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Development of the MOGETRA (Transformation Geometry Monopoly) Game to Foster Mathematical Problem-Solving Skills

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Abstract

Mathematical problem-solving skills are among the essential competencies that students need to develop in mathematics learning. However, classroom instruction remains dominated by teacher-centered approaches and limited use of interactive learning media, particularly in learning geometry transformations. This study was conducted to develop MOGETRA (Monopoly Geometry Transformation) as a Game-Based Learning medium intended to support the development of students' mathematical problem-solving skills. The study adopted a Research and Development (R&D) approach based on the ADDIE model, which comprises five sequential stages: Analysis, Design, Development, Implementation, and Evaluation. The developed media were validated by nine experts comprising three mathematics education lecturers and six junior high school mathematics teachers. A limited implementation was conducted involving 32 ninth-grade students of SMP Negeri 7 Pekalongan. Data were collected through observation, expert validation questionnaires, and student response questionnaires. Media validity was analyzed using Aiken's V Index, whereas practicality was analyzed using descriptive percentage analysis. The results showed that the developed media achieved Aiken's V values of 0.815 for media validity and 0.827 for content validity, indicating that the media were valid. In addition, the practicality score reached 77.9%, categorized as practical. The developed media integrate mathematical problem-solving indicators based on Polya's theory into Game-Based Learning activities, thereby providing meaningful learning experiences that theoretically support the development of students' mathematical problem-solving skills. Therefore, MOGETRA is feasible to be used as an innovative instructional medium for teaching geometry transformations in junior high schools.

Keywords: Game-Based Learning; Geometry Transformation; Mathematical Problem-Solving Skills; Monopoly Game; Learning Media

1. Introduction

The rapid development of digital technology has brought significant changes to the world of education, including the increasing use of Artificial Intelligence (AI) as a learning resource. AI offers students various conveniences in accessing information and quickly solving academic problems. However, the imprudent use of AI has the potential to limit students' opportunities to develop their mathematical skills, particularly their ability to solve mathematical problems. In fact, these skills are among the key competencies required in the 21st century and are a central focus of the implementation of the Merdeka Curriculum through a deep learning approach, as stipulated in Ministry of Education and Culture Regulation No. 13 of 2025. This approach positions students as active learners capable of deeply understanding concepts and applying them in various situations (Samsiah et al., 2026). The need for critical thinking and problem-solving skills aligns with the implementation of the Merdeka Curriculum, which emphasizes that mathematical problem-solving skills are one of the essential competencies that need to be developed in mathematics education. This is consistent with research indicating that problem-solving is at the core of mathematical activities, as it serves as a means for students to build conceptual understanding, develop reasoning, and apply knowledge to new situations (Santos-Trigo, 2024). Therefore, mathematics education should emphasize not only students' mastery of mathematical concepts but also the development of their mathematical problem-solving skills to equip them for real-life challenges and rapid technological advancement.

Mathematical problem-solving ability is defined as a student's ability to solve non-routine problems related to mathematics logically, carefully, critically, and systematically by following the appropriate steps for solving them (Meilani & Meiliasari, 2025). According to Polya's theory of problem-solving, students' mathematical problem-solving skills can be considered good if they are able to meet four key indicators: understanding the problem, devising a plan, carrying out the plan, and reviewing the results obtained (Pangestu et al., 2024). These four stages demonstrate that success in solving a math problem is determined not only by the final answer but also by the quality of the students' thought processes as they work through the problem. Therefore, mathematical problem-solving skills are a key indicator of success in math education.

However, various research findings indicate that the mathematical problem-solving skills of students in Indonesia remain relatively low. The results of the Minimum Competency Assessment (AKM) show that the majority of students still struggle to solve problems that involve mathematical reasoning and systematic problem-solving. These findings are consistent with research Fauziah et al., (2024), Students' mathematical problem-solving skills in solving AKM numeracy questions fall into the low category across nearly all problem-solving indicators. This situation indicates that students still struggle to understand the information in the questions, determine solution strategies, carry out the solution systematically, and check their answers (Salwa et al., 2025). Furthermore, the obstacles students face stem from a lack of precision in interpreting the content of the questions, causing them to struggle with modeling problems mathematically and selecting the appropriate solution concepts (Fachis et al., 2020). This situation indicates the need for instructional interventions that can develop and foster students' problem-solving skills more effectively.

The low level of mathematical problem-solving skills is influenced by the use of AI as a source of instant solutions. Students' low mathematical problem-solving skills can be attributed to various contributing factors. However, another factor contributing to this issue is often the use of learning models that are ineffective in developing students' critical thinking skills and creativity. (Suryono & Tia Purniati, 2025), as well as the limited use of teaching materials capable of actively engaging students. Based on observations conducted at Pekalongan State Junior High School 7, the teaching of geometric transformations still takes place in a conventional manner, relying primarily on textbooks and the teacher's explanations as the main learning resources. This situation causes some students to struggle with understanding the concepts of geometric transformations, to be less active during the learning process, and to become easily bored because the learning activities are monotonous. The results of the needs assessment survey also indicate that the majority of students prefer mathematics instruction that is integrated with play-based activities so that the learning process becomes more engaging and enjoyable.

Game-Based Learning (GBL) is one educational approach considered capable of addressing these needs. This approach integrates game elements into the learning process so that students gain a more meaningful learning experience through challenging, collaborative, and interactive activities. Game-Based Learning positions students as active participants who are involved in exploration, decision-making, and solving various challenges throughout the learning process, thereby enhancing student engagement and the quality of their mathematics learning experience. (Hidayat et al., 2024). In addition to increasing student engagement, various studies have also shown that the implementation of game-based learning in mathematics education can support the development of higher-order thinking skills, including mathematical problem-solving skills (Pravitasari & Apriza, 2026). Theoretically, the characteristics of Game-Based Learning align with the constructivist approach, which emphasizes that knowledge is actively constructed through learning experiences and interactions with the environment. In game-based learning, students have the opportunity to explore various strategies, discuss with their peers, evaluate solutions, and reflect on the results they achieve, thereby making learning more meaningful (Usman et al., 2026).

These conditions indicate the need for relevant solutions to help develop students' mathematical problem-solving skills. One such solution is to integrate learning with the use of interactive learning media as an innovative approach. According to Baun & Bansoma (2025), the use of innovative learning media can increase students' motivation and enthusiasm during the learning process. Mathematics games are learning activities that combine elements of play with mathematical content to increase students' interest and engagement in learning (Nursafitri et al., 2023). According to Widiastita dan Anhusadar (2020), games are a fun way to learn because students can gain learning experiences indirectly through play, making the material easier to remember.

Among the types of educational games, Monopoly has characteristics that support the development of mathematical problem-solving skills. This game requires players to think strategically, make decisions based on the situation at hand, predict the consequences of each action, and interact with other players throughout the game. Additionally, the mechanics of Monopoly allow for the incorporation of various contextual problems that must be solved before players can earn certain privileges in the game. Thus, playing the game serves not only as entertainment but also as a tool capable of facilitating a gradual and meaningful mathematical thinking process. The use of this game creates a more engaging learning environment by integrating play with learning activities (Hermawati & Lestari, 2024). Furthermore, game-based media can enhance students' motivation and interest in participating in learning (Sari et al., 2022). Through play-based activities, students are also encouraged to actively engage in the learning process. These activities can foster collaboration, strategic thinking, and problem-solving skills. Consequently, learning becomes more enjoyable and meaningful for students.

Based on these characteristics, the MOGETRA (Geometric Transformations Monopoly) game was developed as a Game-Based Learning tool for teaching geometric transformations. Unlike traditional Monopoly games, MOGETRA is designed to integrate geometric transformation problems structured according to Polya's indicators of mathematical problem-solving skills. Each property card not only contains a problem to be solved but is also designed to guide students through

the stages of understanding the problem, determining a solution strategy, implementing that strategy, and reviewing the results obtained before continuing the game. Thus, the game mechanism developed is not only oriented toward achieving the game's
objectives but is also designed to facilitate the development of students' mathematical problem-solving skills during the learning process.

Several previous studies have developed Monopoly-based learning media for various mathematics topics and demonstrated that such media are suitable for use in the learning process. Research conducted by Listiana et al. (2022) successfully developed a Monopoly game for probability topics that met the criteria for being highly valid and practical as a learning medium. Furthermore, Kholishoh dan Utami (2025) developed the MONEKA (Monopoly of Exponential Areas) medium for exponential topics, focusing on fostering conceptual understanding and yielding valid and practical results. Meanwhile, Subhan et al. (2025) developed a geometry-based Monopoly game using Realistic Mathematics Education (RME) for the topic of flat-sided three-dimensional shapes and demonstrated that the developed game is valid, practical, and effective in improving mathematical problem-solving skills.

Despite this, these three studies still differ in their characteristics from the present study. The study by Listiana et al. (2022) focused on probability, whereas Kholishoh dan Utami (2025) developed a Monopoly-based learning tool to foster conceptual understanding in exponential topics. On the other hand, the study by Subhan et al. (2025 did examine mathematical problem-solving skills; however, the developed media were integrated with the Realistic Mathematics Education approach on the topic of flat-sided three-dimensional shapes and emphasized testing effectiveness through a quasi-experimental design. To date, research developing a Monopoly-style game medium for geometric transformation topics which integrates Polya's indicators of mathematical problem-solving skills into every component of the game through a Game-Based Learning approach remains very limited. Therefore, this research gap serves as the basis for the development of MOGETRA (Geometric Transformation Monopoly) as a learning medium designed to facilitate the development of students' mathematical problem-solving skills.

Based on this description, this study aims to develop the MOGETRA (Geometric Transformation Monopoly) game-based learning medium, designed based on indicators of mathematical problem-solving skills in geometric transformation topics, and to assess its validity and practicality as a mathematics learning medium. The developed medium is expected to serve as an innovative learning alternative that supports the implementation of Game-Based Learning while facilitating the development of students' mathematical problem-solving skills through active, interactive, and meaningful learning activities.

2. Methods

This study employed the Research and Development (R&D) method using the ADDIE model. This model consists of five phases: Analysis, Design, Development, Implementation, and Evaluation (Prasetyo, 2023). The ADDIE model was chosen because it provides a systematic framework for developing educational products, beginning with needs analysis and concluding with product evaluation and revision. Through these sequential stages, the resulting instructional media are expected to meet the criteria for validity and practicality before being implemented in classroom instruction.

The study was conducted at SMP Negeri 7 Pekalongan. The research subjects included 32 ninth-grade students in Class IX-A who were taking mathematics classes. Meanwhile, the product validation process involved nine validators, consisting of three mathematics education faculty members and six junior high school mathematics teachers. The faculty members were selected based on their expertise in mathematics education and instructional media development, while the teachers were chosen for their teaching experience and familiarity with the ninth-grade geometry transformation curriculum. The involvement of academics and practitioners was intended to obtain a comprehensive evaluation of the suitability of the developed media from both theoretical and practical perspectives.

The development procedure followed the five stages of the ADDIE model. During the analysis stage, classroom observations and needs assessments were conducted to identify students' learning difficulties, classroom conditions, and the availability of instructional media for teaching geometric transformations. The findings indicated that mathematics instruction remains largely teacher-centered, students struggle with solving geometric transformation problems, and both teachers and students expressed a need for interactive learning media. These findings served as the basis for designing the MOGETRA learning media.

During the design phase, a storyboard for the MOGETRA game was developed, including a game board, territory cards, chance cards, community chest cards, play money, game rules, and a user manual. At this stage, the math problems embedded in the territory cards were also designed based on Polya's four stages of mathematical problem-solving: understanding the problem, devising a plan, executing the plan, and reviewing the solution. In addition, research instruments were prepared, including observation sheets, media expert validation questionnaires, content expert validation questionnaires, and student feedback questionnaires. During the development stage, the storyboard was transformed into a complete educational medium using the Canva application. The prototype was then evaluated by expert validators to assess the validity of the content and the quality of the medium. The suggestions provided by the validators were used as the basis for revising the product before its implementation in the classroom.

The implementation phase involved the limited use of the revised MOGETRA media in a classroom with 32 students. Learning activities were conducted using a modified Game-Based Learning approach, in which students learned geometric transformations while playing the MOGETRA game in small groups. After the learning activities were completed, students filled out a feedback questionnaire to evaluate the practicality of the developed media. Finally, the evaluation phase was conducted by analyzing the results of the expert validation and student feedback. Findings from both evaluations were used to determine the feasibility of the developed media and to identify aspects requiring further improvement before wider implementation.

2.1. Data Collection

Two data collection techniques were used: observation and questionnaires. Structured observations were conducted during the analysis phase using observation sheets to identify classroom learning conditions, student learning characteristics, learning barriers, and the availability of learning media. The observation results were supplemented by a needs assessment questionnaire distributed to students and teachers to identify their expectations regarding mathematics learning media. The questionnaire consisted of a media expert validation questionnaire, a subject matter expert questionnaire, and a student response questionnaire. The media expert validation instrument evaluated visual presentation, media quality, and technical aspects of the media. The subject matter expert validation instrument evaluates the appropriateness of the content, the learning process, the problem-solving process, and the language used. Meanwhile, the student response questionnaire measures students' perceptions of appeal, ease of use, clarity of instructions, and language. All questionnaires use a four-point Likert scale to avoid neutral responses and encourage respondents to provide more definitive evaluations.

2.2. Data Analysis

The validity of the MOGETRA instrument was analyzed using the Aiken V-Index, which is commonly used to evaluate content validity based on expert ratings. The developed instrument was considered valid when the Aiken V-coefficient exceeded 0.74, based on the critical value for nine validators using a four-point rating scale with a 5% significance level (Aiken, 1985). The questionnaire was designed using a Likert scale with the response options shown in Table 1 below (Wati & Mulyaningtyas, 2025).

Table 1.
Media Monopoly Assessment Criteria

Scoring Criteria	Score
Highly Relevant	4
Relevant	3
Medium Relevant	2
Less Relevant	1

Media validity is calculated using the Aiken V Index formula, as follows (Aiken, 1985):

$$V = \frac{\sum s}{n(c-1)}$$

The practicality of the media was analyzed using descriptive percentage analysis based on students' questionnaire responses. The analysis procedure followed was as follows. First, the total scores obtained for each statement item on the questionnaire were summed. Second, the percentage of the scores was calculated using the following formula; the interpretation can be seen in Table 2 below (Siregar et al., 2023).

$$P = \frac{TS_e}{TS_h} \times 100\%$$

Description:

P = the percentage being calculatedi

TS_e = the student's total score

$\sum x\, i$ = the expected total score

Table 2.
Interpretation of the Practicality of Media Monopoly

Percentage (%)	Interpretation
85,01 – 100,00	Highly Practical
70,01 – 85,00	Practical
50,01 – 70,00	Rather Practical
01,00 – 50,00	Less Practical

Source: Adapted from Akbar, 2013 in (Siregar et al., 2023)

Because this study focused on developing educational media, the evaluation emphasized product validity and practicality. The implementation stage was intended to obtain initial user responses and identify aspects requiring refinement prior to broader application. Consequently, this study does not claim the effectiveness of the media in improving students' mathematical problem-solving ability; rather, it demonstrates that the media were systematically designed based on mathematical problem-solving indicators and met the criteria for feasibility as an instructional medium.

3. Result and Discussion

3.1. Analysis Stage

During the analysis phase, classroom observations were conducted and needs assessment questionnaires were distributed to teachers and students to identify the state of mathematics instruction on the topic of geometric transformations. The results of the observations showed that the learning process was still dominated by lecture-based methods and problem-solving exercises using textbooks, while the use of interactive learning media remained very limited. These conditions caused students to tend to be passive during lessons and to experience difficulties when faced with problems requiring reasoning or step-by-step problem-solving.

In addition, the results of the needs analysis showed that the majority of students wanted learning media capable of creating a more engaging, interactive, and less monotonous learning environment. Teachers also noted that geometric transformations are a topic that students find particularly difficult to grasp because it requires visualization skills and spatial reasoning. These findings formed the basis for the development of the MOGETRA game as an alternative Game-Based Learning tool, which is expected to increase student engagement during the learning process.

3.2. Design Stage

Based on the results of the needs analysis, the MOGETRA game was designed by adapting the mechanics of Monopoly to the teaching of geometric transformations. The designed product includes a game board, property cards, chance cards, community chest cards, game money, game pieces, dice, house tokens, and a game manual. All components are designed to be fully integrated so that students can learn while playing in a fun atmosphere. Unlike traditional Monopoly games, the property cards in MOGETRA not only contain information about property ownership but also include geometry transformation problems that students must solve before earning the right to purchase a property. Thus, solving math problems becomes a central part of the game's mechanics.

The design of the region cards is the key feature that distinguishes MOGETRA from other math-based Monopoly games. The problems on the region cards are structured based on Polya's indicators of mathematical problem-solving skills. This means that students are not only asked to determine the final answer but are also guided to understand the given information, determine a solution strategy, implement that strategy, and verify the results obtained. With this design, every game activity has been conceptually designed to facilitate the development of mathematical problem-solving skills. In addition to integrating Polya's indicators, the game mechanics also apply the principles of Game-Based Learning through the provision of challenges, clear game objectives, competition among players, and immediate feedback on students' answers. When students successfully solve a problem, they earn the opportunity to purchase a region or gain an advantage in the game. Conversely, if their answer is incorrect, students lose that opportunity. This mechanism gives mathematical problem-solving tangible consequences within the game, thereby enhancing students' motivation to learn and their engagement.

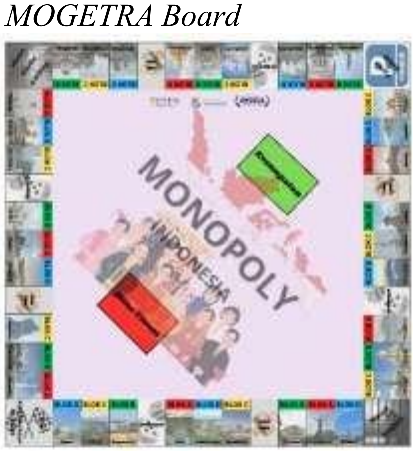
3.3. Development Stage

The development phase began with transforming the entire design based on the storyboard into a tangible product. The learning materials were created using the Canva app and designed to be as engaging as possible with an "Indonesian Landmarks" theme, including the MOGETRA (Transformation Geometry Monopoly) board, territory cards, chance cards, community chest cards, play money, and a user manual.

3.3.1. MOGETRA Board (Monopoli Geometri Transformasi)

The MOGETRA (Geometric Transformation Monopoly) board is square, measuring 45 cm × 45 cm. It consists of 44 spaces, including 36 region spaces, 4 chance spaces, 4 community chest spaces, and 4 corner spaces (start space, free parking space, go to jail space, and pass through jail space). The MOGETRA board is printed on thick photo paper and packaged in a specially designed folder to preserve the quality of the material. The game board design can be seen in Figure 3.

Figure 3
MOGETRA Board



3.3.2. Regional Card, Chance Card, and Finance Card

The regional cards, chance cards, and general fund cards have different contents. The regional cards are rectangular, measuring 8.5 cm × 7 cm, and consist of 36 cards; each regional card features a different region's name. Each regional card contains a question on geometric transformations (translation, reflection, rotation, and dilation), along with housing rent prices and conditional toll-free rates. The region cards are divided into four colors, each representing a different block (region). Block A is represented by red cards, Block B by green cards, Block C by yellow cards, and Block D by blue cards (Figure 4). Chance cards consist of 20 cards, including "Get Out of Jail Free" cards, "Go to Jail Free" cards, financial bonus cards, and social interaction cards (Figure 5). Finance cards consist of 20 cards containing instructions to receive money from the bank or pay a certain amount to the bank (Figure 6). Chance and finance cards are the same size: 5.5 cm × 7.5 cm.

Figure 4
Regional cards

Figure 5
Chance cards,

Figure 6
Finance card

3.3.3. **The Play Money**

Figure 7
The Play Money

3.3.4. The Guidebook

The guidebook contains explanations of the game instructions, game rules, answer keys for the questions on the regional cards, and guidelines for determining the game's winner. The guidebook is printed in A5 size and consists of 29 pages, including: (1) the cover page; (2) the foreword; (3) the table of contents; (4) the introduction, which includes: (a) What is MOGETRA?; (b) learning objectives; (c) MOGETRA media components; (5) instructions for use, including: (a) game preparation; (b) game mechanics; (c) game rules; (6) answer keys; (7) assessment and evaluation, including: (a) criteria for determining the winner; (b) evaluation; (8) student worksheets; and (9) conclusion. The design of the guidebook can be seen in Figure 8.

Figure 8
The Guidebook

The design was developed with careful consideration of Polya's indicators of mathematical problem-solving used in this study, such as the indicator of understanding the problem, the indicator of planning the solution, the indicator of carrying out the solution correctly, and the indicator of checking the results of each step in the solution process. This can be seen through the activity cards, which provide contextual questions to develop students' mathematical problem-solving skills regarding geometric transformations.

Once the teaching media were developed, the next stage of the development process involved validation by nine experts to assess the media's suitability. The validation was conducted from both the media and content perspectives.

1.) Media validation

The media validation panel consisted of 9 media experts, including 3 mathematics professors and 6 mathematics teachers. The results of the media validation test are shown in Table 3.

Table 3.
The Media Validation Results

Butir	Penilai									S1	S2	S3	S4	S5	S6	S7	S8	S9	∑s	n(c-1)	V
	I	II	III	IV	V	VI	VII	VIII	IX												
Butir 1-9	35	27	32	31	26	31	36	32	29	26	18	23	22	17	22	27	23	20	198	243000	0,815

Based on the data above, the media validation results yielded an Aiken-V Index value of 0.815. This score exceeds the minimum score of 0.74; therefore, the product can be deemed media-valid.

2.) Material validation

The content validation panel consisted of 9 subject matter experts, including 3 mathematics professors and 6 mathematics teachers. The results of the content validation test are shown in Table 4.

Table 4.

The Material Validation Results

Butir	Penilai									S1	S2	S3	S4	S5	S6	S7	S8	S9	∑s	n(c-1)	V
	I	II	III	IV	V	VI	VII	VIII	IX												
Butir 1-9	56	45	53	54	49	51	53	59	53	38	30	38	39	34	36	38	44	38	335	405000	0,827

Based on the data above, the material validation results yielded an Aiken-V Index value of 0.827. This score exceeds the minimum score of 0.74; therefore, the product can be deemed materially valid.

Based on the results of the media validation and overall content validation, it can be concluded that the MOGETRA (Transformation Geometry Monopoly) media meets the validity criteria. However, during the validation stage, experts offered several suggestions regarding the content listed on the region cards, such as omitting the names of the transformations listed on the cards and using simple yet progressive question types aligned with mathematical problem-solving ability indicators, so that students can gradually develop their mathematical problem-solving skills each time they play the game. After the validation results were obtained, the researcher made initial revisions based on the suggestions received from the experts during the validation process before conducting the pilot test. The initial revisions to improve the problems can be seen in Figure 9 and Figure 10.

Figure 9

Regional Card Before the Revision

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Figure 10
Regional Card After the Revision

3.4. Implementation Stage

The study was conducted in Class IX-A at Pekalongan State Junior High School 7. The research subjects consisted of 32 students, and the study employed a Game-Based Learning approach. During the lesson, students worked in small groups, following predetermined game rules. The lesson was conducted using a modified game-based learning model. After the lesson concluded, the researcher distributed a media feasibility questionnaire for students to complete as part of the practical test evaluation. The following are the results of the practical media test conducted by the students:

Table 5.
Student Response Survey Results

Aspeck	Percentage Score	Intepretation
Student Interest	77,9%	Practical
Content	77,7%	Practical
Language	79,2%	Practical

Based on the data above, the results of the practical test from the response questionnaire completed by 32 students as respondents yielded an overall average score of 78.3%, with a score of 77.9% for student interest, 77.7% for content, and 79.2% for language aspects. These percentage scores fall within the range of 70.01% ≤ P ≤ 85.00%, which, based on practical interpretation, indicates that the product can be deemed practical.

During the implementation of the MOGETRA (Geometric Transformation Monopoly) medium in geometric transformation instruction, student responses began with a high level of curiosity. Students were very enthusiastic about learning mathematics using the MOGETRA (Geometric Transformation Monopoly) medium. The high practicality percentage indicates that students responded positively to the use of MOGETRA in geometric transformation instruction. Students found the game easy to understand, engaging, and capable of creating a fun learning atmosphere. This indicates that the game's mechanics successfully increased student engagement during the learning process. This is evidenced by the results showing that student interest reached 77.9%, which falls under the "practical" interpretation. During the learning process, the game fostered a high level of competitiveness and good collaboration among players, resulting in students' enthusiasm for learning exceeding that of a typical day. As noted in the study by Subhan et al. (2025), a more enjoyable learning atmosphere created through the use of the Monopoly game can help students feel more comfortable learning mathematics, thereby reducing learning anxiety and increasing motivation to learn. These positive responses can also be explained by the characteristics of Game-Based Learning. In the game, students not only interact with the medium but also discuss, exchange strategies, justify their chosen answers, and evaluate solutions together with their group members. These activities provide students with opportunities to actively construct knowledge, making the learning process more meaningful compared to teacher-centered instruction.

3.5. Evaluation Stage

The final evaluation phase was conducted after a limited pilot test as a means of refining the product based on feedback provided by the students. Although the survey results indicated that MOGETRA was rated as "practical," the students still offered several constructive suggestions to improve the quality of the learning material. The most common feedback concerned the size of the game money, which was considered too small and therefore uncomfortable to use during gameplay. In addition, some students also suggested that the color combinations on the MOGETRA board be made more contrasting so that each game square would be easier to distinguish and the game would look more appealing.

Based on this feedback, the researcher made a final revision to the product by enlarging the size of the game money to make it easier for students to hold and use during the learning process—increasing it from 4 cm × 1.7 cm to 10 cm × 5 cm. The researcher also made adjustments to the visual design of the MOGETRA board by emphasizing the colors of each game square to improve the medium's readability and appeal. These revisions were made without altering the substance of the material or the game mechanics, ensuring that MOGETRA's function as a Game-Based Learning medium designed to facilitate mathematical problem-solving skills remains intact, while offering improved visual quality and ease of use. Examples of the final revisions to refine the media's design can be seen in Figure 11 and Figure 12.

Figure 11
MOGETRA Board Before the Revision

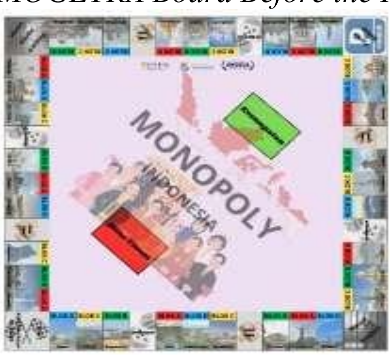

Figure 12
MOGETRA Board After the Revision

3.6. MOGETRA in Fostering Mathematical Problem-Solving Skills

Although this study did not evaluate the effectiveness of MOGETRA through an experimental design, the developed media was intentionally designed to facilitate students' mathematical problem-solving skills. This design is reflected in the structure of the region cards, the game rules, and the learning activities, all of which were developed based on Polya's four stages of mathematical problem solving. Each region card requires students to identify the known and unknown information before determining an appropriate solution strategy. Students are then expected to implement the chosen strategy and verify the correctness of their answers before gaining an advantage in the game. As a result, the game does not merely assess the final answer but also encourages students to experience the complete problem-solving process. The following is an explanation of the integration of mathematical problem-solving indicators into the MOGETRA region card activities, as presented in Table 6.

Table 6.
Integration of Polya's Mathematical Problem-Solving Indicators into MOGETRA Region Card Activities

MOGETRA Component	Student Activity	Polya Indicator	Expected Learning Outcome	Problem-Solving Indicator
Region Card	Solve transformation problems	Understanding	Identify known and unknown information	Understanding the problem
Region Card	Choose solution strategy	Planning	Determine appropriate mathematical method	Devising a plan
Region Card	Perform calculations	Carrying Out	Apply transformation concepts correctly	Carrying out the plan
Region Card	Check answers	Looking Back	Evaluate and reflect on the obtained solution	Looking back

Furthermore, the Game-Based Learning approach strengthens this process by providing meaningful learning experiences. Through challenges, competition, collaboration, and immediate feedback, students become actively involved in mathematical reasoning rather than passively receiving information. Group discussions occurring during the game also encourage students to explain their reasoning, compare alternative solution strategies, and reflect on the correctness of their answers. These learning activities are consistent with constructivist theory, which emphasizes that knowledge is actively constructed through interaction and experience. Therefore, although this research focused on examining the validity and practicality of the developed media, the design characteristics of MOGETRA indicate that it has the potential to foster students' mathematical problem-solving skills. Future studies are recommended to investigate this potential through experimental research involving pretest-posttest designs or other effectiveness measures.

4. Conclusion

This study successfully developed MOGETRA (Geometric Transformation Monopoly) as a game-based learning tool for teaching geometric transformations in junior high school. The development process followed the ADDIE model, including the analysis, design, development, implementation, and evaluation phases. Throughout the development process, the tool was systematically designed by integrating mathematical problem-solving indicators based on Polya's theory into the game components, particularly the territory cards and game mechanics. Validation results showed that MOGETRA met the criteria for a valid learning tool, with an Aiken V coefficient of 0.815 for tool validity and 0.827 for content validity, both of which were categorized as valid. Furthermore, implementation results show that students responded positively to the developed learning material, with an average practicality score of 78.3%, indicating that MOGETRA is practical for use in the classroom.

In contrast to conventional Monopoly games, MOGETRA was specifically designed to facilitate students' engagement in all stages of mathematical problem solving. The game encourages students to understand the given problem, formulate suitable solution strategies, execute those strategies systematically, and reflect on the accuracy of the obtained solutions. Combined with the characteristics of Game-Based Learning such as active participation, collaboration, competition, and immediate feedback—these design features provide a meaningful learning experience that theoretically supports the development of students' mathematical problem-solving skills. Therefore, MOGETRA can be recommended as an alternative learning medium for teaching geometric transformations in junior high school. Although this study focused on establishing the validity and practicality of the developed medium, further research is recommended to test its effectiveness in improving students' mathematical problem-solving skills through experimental or quasi-experimental research designs.

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