapiro-Wilk normality test showed that the pretest and posttest data for learning motivation and mathematical problem-solving ability in both groups had significance values > 0.05 (ranging from 0.279 to 0.927), indicating that all data were normally distributed. The homogeneity of variance test using Levene's Test showed significance values > 0.05 for all variables, indicating homogeneous variances between groups. These results confirmed that the assumptions for parametric testing were met.

Table 4. Normality Test Results (Shapiro-Wilk)

Variable	Group	Statistic	df	Sig.
Motivation Pretest	Experimental	0.954	26	0.29
Motivation Pretest	Control	0.943	20	0.279
Motivation Posttest	Experimental	0.962	26	0.431
Motivation Posttest	Control	0.962	20	0.594
Problem-Solving Pretest	Experimental	0.959	26	0.374
Problem-Solving Pretest	Control	0.964	20	0.631
Problem-Solving Posttest	Experimental	0.976	26	0.773
Problem-Solving Posttest	Control	0.979	20	0.927

Table 5. Homogeneity of Variance Test Results (Levene's Test)

Variable	F	df1	df2	Sig.
Motivation Pretest	0.006	1	44	0.937
Motivation Posttest	0.394	1	44	0.534
Problem-Solving Pretest	0.128	1	44	0.722
Problem-Solving Posttest	0.05	1	44	0.824

Descriptive Statistics

Learning Motivation.

Table 6 presents the descriptive statistics of students' mathematics learning motivation in both the experimental and control groups.

Table 6. Descriptive Statistics of Mathematics Learning Motivation

Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)	N-Gain	Category
Experimental (n=26)	54.23 ± 5.67	78.15 ± 6.42	0.53	Medium
Control (n=20)	53.85 ± 5.92	61.40 ± 6.18	0.18	Low

Pretest scores were similar across groups (54.23 vs 53.85), confirming equivalence. The experimental group improved by 23.92 points to 78.15 (N-Gain = 0.53, medium), while the control group improved by only 7.55 points to 61.40 (N-Gain = 0.18, low). This indicates that STEAM-oriented Wayground media was more effective in improving motivation.

Mathematical Problem-Solving Ability

Table 7 presents the descriptive statistics of students' mathematical problem-solving ability in both groups.

Table 7. Descriptive Statistics of Mathematical Problem Solving Ability

Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)	N-Gain	Category
Experimental (n=26)	58.46 ± 6.23	84.92 ± 5.87	0.64	Medium
Control (n=20)	57.90 ± 6.45	65.35 ± 6.72	0.20	Low

The mean pretest problem-solving scores were not significantly different (58.46 vs 57.90), confirming the equivalence of both groups before the intervention. After the treatment, the experimental group increased by a mean of 26.46 points to 84.92, while the control group increased by only 7.45 points to 65.35. The N-Gain value of the experimental group (0.64) approached the high category, while the control group (0.20) remained in the low category. This finding demonstrates that STEAM-oriented Wayground media had a substantial positive effect on students' mathematical problem-solving ability.

Analysis per Dimension of Learning Motivation (ARCS Model)

To better understand the effect on learning motivation, we analyzed each ARCS dimension.

Table 8. Mean Scores of Motivation Dimensions by Group

Dimension	Experimental Group Pretest	Control Group Posttest	Gain	Pretest	Posttest	Gain
Attention	13.12	19.85	6.73	13.08	15.20	2.12
Relevance	13.54	19.92	6.38	13.46	15.35	1.89
Confidence	13.85	19.23	5.38	13.77	15.65	1.88
Satisfaction	13.72	19.15	5.43	13.54	15.20	1.66

Table 8 shows that the experimental group experienced the highest increase in the Attention dimension (6.73 points), followed by Relevance (6.38 points). This indicates that Wayground's interactive and gamified features, combined with STEAM elements, successfully captured students' attention and made learning more relevant to their daily lives. The Confidence and Satisfaction dimensions also increased substantially (5.38 and 5.43 points, respectively), suggesting that instant feedback and leaderboard features helped build students' confidence and provided satisfaction through recognition of their achievements. In contrast, the control group showed only minimal gains across all dimensions (1.66 to 2.12 points).

Analysis per Stage of Problem-Solving (Polya's Framework)

Table 9. Mean Scores of Problem-Solving Stages by Group

Polya's Stage	Experimental Group			Control Group		
	Pretest	Posttest	Gain	Pretest	Posttest	Gain
Understanding the problem	14.62	21.92	7.30	14.50	16.40	1.90

Polya's Stage	Experimental Group			Control Group		
	Pretest	Posttest	Gain	Pretest	Posttest	Gain
Devising a plan	14.15	21.38	7.23	14.20	16.25	2.05
Carrying out the plan	15.23	21.69	6.46	15.10	16.75	1.65
Looking back	14.46	19.93	5.47	14.10	15.95	1.85

Table 9 shows that the experimental group experienced the highest increase in Understanding the problem (7.30 points) and Devising a plan (7.23 points). This indicates that Wayground's visualization features, combined with STEAM-oriented questions, helped students better understand the problems and formulate appropriate strategies. The Carrying out the plan stage also showed substantial improvement (6.46 points). However, the Looking back stage showed the lowest gain (5.47 points), suggesting that this remains the most challenging stage for elementary school students. The control group showed minimal gains across all stages (1.65 to 2.05 points).

Hypothesis Testing

Effect on Learning Motivation (H_1)

The independent t-test results for posttest learning motivation scores showed a significance value (2-tailed) of < 0.001 and a t-value of 10.662 (df = 44). Thus, H_0 was rejected, and H_1 was accepted, indicating that using STEAM-oriented Wayground media significantly affected fourth-grade students' mathematics learning motivation compared with conventional learning. The effect size was very large, with Hedges' g = 3.117 (95% CI [2.243, 3.974]).

Effect on Mathematical Problem-Solving Ability (H_2)

The independent t-test results for posttest problem-solving ability showed a significance value (2-tailed) of < 0.001 and a t-value of 12.894 (df = 44). Thus, H_0 was rejected, and H_2 was accepted, indicating that using STEAM-oriented Wayground media significantly affected fourth-grade students' mathematical problem-solving ability compared with conventional learning. The effect size was very large, with Hedges' g = 3.769 (95% CI [2.789, 4.733]).

Simultaneous Effect (H_3)

The MANOVA test results showed significance values for Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root of < 0.001, with F = 165.468 and Partial Eta Squared = 0.885, indicating a very large effect size. These results indicate that STEAM-oriented Wayground media use has a significant effect on both learning motivation and mathematical problem-solving ability in fourth-grade students.

This study found that STEAM-oriented Wayground media significantly affected elementary school students' mathematics learning motivation in the flat shapes material. The success of STEAM-oriented Wayground media in improving learning motivation and mathematical problem-solving ability cannot be separated from questions designed to explicitly integrate the five STEAM elements (Purba et al., 2022; Purnadewi & Widana, 2023).

The Science element appears in questions about kite balance that activate the Attention dimension because natural phenomena arouse students' curiosity about why one shape is more stable than another. This finding supports the importance of connecting mathematics with real-world phenomena to enhance student engagement (Bishop, 2021; Pratama et al., 2024).

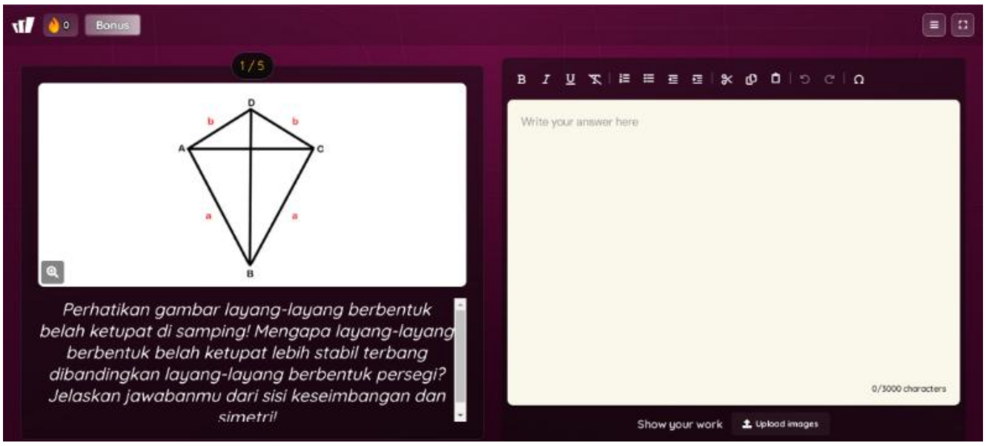

Image 1. Questions with Science (S) Content

The Technology element is manifested through Wayground's drag-and-drop and graphing tool features, which require students to navigate digitally while fulfilling the Attention dimension through interactive and engaging learning experiences (Yim et al., 2025).

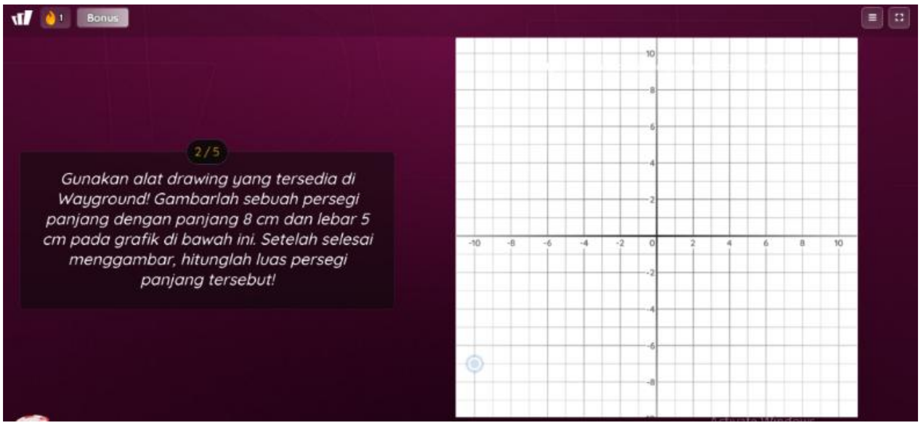

Image 2. Questions with Technology (T) Content

The Engineering element appears in chicken coop design questions that activate the Relevance dimension because students can see the direct application of perimeter and area concepts in solving real everyday problems, namely building material efficiency. This finding reinforces the importance of problem-based learning in mathematics (Herro et al., 2023).

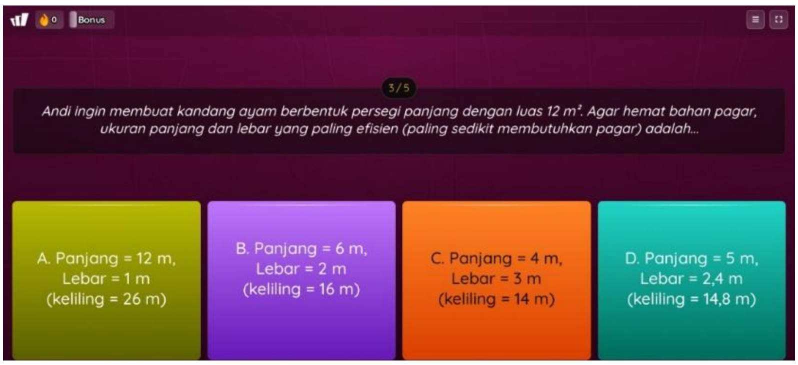

Image 3. Questions with Engineering (E) Content

The Arts element appears in questions identifying Kawung batik patterns that activate the Attention and Satisfaction dimensions, because students not only learn mathematics but also appreciate local culture and feel satisfied when they successfully identify flat shapes in traditional art motifs. This integration of local wisdom in mathematics learning is particularly relevant in the Indonesian context (Waliah et al., 2026).

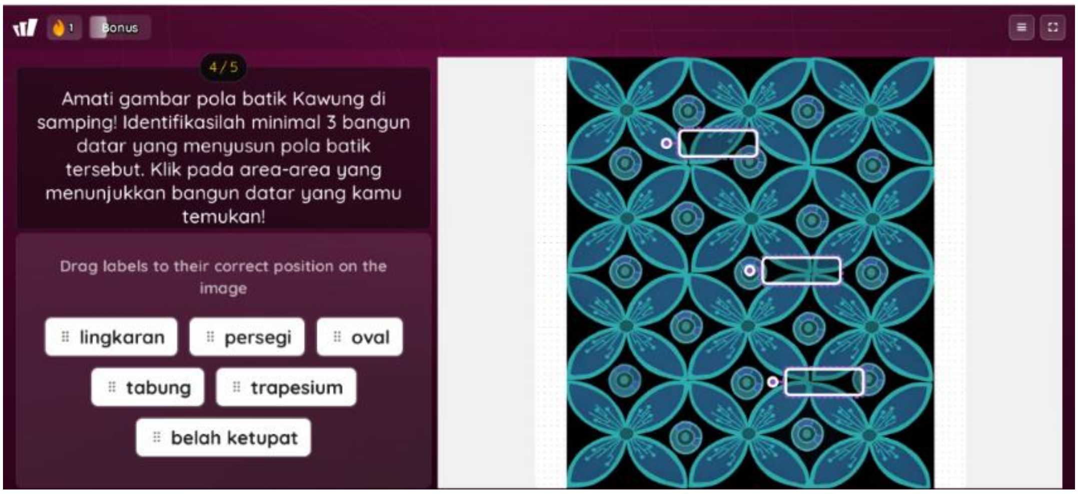

Image 4. Questions with Arts (A) Content

The Mathematics element as the core of learning appears dominantly in perimeter and area calculation questions that build students' Confidence dimension through systematic mastery of concepts. The simultaneous integration of the five STEAM elements in one Wayground platform creates a holistic learning experience not found in conventional learning, which tends to be verbal and fragmented (Afifah & Arnellis, 2025).

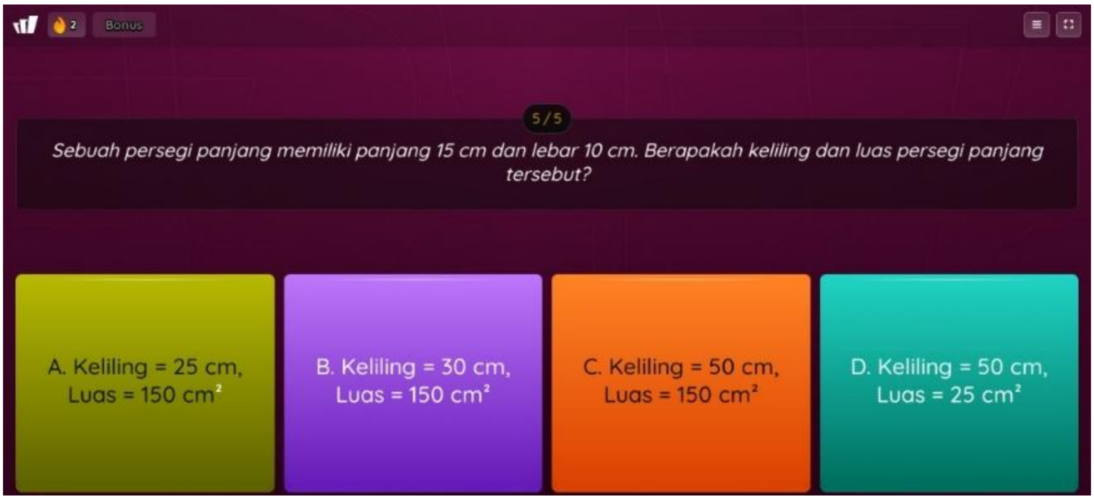

Image 5. Questions with Mathematical (M) Content

Wayground fulfills the four ARCS dimensions: attention through interactive quiz displays and avatars Paksi & Ariyanti (2020) relevance through STEAM contexts such as batik patterns and measurement; confidence through instant feedback; and satisfaction through a real-time leaderboard.

The N-Gain value for learning motivation in the experimental group (0.53; medium category) indicates that motivation increased gradually rather than instantly, requiring an adaptation process. This is natural because students in rural areas like Randulawang had never been exposed to interactive digital learning media before. However, the increase was much higher than in the control group, which achieved an N-Gain of 0.18 (low). This finding reinforces Uno & Koni (2022) argument that gamification in learning can be a catalyst for extrinsic motivation which ultimately builds students' intrinsic motivation.

This study also found that STEAM-oriented Wayground media significantly affected students' mathematical problem-solving ability. This finding is consistent with Mawaddah et al. (2021) which reported an increase in problem-solving ability from 65.19 to 88.08 after using Wayground, as well as (Afifah & Arnellis, 2025) and (Nur & Yusu, 2026). In Polya (1973) framework, the four stages of problem solving were well facilitated. The understanding stage is supported through questions with pictures and real contexts. The stage of devising a plan is supported by questions designed to progress gradually from easy to difficult. The plan-carrying-out stage is supported by answer columns and a scratchpad feature for calculations. The looking-back stage is supported by instant feedback and discussion that appears after students answer.

The experimental group's N-Gain for problem-solving ability reached 0.64, approaching the high category and far exceeding the control group (0.20). The highest increase occurred in the indicators of understanding the problem and carrying out the plan, while the indicator of looking back remains a challenge. This aligns with Fitriani (2025) and Bereczki et al. (2026), who found that the looking back stage is the most difficult for elementary school students. STEAM integration through collaborative projects makes students not only memorize formulas but also apply them in real contexts. When students design floor patterns, they naturally identify flat shapes, measure side lengths, calculate perimeter and area, and re-evaluate their design results.

The MANOVA results showing a significant simultaneous effect confirm that learning motivation and mathematical problem-solving ability do not stand alone but reinforce each other in a dynamic learning cycle. Motivated students tend to be more persistent when facing mathematical problems, and success in solving problems increases their motivation (Sanjaya, 2019). This finding reinforces constructivist theory, which states that knowledge is built through active experience and reflection (Hendriana et al., 2017). STEAM-oriented Wayground creates a positive virtual circle: Attention → Engagement → Challenge → Feedback → Confidence → Satisfaction → Higher Motivation → Better Problem Solving.

The research context in rural areas such as Randulawang also contributes. Most research on interactive digital learning media has focused on urban contexts with adequate infrastructure. This study shows that with careful planning (using live session mode to save bandwidth, keeping quizzes light, and preparing printed worksheets as a backup), digital media such as Wayground can be implemented effectively in areas with limited resources. This aligns with the spirit of the Merdeka Curriculum, which encourages inclusive, technology-based pedagogical transformation (Kemendikbudristek, 2023), and reflects the broader need for educational technology accessible to all students regardless of geographic location (Suryani et al., 2022).

Limitations of the Study

This study has limitations, including a small sample size (46 students), a short treatment duration (four weeks), no comparison with other platforms (Kahoot!, Quizizz), and a limited scope to flat shapes, which may restrict generalizability.

Conclusion

Based on the results and discussion, the use of STEAM-oriented Wayground media significantly improves both mathematics learning motivation and mathematical problem-solving ability in fourth-grade students on flat shapes material compared to conventional learning, with moderate to high improvements and very large effect sizes. Simultaneously, STEAM-oriented Wayground media has a significant combined effect on both dependent variables. STEAM-oriented Wayground media is recommended as an effective, adaptable innovation for elementary mathematics instruction, particularly in resource-limited settings. Future research should expand the sample to more schools with diverse characteristics, extend the treatment duration to measure long-term effects, compare Wayground with other gamification platforms, and test its effectiveness on other mathematics topics such as fractions, integers, or measurement.

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