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Development of a Desmos-Assisted Flipbook E-Module to Improve Mathematical Problem-Solving Ability

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ABSTRACT

The ability to solve problems in mathematics is an essential competency that every student must have because in fact, this ability is still low. Many students still find it difficult when they have to solve story-based problems, especially on the topic of geometric transformations. The limited teaching materials that support learning also become an obstacle, because the available media are not interactive or interesting enough to facilitate students' understanding of the material. Based on these problems, this research is focused on the development of a Project Based Learning (PjBL)-based flipbook e-module designed to improve mathematical problem-solving skills on geometric transformations. The type of research used is research and development (R&D) by applying the ADDIE model as a reference for product development. The research subjects were 26 students of grade IX A of SMP Negeri 1 Hantara. Data were collected using questionnaires, interviews, and tests. The assessment results from three material experts obtained a feasibility percentage of 87% while from two media experts 81% were categorized as very valid. The results of the practicality test using a questionnaire obtained a percentage of 97% from teachers and 95% from students (very practical). Effectiveness is shown through N-Gain of 0.71 with a high category because it is in the range of N-Gain> 0.70 from an average pre-test of 24.31 and post-test of 75.95. This e-module is proven to have a good level of validity, practicality, and effectiveness in helping improve students' mathematical problem-solving abilities. Further research is expected to be able to expand the scope of subjects and emphasize other indicators of mathematical problem-solving abilities in media development.

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Introduction

Mathematical problem-solving ability (PMA) is an essential skill that every student should possess. According to Astutiani et al. (2019), this ability reflects how well students can apply their understanding to address emerging problems. However, studies show that most students have low proficiency (Hermawati et al., 2021). This is due to, among other factors, inappropriate learning strategies, rote memorization habits, and a weak understanding of mathematical concepts (Selvia et al., 2019). Mathematics is not only an important subject in education but also plays a significant role in everyday life. Besides being the foundation for the development of science and technology, learning mathematics also helps students hone logical, critical, creative, and organized thinking (Ulfa, 2019). However, the fact is that most students still view mathematics as a complex and non-abstract subject, which then impacts low learning outcomes (Agustina & Lestari, 2020). Yet, in the 21st century, mathematics learning is required to develop the 4C skills, especially in problem-solving (Gravemeijer et al., 2017; Prayogi, 2020).

Students' abilities in this area still show various obstacles. Survey results showed that approximately 93% experienced difficulty in solving problems, while another 81% admitted to not liking mathematics. One reason is that students are not accustomed to following the problem-solving stages sequentially according to the steps proposed by Polya (1973), starting from understanding the problem, designing a strategy, implementing the plan, and re-evaluating the answers obtained. However, introducing Polya's strategy can help students work on problems in a more focused manner (Daulay & Ruhaimah, 2019).

This ability can also be improved through familiarization with problems designed based on everyday experiences to facilitate understanding of concepts (Muliyana et al., 2024), as emphasized in the independent curriculum that problem-solving is the primary goal of mathematics learning (Harefa & La'ia, 2021). However, in reality, teachers still predominantly use the lecture method, resulting in low student participation (Kamran et al., 2022), and difficulties become more apparent when students learn abstract geometric transformation material that is closely related to everyday life (Laia, 2023).

This difficulty is even more apparent in geometric transformations. This material is often taught through abstract, routine exercises, resulting in students often following the steps mechanically without truly grasping the underlying concepts. Analysis of students' answers to geometric transformations also shows numerous conceptual and procedural errors, indicating their weak ability to connect concepts to real-world applications. Yet, geometric transformations are closely related to everyday life, for example, in the movement of clock hands, mirror images, and even graphic design. Furthermore, supporting learning factors, such as the availability of interactive teaching materials, are also still limited.

The teaching materials used by teachers are generally static, such as PDF modules or printed worksheets, which are less engaging and don't fully support students in systematic problem-solving. This leads to low student motivation, low participation, and suboptimal learning outcomes (Maulani & Zanthy, 2020). Therefore, innovative learning materials are needed that can provide a more interactive, enjoyable, and contextual learning experience. One alternative is the e-module flipbook, which allows for digital presentation of materials in an attractive, easily accessible manner, and can be equipped with interactive features.

The integration of flipbook e-modules with the Project-Based Learning (PjBL) model is considered relevant for addressing student difficulties. Through a project-based approach, students not only learn to understand abstract concepts but also relate them to real-life situations in the form of contextual projects (Fitriani & Indriaturrahmi, 2020). Flipbooks in a learning context can facilitate teacher-student interaction (Prayitno et al, 2022; Syafari et al, 2021), while

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Project-Based Learning (PjBL) can engage students in collaborative, real-world projects to hone mathematical problem-solving skills (Fisher et al, 2021; Laia, 2023). Previous research has also shown that integrating digital media such as Desmos with Project-Based Learning (PjBL) can significantly improve students' mathematical literacy, analytical skills, and problem-solving compared to conventional methods (Chechan et al., 2023; George et al., 2023; Nuri et al., 2023). Referring to Polya's (1973) problem-solving stages, the development of e-modules is expected to become an alternative digital teaching material.

Several previous studies have developed e-modules to support mathematics learning, but most are still static, such as PDFs, making them less interactive and engaging for students. Furthermore, the use of learning models in previous studies has focused more on conventional approaches or Problem-Based Learning (PBL), while the application of PjBL in the development of digital e-modules is still limited. In terms of material, geometric transformations are often taught through routine exercises, which tend to be abstract and difficult for students to understand. Furthermore, the large number of formulas also poses a barrier because students tend to memorize the formulas. However, this material can be linked to real-world, contextual projects to facilitate student understanding of the concepts. Furthermore, previous studies tend to emphasize improving general learning outcomes, while studies specifically developing teaching materials to improve KPMM are still rare. Thus, there is a research gap in combining PjBL-based flipbooks with Desmos to improve KPMM for junior high school students, which has not been widely studied in geometric transformations. The research was conducted with the aim of developing a PjBL-based flipbook e-module aimed at supporting students' mathematical problem-solving skills in geometric transformations.

Method

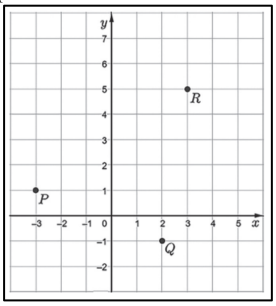
Type of Research and Subject

The research methodology used in this activity is Research and Development (R&D). This method was chosen because it provides opportunities for researchers to design, develop, and test the results of product development in education that can improve students' KPMM. The development process is carried out through five main steps: identifying needs, designing, compiling the product, implementing it in learning activities, and conducting an evaluation to assess the results and provide necessary improvements. The development process begins with the initial design stage, validation by experts, limited trials, and finally an evaluation of practicality and the results of student improvement. Specifically, we analyze the extent of students' mathematical problem-solving abilities. The subjects of this study were 26 grade IX A students of SMP Negeri 1 Hantara in the 2024/2025 academic year. The determination of research subjects was adjusted to the materials and products developed by the researchers, as well as suggestions from the grade IX mathematics teacher of SMP Negeri 1 Hantara.

Research Instrument

Our research used interview guidelines, questionnaire guidelines, e-module validation instruments, e-module practicality instruments, and test instruments. The interview questions addressed to teachers were structured in an unstructured manner with the aim of obtaining information related to several things, including the curriculum and learning models used, the type and suitability of teaching materials, the utilization and experience of teachers in using technology and e-modules, their influence on student learning interest, KPMM, and technical obstacles in implementing learning technology. A questionnaire guide was provided to teachers and students to obtain information regarding learning needs. The e-module validation instrument was provided to experts competent in materials and media to evaluate the feasibility of the e-module. The practicality instrument was intended for teachers and students after the e-module was implemented in the classroom to determine whether the e-module was practical when used and could facilitate learning activities. The test instrument, which consisted of a pre-test before and a post-test after the e-module implementation, aimed to observe the increase in KPMM. The instrument was validated by experts to ensure its suitability, clarity, and relevance to the research objectives before use, thus being deemed valid and able to be used in collecting data accurately and reliably.

Table 1. Test Instrument

No	***Pre-test***	***Post-test***	**Measured Aspects**
1	A gardener wants to relocate a triangular fish pond as shown in the figure. The pond's coordinates are shown in the figure below, with each unit being meters. The pond will be relocated by shifting its location 4 meters to the right and 3 meters upward. Draw and record the new coordinates after the pond has been moved. 	An architect is designing the layout of a city park. He has a map with coordinates for a fountain pond with vertices at A(2,1), B(5,-1), and C(4,3). To enhance the aesthetics, he wants to move the entire pond to a new position by shifting it a distance (3,-2). Determine the new position of the pond and plot the location changes.	The ability to understand and apply the concept of translation (shift) in real contexts.
2	An artist creates a symmetrical pattern with fold lines on the y-axis. The initial pattern has coordinates A(-3,2), B(5,-2), and C(4,4). Determine the coordinates of the resulting reflection of the pattern.	An interior designer wants to place a large mirror on one side of a square living room. The corner coordinates of the room are P(0,0), Q(6,0), R(6,6), and S(0,6). If the mirror is placed parallel to the y-axis, determine the image of the living room in the mirror.	The ability to understand and determine the results of reflection (mirroring) on the axis.
3	An architect draws a house design with dimensions of P(2,-3), Q(6,3), R(4,7) and S(-1,2). The architect wants to enlarge the design to twice its original size. Determine the house design after the enlargement, if the enlargement is done to the fountain directly in front of the house.	A graphic designer creates promotional posters in sizes A(1,-2), B(4,-2), C(4,5), and D(1,5). These posters will be enlarged 3 times their previous size. Determine the latest poster, if the enlargement is done on the position of the pizza doll in the image.	The ability to understand the concept of dilation (enlargement or reduction) with a certain central point.

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	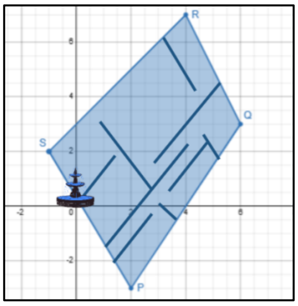		
4	A helicopter pilot rotates the flight route from coordinates A(3,2), B(6,-4), and C(5,6) by 90° counterclockwise with the center of rotation at point (0,0) due to bad weather. Determine the coordinates of the route after the rotation and draw a graph to check its accuracy.	A windmill with blade sizes A(2,0), B(4,2), and C(2,2) is rotated 90° clockwise with the rotation at point O(0,0). Determine the coordinates of the blades after rotation.	The ability to understand and apply rotation (rotation) with a certain center.

The designed test was then tested for validity and reliability. Based on data analysis techniques, a question is considered valid if $\boldsymbol{r_{count}} \geq \boldsymbol{r_{table}}$.

Furthermore, to measure the level of validity of the questions, researchers used the formula according to Rosidin quoted in (Sari et al., 2019):

$$\frac{N\,\Sigma XY - (\Sigma X)\Sigma Y}{\sqrt{(N\Sigma X^2 - (\Sigma X)^2(N\Sigma Y^2 - (\Sigma Y)^2)}}$$

Description:
N = Number of Participants
X = Item Score
Y = Total Score for each question
r_{xy} = Correlation coefficient between question score (X) and total score (Y) (Sari et al., 2019)

Furthermore, in the reliability test, the researcher used the formula:

$$r_{11} = \left[\frac{k}{k-1}\right] - \left[1 - \frac{\Sigma {\sigma_t}^2}{{\sigma_t}^2}\right]$$

Description:
r_{11} = Item reliability value
k = Number of items
${\sigma_t}^2$ = Total variance
$\Sigma {\sigma_i}^2$ = Total variance of scores for each item
${\sigma_t}^2$ = Total variance of all items on the instrument

Data Collection

In this research, a preliminary study was conducted directly and unstructured with the aim of gathering information regarding the research problem. Interviews were conducted directly, the results of which indicated that the school had already implemented the Independent

Curriculum, the teaching materials used focused on textbooks, learning was dominated by teachers, and the need for e-modules as a more interactive learning alternative. The questionnaire guidelines were conducted directly to estimate the level of validity and practicality of the developed e-modules. The validity questionnaire was distributed to mathematics education lecturers at Kuningan University and Muhammadiyah University of Kuningan, computer science lecturers at Kuningan University, and mathematics teachers at SMA Negeri 1 Jalaksana. Meanwhile, the practicality questionnaire was given to students and teachers concerned as e-module users. Tests were administered at the beginning and end of the e-module implementation. Four pre-test items measured students' initial problem-solving skills before using the e-module, and four post-test items measured students' initial problem-solving skills after using the e-module in their learning. The results of these tests aimed to determine the extent to which students' problem-solving abilities improved after using the e-module developed by the researchers. This approach enabled researchers to gather more comprehensive and valid information as a basis for analyzing the KPMM. Furthermore, the data collection procedure enabled us to obtain more accurate and comprehensive information, and helped broaden our insight and understanding of the phenomena under study.

Procedure

The e-module development uses the ADDIE model stages. The first stage, analysis, focuses on assessing the urgency of innovation in developing learning products, including methods, models, media, and teaching materials. This stage also evaluates the feasibility and requirements that must be met during the development process. The development process begins by identifying problems arising from previous products or learning activities, including analyzing student needs and obstacles experienced in the classroom. The second stage, design, encompasses the product planning process from the formulation of initial ideas to determining the content to be developed. This design remains conceptual as a basis for subsequent development stages. In this stage, researchers determine learning materials, design the structure and appearance of the e-module, and compile the necessary research instruments. The third stage, development, is the process of implementing the design results into actual teaching materials. The main activities at this stage include creating and refining teaching materials to suit learning needs. The validation instruments prepared in the previous stage were used to assess the product's feasibility and suitability. The fourth stage was implementation, which involved applying the teaching materials to real classroom learning situations. The product was tested directly in a learning context to obtain feedback on its effectiveness and usefulness. Furthermore, a practicality instrument was provided to measure the product's optimal use in teaching and learning activities. The fifth stage was evaluation, which aimed to assess the results of the entire development process. The evaluation was conducted to determine the effectiveness of the e-module as a learning medium, particularly in helping students develop mathematical problem-solving skills in geometric transformation material.

Data Analysis

This study analyzed the data quantitatively and descriptively, using a Likert scale of 1-5 applied to the validation questionnaire. The quantitative data obtained were derived from qualitative data for the research purposes. The data collected from the validator was analyzed by the researcher to determine the e-module's validity level. If the e-module obtained a minimum percentage of 61%, it was categorized as valid or very valid (Gulo & Harefa, 2022).

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$$\text{Percentage Value} = \frac{\text{overlall score obtained}}{\text{maximum score}} \times 100\%$$

The results were analyzed based on the validity level criteria listed in the Table 2.

Table 2. E-Module Validity Criteria

Interval	Criteria
81% – 100%	Very Valid
61% – 80%	Valid
41% – 60%	Fairly Valid
21% – 40%	Less Valid
0% – 20%	Invalid

(Gulo & Harefa, 2022)

Researchers collected qualitative data and converted it into quantitative data. This data was obtained after using the e-module and used by researchers to determine the practicality level of the e-module. An e-module is considered practical if it achieves a minimum percentage of 61% (Gulo & Harefa, 2022).

$$\text{Percentage of Respondents} = \frac{\text{total score from respondents}}{\text{ideal total score}} \times 100\%$$

The calculation results were analyzed based on the e-module practicality categorization criteria:

Table 3. E-Module Practicality Criteria

Interval	Level of Practicality
$80\% < P \leq 100\%$	Very Practical
$60\% < P \leq 80\%$	Practical
$40\% < P \leq 60\%$	Quite Practical
$20\% < P \leq 40\%$	Not Practical
$0\% < P \leq 20\%$	Very Not Practical

(Gulo & Harefa, 2022)

The researchers collected quantitative data from the descriptive questions distributed to students to measure their improvement. The data was then analyzed to determine the improvement category. The formula used to calculate improvement in problem-solving skills is**:**

$$Normal\ Gain = \frac{score_{post-test} - score_{pre-test}}{score_{ideal} - score_{pre-test}}$$

The level of e-module improvement can be seen in the following Table 4

Table 4. N-Gain Level Criteria

Limitation	Category
$g > 0{,}70$	High
$0{,}30 \leq g \leq 0{,}70$	Medium
$g < 0{,}30$	Low

(Hake, 1998)

Research Findings

Analysis Phase

The analysis phase was conducted through a preliminary study at SMPN 1 Hantara on October 16, 2024, which included a student needs analysis and teacher interviews. The results indicated that mathematics instruction remained conventional and did not improve students' KPMM, especially in word problems. Students struggled to understand geometric transformations due to the large number of formulas to memorize and the lack of engaging learning resources. Referring to the Independent Curriculum, which focuses on meaningful learning and student engagement, the researchers developed a PjBL-based e-module to help students develop their problem-solving skills independently and contextually. This e-module was deemed valid, practical, and effective in improving these skills. Innovative teaching materials that present real-world contexts and align with the demands of the Independent Curriculum are also needed.

Design Phase

In the design stage, the researcher conducted three activities: determining the material, designing the e-LKPD (Educational Worksheet), and developing the research instrument. The researcher selected geometric transformation material for grade IX semester 2. Information obtained through interviews with teachers indicated that students struggled because the formulas were too numerous to memorize. This material was adapted to the learning objectives and indicators in the Independent Curriculum.

The researcher prepared contextual story-based questions to improve students' KPMM (Quality Assurance Competency Index). The e-module was designed in portrait format (37.4 x 52.9 cm) with Roboto 15 font using Canva, then converted into a flipbook via Heyzine. The e-module design included a complete cover, materials, practice questions, and a bibliography.

The validation sheet included validation by material experts (24 statements, validated by three validators) and validation by media experts (17 statements, validated by two validators). The practicality questionnaire contained 14 statements for students and 15 statements for teachers. The pre-test and post-test consisted of four essay questions and were validated by three material experts. The assessment scale uses 1-5 with a column for criticism and suggestions.

Development Phase

The development stage is the e-module development stage. This stage involves developing the e-module components. Below are some examples of the appearance of the teaching materials contained in the e-module:

Cover (Cover Page)

The e-module cover includes the name of the e-module, the topic title (geometric transformations), the skills being developed (QA), the research institution, and the class identity. The cover also includes images related to the topic to attract students' interest.

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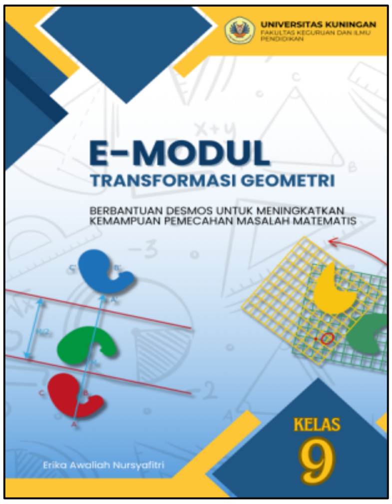

Figure 1. Cover (Cover Page)

Each Learning Activity Page

The material presented includes definitions, properties, example problems, steps for using Desmos, and projects. The PjBL model syntax is used in the learning process, resulting in a project at the end of each sub-chapter.

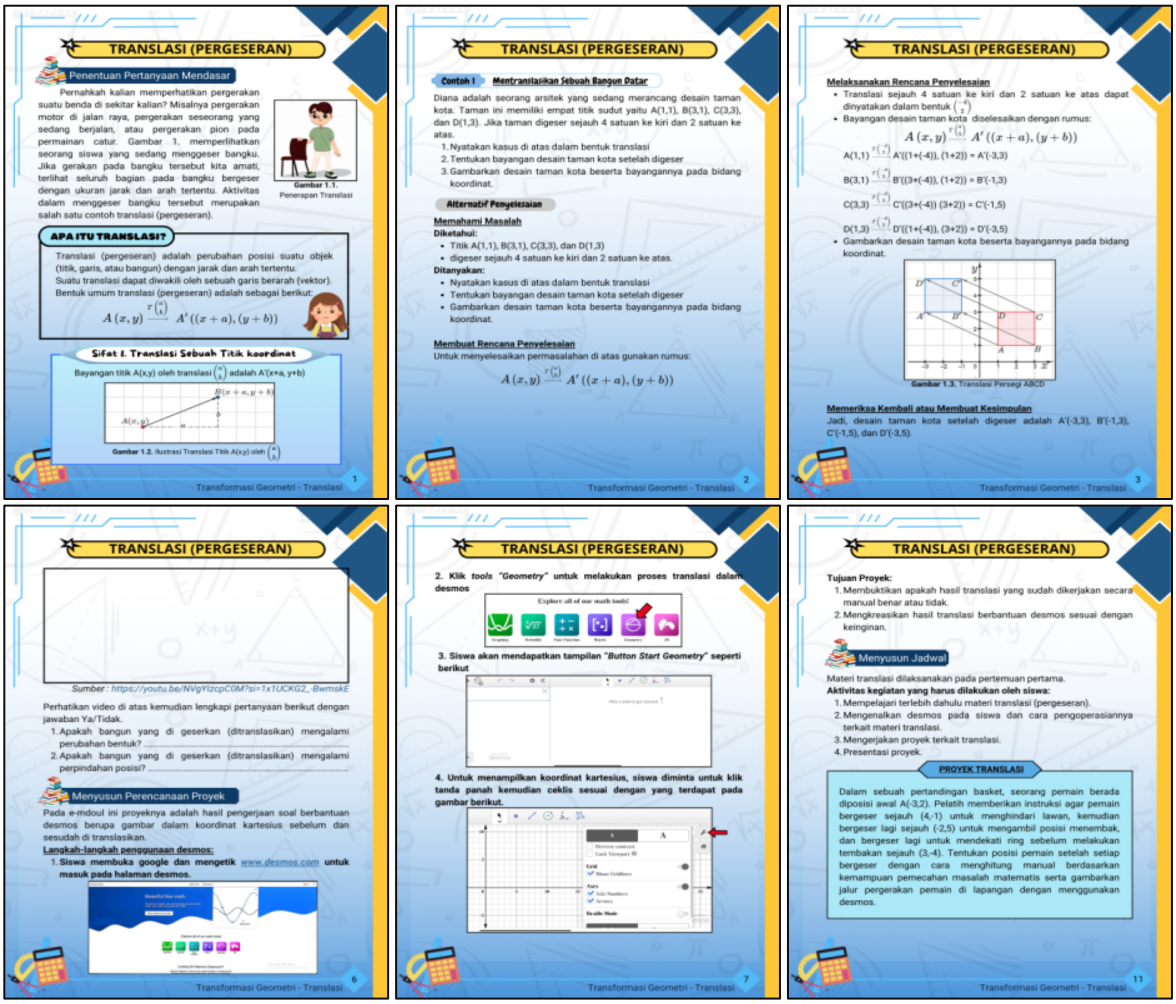

Figure 2. Each Learning Activity Page

After the prototype was produced, the e-module material was validated by three validators and two media experts. The results of the material expert validation were as follows in Table 5

Table 5. Material Expert Validation Results

No	Aspect	Material Expert 1			Material Expert 2			Material Expert 3		
		Score	%	Note	Score	%	Note	Score	%	Note
1	CP and TP Achievement	15	100	Very Valid	15	100	Very Valid	13	87	Very Valid
2	Material Content	30	100	Very Valid	23	77	Valid	26	87	Very Valid
3	Language	22	88	Valid	18	72	Valid	21	84	Very Valid
4	KPMM	20	100	Very Valid	15	75	Valid	16	80	Valid
5	Project based learning (PjBL)	28	93	Very Valid	25	83	Very Valid	27	90	Very Valid
Total Score Obtained									**314**	
Maximum Score									**120**	
Percentage									**87%**	
Note									**Very Valid**	

Table 5 shows that the assessment, which contains 24 statements with a maximum score of 5, obtained an average percentage of 87% (very valid), so it can be used with only a few revisions. The results of the validation by media experts with two validators obtained the following results in Table 6

Table 6. Media Expert Validation Results

No	Aspect	Material Expert 1			Material Expert 2		
		Score	%	Note	Score	%	Note
1	Presentation Feasibility	41	68	Valid	53	88	Very Valid
2	Compliance with E-Module Principles	21	84	Very Valid	23	92	Very Valid
Total Scores Obtained					**138**		
Maximum Score					**85**		
Percentage					**81%**		
Note					**Very Valid**		

The media expert validation assessment in Table 6 contains 17 statements with a maximum score of 5, achieving an average of 81% (very valid), allowing for use with some revisions. The item validity results are presented in Table 7, with the category "valid," meaning the items can be used because they meet the criteria.

Table 7. Item Validity Test

	Pre-test Item				Post-test Item			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
r_{count}	0,825	0,871	0,471	0,442	0,727	0,667	0,613	0,790
r_{table}	0,355	0,355	0,355	0,355	0,355	0,355	0,355	0,355
Note	**Valid**	**Valid**	**Valid**	**Valid**	**Valid**	**Valid**	**Valid**	**Valid**

Implementation Phase

The e-module was implemented after the validators declared it suitable for use and a trial was conducted. This e-module is accessed online using a smartphone, laptop, or computer. The e-module was trialed on 26 grade IX A students of SMP Negeri 1 Hantara during four meetings on February 13, 14, 20, and 21, 2025. The aim was to assess the practicality and effectiveness

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of the e-module in improving students' KPMM. Students and teachers can access the e-module by accessing the following link: *https://heyzine.com/flip-book/aa19731193.html*. After the implementation phase, students and teachers were asked to complete a practicality questionnaire for the e-module. The results were as follows in Table 8

Table 8. Teacher Practicality Questionnaire Results

No	Indicator	Score	Percentage	Note
1	E-Module Presentation	34	97%	Very Practical
2	Material	29	97%	Very Practical
3	Benefits	10	100%	Very Practical
Total Respondent Score			**73**	
Total Ideal Score			**75**	
Percentage			**97%**	
Note			**Very Practical**	

The teacher practicality questionnaire, consisting of 15 statements and three assessment aspects, obtained a total score of 73, or 97%. The Desmos-assisted flipbook e-module is highly practical for classroom use. The practicality results of the e-module from 26 students are as follows Table 9

Table 9. Student Practicality Questionnaire Results

No	Indicator	Score	Percentage	Note
1	E-Module Presentation	854	84%	Very Practical
2	Material	630	87%	Very Practical
3	Benefits	251	87%	Very Practical
Total Respondent Score			**1.735**	
Total Ideal Score			**1.820**	
Percentage			**95%**	
Note			**Very Practical**	

The teacher practicality questionnaire with 14 statements and 3 assessment aspects obtained a total score of 1,735 or 95%, the Desmos-assisted flipbook e-module is very practical when used during classroom learning.

Evaluation Phase

The purpose of the evaluation phase is to determine the effectiveness of the Desmos-assisted e-module in improving KPMM on geometric transformation material. The evaluation was conducted on February 13 and 21, 2025. The data from the students' KPMM test results are obtained in the following Table 10

Table 10. Test Results

	Pre-test	*Post-test*
Smallest Score	5	47,5
Highest Score	85	100
Average Score	24,31	75,95
Average N-Gain Score	**0,71**	

The results showed an average pre-test score of 24.31 and a post-test score of 75.95, with an N-Gain score of 0.71 (high). These results indicate that the use of the Desmos-assisted flipbook e-module was effective in improving students' KPMM. The results of the reliability test for the questions used are presented in the Table 11 (Sari et al., 2019).

Table 11. Item Reliability Test

	Pre-test	*Post-test*
Total Variance	8,796	8,026
Standard	0,60	0,60
Note	**Reliable**	**Reliable**

The following shows the increase in KPMM per indicator.

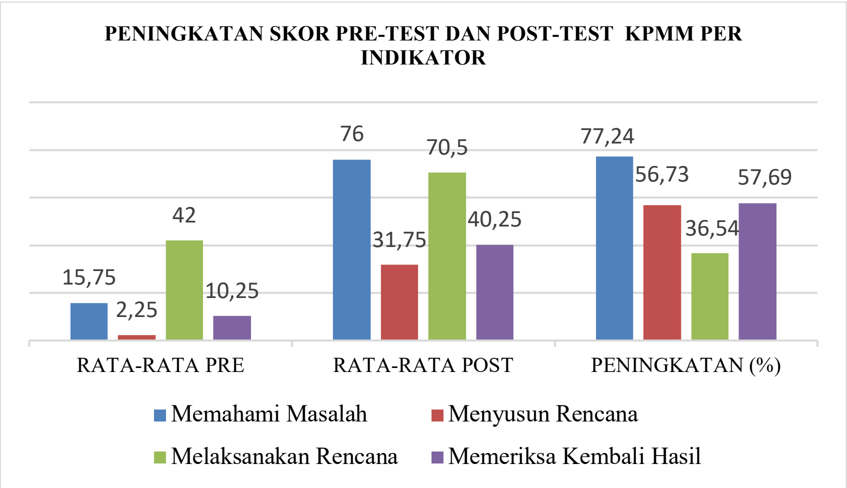

Figure 3. Results of Improvement Per Indicator

Based on Figure 3, all KPMM indicators experienced improvements. The highest percentage increase occurred in the understanding problem indicator (77.24%), followed by reviewing results (57.69%), developing a plan (56.73%), and implementing the plan (36.54%). However, high score increases do not always reflect in-depth understanding. The highest post-test score for the understanding problem indicator indicates that students are becoming accustomed to identifying information in problems, while improvements in the reviewing results and developing a plan indicator reflect students' ability to evaluate and select problem-solving strategies. The implementing the plan indicator experienced the lowest increase, likely because students are already accustomed to solving problems using the strategies developed in the pre-test. The following shows the results of the overall increase in students' KPMM:

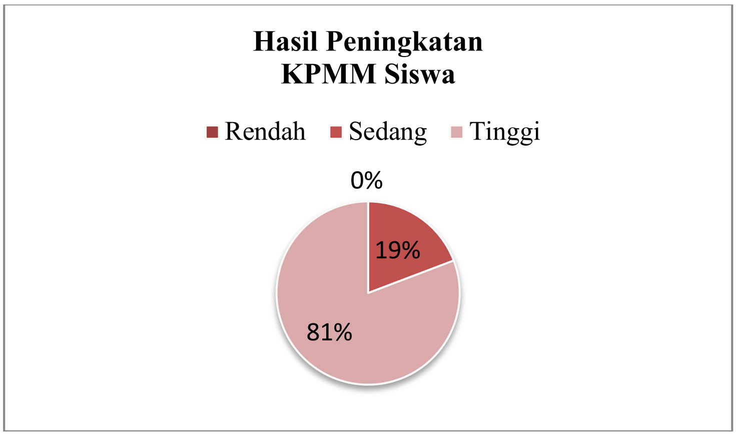

Figure 4. Overall Improvement Results

Based on the N-Gain calculation, of the 26 students, 81% showed an increase in KPMM (high), and 19% (moderate). This means that the Desmos-assisted flipbook e-module is effective in improving KPMM for junior high school students. This is in line with the benefits

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of e-modules according to Wulandari et al. (2021), namely increased motivation, understanding, literacy, learning outcomes, students are more independent, and flexible in their use. The e-module obtained very valid results, was considered very practical by teachers and students, and was proven effective after implementation in the classroom.

Discussion

The research results confirmed that the Desmos-assisted flipbook e-module on geometric transformation material met the validity criteria. This validity criterion was obtained because the e-module was in accordance with basic competencies, learning indicators, and contained systematic Polya problem-solving stages. In addition, the interactive display of the flipbook e-module with Desmos integration made it easier for students to visualize the previously abstract geometric transformation concept. In line with Fitriani & Indriaturrahmi (2020), who explained that flipbook-based e-modules can improve material readability and learning appeal. Nugraha et al. (2022) emphasized that PjBL is effective because it presents contextual problems relevant to everyday life, thereby improving students' mathematical problem-solving abilities. Desmos integration also supports the content validity aspect because this media can help students understand geometric concepts visually and dynamically (George et al., 2023).

In terms of practicality, this e-module was deemed practical based on teacher and student responses. Survey results showed that students felt more motivated to learn because the material was presented with an attractive visual design, complemented by contextual examples, and project-based exercises. Teachers also considered the e-module easy to use in learning because it can be accessed digitally without the need for special devices. Prayitno et al. (2022) also stated that flipbooks can strengthen communication and engagement between teachers and students during the learning process. Research by Nuri et al. (2023) also showed that combining PjBL with interactive digital media can increase active student participation while strengthening mathematical problem-solving skills. The practicality of this e-module is also reflected in its alignment with 21st-century learning principles, namely project-based, contextual, and interactive. Through the PjBL approach, students can relate the concept of geometric transformation to real-life projects such as garden design, mirror patterns, rotation of shapes, and enlargement of graphic designs. This is in line with Fisher et al. (2021) who emphasized that PjBL is effective in training the ability to analyze logically and find solutions to mathematical problems. Furthermore, research by Saswita et al. (2023) also confirmed the findings that PjBL-based e-modules provide a more meaningful learning experience than conventional methods.

The effectiveness of the Desmos-assisted flipbook e-module is evident in the increase in students' KPMM from the pre-test and post-test results. The results show a significant increase in the average score after the implementation of the e-module. This finding indicates that the e-module is not only feasible and practical to use in learning, but also effectively helps students understand the concept of geometric transformations that were previously considered difficult and abstract. Student involvement in contextual projects through the PjBL approach enables them to connect mathematical concepts with real-world situations. For example, in the translation and rotation material, students can directly visualize the displacement of objects and the rotation of shapes with the help of the Desmos application integrated in the e-module. Nuri et al. (2023) also found that the combination of PjBL with digital media has a positive and significant impact on improving critical thinking and problem-solving skills, supporting the findings of this study. Thus, these results confirm that the Desmos-assisted flipbook e-module is valid because it is in accordance with the content and learning objectives and is practical and effective because it is easy to use, interesting, and encourages active student involvement in improving mathematical problem-solving abilities.

Previous research supports this study in terms of the effectiveness of the use of interactive e-modules and innovative learning models in increasing student engagement, learning independence, and mathematical problem-solving skills. However, most studies still focus on the Problem-based Learning (PBL) model or the use of static e-modules such as PDFs, so they have not specifically examined the development of Desmos-assisted flipbook e-modules based on Project-based Learning (PjBL) for geometric transformations. This condition indicates an important research gap that needs to be filled, considering that geometric transformations are often taught abstractly and are difficult for students to understand. Therefore, the innovation in the form of developing Desmos-assisted flipbook e-modules with a PjBL approach is a significant new step, because it not only aims to improve understanding of geometric transformation concepts, but is also specifically designed to hone junior high school students' mathematical problem-solving skills through contextual projects. This approach is expected to help students more easily understand abstract concepts, as well as prepare them to face the challenges of more complex mathematics learning.

Conclusion

This research produces a Desmos-assisted flipbook e-module with Project based learning (PjBL) syntax on geometric transformation material that is proven valid, practical, and effective in improving junior high school students' mathematical problem-solving abilities (KPMM). Validity is proven through expert assessments that state the e-module is suitable for use, practicality is reflected in positive responses from teachers and students, and effectiveness is demonstrated through significant improvements in learning outcomes with N-Gain values in the high category. The main contribution of this research is the integration of Desmos-assisted interactive flipbooks within the PjBL framework that is able to visualize abstract concepts of geometric transformations into more concrete ones, while providing project-based learning experiences that support the development of KPMM. This e-module can be an innovative alternative digital teaching material for mathematics learning, both as a supporting medium for teachers and a means for student independent learning. Operationally, this research is still limited to implementation within a specific classroom setting. Therefore, further research is recommended to expand the context, levels, and features such as automatic evaluation, as well as test its effectiveness in blended and distance learning. Thus, this Desmos-assisted flipbook e-module has the potential to be a long-term solution to improve the quality of mathematics learning in the digital era.

Conflict of Interest

The researcher revealed that there was no conflict interest.

Authors' Contributions

N.N. conducted the research by identifying the background of the presented problems, performing the study, processing and analyzing the data, and drafting the research results. E.A.N. and N.A. participated in instrument development, data analysis techniques, and finalizing the journal manuscript. All authors have declared that this paper has been read and approved. The contribution percentages are N.N.: 50%, E.A.N.:25% and N.A.: 25%.

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Data Availability Statement

The authors state that the data supporting the findings of this study will be made available by the corresponding author, [E.A.N.], upon reasonable request.

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