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SCRATCH APPLICATION: ENCOURAGING INNOVATION IN GEOMETRY LEARNING AND ITS IMPACT ON STUDENTS' NUMERACY LITERACY

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ABSTRACT

Students' low numeracy literacy skills in geometry are often caused by high spatial abstraction and a learning approach that tends to rely on memorizing formulas. This study aims to develop a Scratch-based learning medium using the Discovery Learning model for quadrilateral geometry, as well as to test its practicality and effectiveness on students' numeracy literacy. Using the Research and Development (R&D) method with the ADDIE model, this study applied a One-Group Pretest-Posttest Design without a control group in the evaluation phase as a limitation of the scope of the trial. The research subjects consisted of 3 expert validators, 6 students in a small-group pilot test, and 30 junior high school students in the field test. The results showed that the Scratch-based learning media met the criteria for high validity, with a media feasibility percentage of 95.90% and a content feasibility percentage of 96.33%. This medium was also deemed practical, with student response questionnaire scores reaching 80.20%. An analysis of effectiveness using the non-parametric Wilcoxon test confirmed a significant difference in academic performance between pre- and post-intervention scores ($Z = -4{,}704$; $p < 0{,}001$), supported by an average N-Gain index of 0.6344, which falls into the moderate category. This study concludes that although its generalizability is limited to the test sample due to the absence of a control class, Scratch-based interactive learning media has positive potential as an alternative to minimize students' reliance on rote memorization of geometry.

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INTRODUCTION

Numeracy literacy is one of the key skills that requires practical problem-solving. Numeracy literacy is assessed by the Minimum Competency Assessment (AKM), which is specifically designed to measure cognitive abilities in arithmetic and reading skills. Results from the 2022 Programme for International Student Assessment (PISA) show that Indonesian students' numeracy literacy scores stand at 366, which is still below the OECD average of 472. The numeracy literacy indicators used were adapted from the Ministry of Education and Culture in Yani et al. (2024).According to Yani et al. (2024) the indicators in this study are: 1) analyzing information presented in various formats such as tables, charts, graphs, and so on; 2) utilizing symbols and numbers related to basic mathematics to solve real-life problems, which includes the practical application of mathematical operations and concepts in everyday situations; 3) interpreting analytical results to make predictions and decisions that highlight the importance of problem-solving based on the information obtained. In geometry, students need to apply numerical reasoning to understand shapes, measurements, and spatial relationships. Geometry is a branch of mathematics that studies shapes, sizes, composition, properties of space, and the position of objects. According to Freudenthal, geometry is where children live and grow because it is the study of shape and space (Ridwan et al., 2020) . Therefore, understanding geometric concepts is crucial for more complex mathematical topics and their application in daily life. The quadrilateral unit in junior high school provides ample opportunities to foster students' creativity through observation activities, exploration of the properties of two-dimensional shapes, and problem-solving in real-world contexts (Kadir et al., 2022) . One of the most challenging mathematical topics for students is geometry. In a study by Indrayany and Lestari,(2019) , it was found that students often struggle to understand geometric concepts, which is a global issue in mathematics education. This is due to the fact that geometry requires students to understand abstract objects, which may lead to a more realistic learning process. There is a wide range of understanding among students when studying geometry. According to the findings of a study by Ali et al. (2023), students face difficulties when learning geometry in a conceptual context; they often struggle to develop mathematical procedures and strategies when solving problems. In a study by Lailiyatul et al. (2024) it was identified that some students reported the material as difficult due to frequent mistakes and negative perceptions of mathematics. On the other hand, some students were found to have partial understanding, where they might grasp general concepts but remain confused about minor details, while others tended to focus on procedural problem-solving methods and heavily relied on formulas without understanding the underlying concepts. This aligns with the research Nu'man and Azka (2023) , which noted that students' difficulties in geometry are extensive and diverse, encompassing both conceptual understanding and problem-solving skills. These issues often stem from the abstract nature of geometry material; additionally, they may be caused by teaching methods that may not fully support students' cognitive development. Therefore, developing numeracy literacy in geometry is a strategic step toward creating meaningful mathematics learning.

Table 1. Summary of Students' Daily Test Scores

No	Completion	Total	Percentage
1	Complete	8	26.66%
2	Incomplete	22	73.33%

Based on classroom observation data, several challenges were encountered during the mathematics learning process when covering geometry material. During the first session before beginning the lesson, many students still struggled to identify the names of quadrilateral shapes. The results of the daily quizzes on quadrilaterals also showed that the students' average score was only 67.33. This figure remains below the school's minimum passing score of 75. As shown in Table 1, out of a total of 30 students in the class, only 8 students successfully completed the problems, while the rest still needed to participate in remedial instruction. The low learning outcomes can likely be attributed to challenges in the learning process. Previous research indicates that students also continue to face difficulties with mathematical abstraction, particularly in geometry—a subject that poses a challenge because students often rely on memorization and lack conceptual understanding (Fitriani et al., 2021) . These difficulties are often exacerbated by conventional teaching practices that tend to be *teacher-centered*, procedural, and lack the use of visual aids. Conventional learning is a traditional teaching method. One method frequently used in schools is the lecture method. However, it is clear that the lecture method has both its strengths and weaknesses. This method facilitates the direct and concise delivery of information to a group of students but makes students passive and can lead to a lack of creativity among learners, ultimately preventing them from fully grasping the material. Al Fajrin et al. (2023) also state that the main weakness of the lecture method is that it can indeed make students passive in the learning process because the teaching and learning activities primarily involve students merely receiving information from the teacher. The impact of this is that it hinders students' creativity, leading to their inability to comprehensively understand the material, which ultimately results in intellectual dysfunction and rote memorization.

To address this issue, innovation in mathematics education is essential, particularly in effectively integrating technology. In today's digital age, technology offers great potential to transform passive learning into interactive learning. Interactive learning media focuses on instructional materials that encourage students to participate actively, often by simulating real-world situations. Such media can be designed to help students easily and independently grasp complex learning material (Gulo & Harefa, 2022) . Interactive learning media can create a more engaging learning environment and make the learning process more enjoyable for students. This is particularly useful for subjects like mathematics, which are often perceived as difficult and uninteresting to students (Hapsari & Fahmi, 2021) . By using interactive learning media, it is hoped that students' enthusiasm for learning can be enhanced, especially in mathematics. Interactive learning can also shorten learning time and improve the quality of learning. Interactive learning media combines technology with active learning methods aimed at helping students better understand the material and appreciate the learning process. This approach is considered a significant opportunity to improve the quality of education, especially in the digital age (Irawan et al., 2023) .

In the study Fauzia et al. (2023) , Scratch was used to create interactive multimedia for middle school students to learn geometry. This application aims to address the challenges of teaching abstract and procedural mathematical concepts by creating lessons that are more engaging and easier to understand. Interactive multimedia created using Scratch can help students understand the difference between concrete and abstract concepts. Scratch is also equipped with features such as animation, sound, and interactivity, which are crucial for developing engaging and relevant learning activities, particularly in mathematics. This helps create an engaging learning experience—especially in educational fields that are often overlooked—by boosting students' motivation and enthusiasm. This application facilitates the development of logical thinking and interactive understanding of learning materials (Rahadi & Ismiyati, 2024) . As shown in Figure 1, the Scratch application can help students think critically and visualize abstract images to manipulate two-dimensional shapes. In the figure, the initial shape of the plane figure is a parallelogram, then its position changes, eventually forming a rectangle.

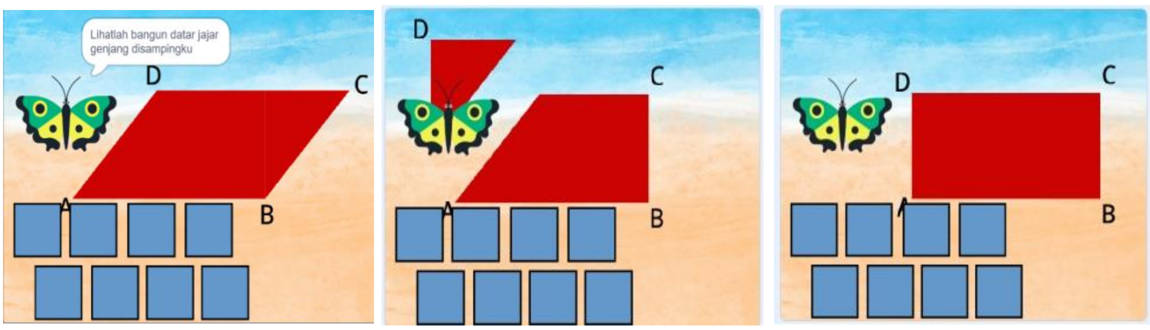

Figure 1. Manipulating Two-Dimensional Shapes in Scratch Application

Previous studies have investigated how effective Scratch is in teaching mathematics. For example, Nuraeni L et al. (2021) in the creation of educational games featuring quadrilateral geometric shapes using the Multimedia Development Life Cycle (MDLC) paradigm. This research is also aligned with the study Nurhasanah et al. (2023) which developed geometry teaching materials using the 4D model and Nurhayati et al. (2023) which used Scratch to assess students' problem-solving abilities. This research continues to expand on a larger scale. According to a study by Dewi et al. (2025) , the integration of Scratch has the potential to encourage students to actively participate in school activities. This indicates that Scratch integration can focus on aspects of numeracy competency development. Furthermore, in the study Budiarti et al. (2025) , which used the ADDIE development model assisted by Scratch to improve numeracy skills in geometric transformation material. In the study by Setyoningtyas,(2024) , the ADDIE model was also used to test the effectiveness of Scratch on arithmetic operation material focused on basic arithmetic. This research fills a gap by shifting the focus to geometry, which requires dynamic spatial visualization to promote numeracy literacy. Previous research has used Scratch to support students' numeracy competencies, but there is a significant research gap distinguishing this study from prior work. First, regarding the conceptual understanding of perimeter, previous studies presented the perimeter formula for quadrilaterals instantly via static text. In contrast, this study employs dynamic visualization where objects in Scratch move around a designated garden. This aligns with the theoretical essence that perimeter is a physical process of going around and encourages students to discover the perimeter formula inductively. Second, regarding the understanding of the concept of the area of two-dimensional shapes using the method of discovering the formula for the area of a quadrilateral. Previous research was still limited to numerical calculations that relied on ready-made formulas. By using Scratch as a virtual laboratory to reconstruct shapes, this study can bridge that gap. The Scratch application will find that the box does not fit with some other quadrilateral shapes; eventually, the Scratch application will display an animation of cutting and rotating parts of the shape precisely until it transforms into a complete rectangle when students calculate the area using small unit squares and discover the formula for the area of that two-dimensional shape.

The main innovation in this study is the use of Scratch to develop students' mathematical creativity through the discovery of formulas. Unlike standard learning materials that present formulas as facts, the innovation in this study is encouraging students to break down and transform various structures visually into rectangles. This substitution process encourages students to be creative in manipulating the properties of two-dimensional shapes so that they can discover area formulas conceptually rather than by rote memorization. As in the study by Inayatusufi et al. (2020) which emphasizes the importance for students to understand mathematical concepts, including the ability to use concepts or algorithms to solve problems. This study shows that students often struggle to understand geometric and measurement concepts; it is therefore crucial for students to gain a better understanding of basic formulas and their applications.

Previous studies conducted by Nuraeni L et al. (2021) and Nurhasanah et al. (2023) largely utilized the Multimedia Development Life Cycle (MDLC) paradigm or the 4D product development model, which focuses solely on the production phase. However, they did not provide strong empirical evidence regarding the cognitive impact on students. Unlike previous studies, this research employs a research and development (R&D) approach systematically organized into 5 stages. The analysis, design, and development stages concentrate on analyzing numeracy literacy standards, designing storyboards, and creating Scratch-based virtual laboratory media. During the implementation phase, the product will be tested in stages through small-group trials with six students, followed by a field trial in a single classroom to assess practicality via a response questionnaire. Finally, in the evaluation phase, the product's effectiveness will be tested using a One-Group Pretest-Posttest Design to determine the significance of improvements in students' numeracy literacy skills.

Therefore, this study aims to introduce an innovation in geometry learning through the development of Scratch-based media and to test its impact on improving the numeracy literacy of junior high school students. The primary novelty of this study lies not only in the quantitative assessment of cognitive learning outcomes but also in the students' creative process as they explore contextual problems in their surroundings, visually manipulate two-dimensional shapes, and independently derive formulas for perimeter and area. To achieve this, this study will employ the Research and Development (R&D) methodology using the ADDIE model to investigate, design, produce, and test the validity, practicality, and effectiveness of the resulting product.

METHOD

This study is a Research and Development study using the ADDIE model. To test the impact of the media on students' numeracy literacy, this study employs a One-Group Pretest-Posttest Design. The study was conducted in two junior high schools (SMP) of the same level to ensure data objectivity and avoid experimental bias. The ADDIE development procedures in this study were implemented as follows:

1. Analysis

   The initial stage involved identifying students' needs and challenges in the field of geometry learning. This included analyzing the cognitive characteristics of junior high school students and identifying the difficulties that contribute to low initial numeracy literacy skills. Subsequently, learning outcomes in geometry regarding quadrilateral shapes were analyzed to align with numeracy literacy indicators and to ensure accessibility to the Scratch platform.

2. Design

   Following the analysis, this stage involves conceptualizing the instructional media to be developed. This phase is a systematic process that begins with setting learning objectives, designing a storyboard for the learning media to be used, and adapting it to student characteristics and the learning strategies to be implemented. Additionally, it involves drafting assessment instruments, including an expert validation sheet, a practicality response questionnaire, and numeracy literacy test questions (pre-test and post-test).

3. Development

   At this stage, the conceptual design is transformed into a practical educational media product that can be used. The first activity involves arranging a sequence of visual code blocks on the Scratch platform to visualize the properties of quadrilaterals, the concept of perimeter, and the derivation of the quadrilateral area formula. Next, a feasibility test of the initial product draft is conducted through evaluation by subject matter experts to verify the geometric content concepts and by media experts to verify coding, navigation, and visual functions. Subsequently, the media is tested on a limited scale with 6 middle school students at the same grade level to identify technical usability issues, allowing for revisions based on feedback from experts and the small group until the media is deemed suitable.

4. Implementation

   After the product was validated, the refined learning media was used directly with the target users in actual learning sessions. In this step, to maintain data objectivity and prevent bias, a field test (School A) was conducted to assess the practicality of the media in one class at Junior High School A, observing student responses, enthusiasm, interactions, and field challenges during Scratch-based geometry learning. For the effectiveness test (School B), the mature Scratch media was also used in one class at Junior High School B using a single-group experimental design to test the impact of the media intervention on numeracy literacy.

5. Evaluation

   At the end of each stage (formative evaluation), continuous evaluation was conducted to improve the media, while the final (summative) evaluation focused on assessing the quality of the final product. The first evaluation was a practicality analysis that distributed and analyzed a satisfaction survey regarding the ease of using the Scratch media among students at School A. Subsequently, for the effectiveness analysis to demonstrate the tangible contribution of Scratch media in improving students' numeracy literacy at School B, pre-test and post-test scores were compared using the Normalized Gain (N-Gain) statistical test.

Data in this study were collected through three main instruments: an expert validation sheet for content and media, a student response questionnaire to measure practicality, and a numeracy literacy assessment instrument. The validation sheet was used during the development stage to assess the media's suitability, evaluated by three expert validators in media and content. Data on scores from the expert validation sheets and readability tests were calculated by summing the scores achieved across all evaluated aspects and then applying the following formula: (Tarliany et al., 2019) :

$$N = \frac{K}{Nk} \times 100\%$$

Notes

N : percentage of aspect feasibility

K : score from data collection

Nk : maximum score (highest criterion score× number of aspects× number of validators)

After calculating and determining the percentage results, the media and material validation score criteria can then be applied as shown in Table 2.

Table 2. Media Validation Score Criteria

Criteria Interval	Criteria
$86\% \leq N < 100\%$	Highly valid
$72\% \leq N < 85\%$	Valid
$58\% \leq N < 71\%$	Moderately valid
$44\% \leq N < 57\%$	Less valid
$N < 44\%$	Very low validity

Next is a closed-ended questionnaire using a 1–4 Likert scale, which was used during the implementation phase at School A. This questionnaire aims to measure the level of practicality of the media from the users' perspective. The data on practicality from the questionnaire was analyzed as follows:

$$P = \frac{f}{N} \times 100\%$$

Notes:

P : percentage of learning implementation

f : average score obtained

N : maximum score

Then, the data is classified as shown in Table 3.

Table 3. Practicality Criteria

No	Percentage	Category
1	$P \geq 100\%$	Very practical
2	$80\% \leq P < 90\%$	Practical
3	$70\% \leq P < 80\%$	Fairly practical
4	$60\% \leq P < 70\%$	Not very practical
5	$P < 60\%$	Not practical

Furthermore, the test instrument was designed to measure the impact of using Scratch on students' numeracy literacy skills regarding quadrilateral shapes. The numeracy literacy indicators from "(Yustinaningrum, 2021)(Yustinaningrum, 2021) are shown in Table 4.

Table 4. Numeracy Literacy Indicators

No	Numeracy Literacy Indicators
1	Applying various types of symbols and numbers related to basic mathematics to solve problems in daily life
2	Analyzing information presented in charts, graphs, tables, etc.
3	Interpreting analysis results to make predictions and decisions

The test consists of 6 contextual problem-based open-ended items at the C4 cognitive level, used in both the pre-test and post-test sessions. Item scoring aligns with numeracy literacy competency indicators based on the Polya-based scoring guidelines (. in Table 5.

Table 5. Numeracy Literacy Test Assessment Rubric Based on Polya's Stages

No.	Stage	Assessment Guidelines for Student Answers	Score
1.	Understanding the problem	Did not write down what is known or asked in the question	0
		Writing down what is given or asked but incorrectly	1
		Writing down what is given or asked but incomplete	2
		Writing down what is known and asked in full	3
2.	Formulating a solution	Failing to formulate a solution	0
		Formulating a solution but getting it wrong	1
		Formulating a solution but not quite correct	2
		Formulating the solution correctly	3
3.	Implementing the solution	Failing to implement the solution	0
		Implementing the solution but incorrectly	1
		Implementing the solution but not quite right	2
		Implementing the solution correctly	3
4.	Review	Failing to document the conclusion of the problem-solving process	0
		Writing the conclusion of the problem-solving process but incorrectly	1

	Writing a conclusion to the solution but it is not entirely correct	2
	Writing the conclusion of the problem-solving process correctly	3

Before being officially used in the experimental class, this draft instrument consisting of six items was first pilot-tested on students outside the research sample who had already covered the material on quadrilaterals. The process of testing the quality of the ability test questions also utilized SPSS Statistics 23 software. The final results for item validity were determined by comparing the significance value (p -value) in the SPSS output with the significance level ($\propto = 0.05$) . Meanwhile, the interpretation of the *Product* Moment correlation categories (Son, 2019) is presented in Table 6.

Table 6. Product-Moment Correlation Coefficient Criteria

No	r_{xy}	Category
1	$0,80 \leq r_{xy} \leq 1,00$	Very high
2	$0,60 \leq r_{xy} < 0,80$	High
3	$0,40 \leq r_{xy} < 0,60$	Fair
4	$0,20 \leq r_{xy} < 0,40$	Low
5	$0,00 \leq r_{xy} < 0,20$	Very low

Meanwhile, reliability was measured using *Cronbach's Alpha* formula with the reliability criteria proposed by Hinton (Son, 2019) to ensure consistency in the measurement results in Table 7.

Table 7. Item Reliability Criteria

No	Reliability Coefficient	Interpretation
1	$0,00 \leq r_i < 0,50$	Low reliability
2	$0,50 \leq r_i < 0,70$	Moderate reliability
3	$0,70 \leq r_i < 0,90$	High reliability
4	$0,90 \leq r_i < 1,00$	Very high reliability

To test the difficulty level of items, the formula (Johari et al., 2011) is also used :

$$\text{Difficulty index} = \frac{\text{Average score}}{\text{Full item score}}$$

Students can use Table 8 to determine the difficulty index of the numeracy literacy test.

Table 8. Item Difficulty Index Criteria

No	Difficulty Index	Criteria
1	$0,00 \leq DI \leq 0,30$	Difficult question
2	$0,30 \leq DI < 0,80$	Medium-difficulty question
3	$0,80 \leq DI < 1,00$	Easy questions

There is discriminative power to distinguish each student's ability according to their level. The discriminative power index value is obtained through the item–total correlation coefficient in the SPSS software output. Furthermore, for the discriminative power criteria, see Table 9.

Table 9. Item Discrimination Index Criteria

No	IDP	Interpretation
1	Negative sign	No discriminatory power
2	$0,00 \leq D < 0,20$	Weak
3	$0,20 \leq D < 0,40$	Fair
4	$0,40 \leq D < 0,70$	Good
5	$0,70 \leq D < 1,00$	Very good

Data on students' numeracy literacy skills, in the form of pre-test and post-test scores obtained from the experimental class at School B, were analyzed using SPSS software through statistical tests. The first test was a normality test, in which the distribution of the pre-test and post-test scores was examined. In the Shapiro–Wilk column, the criterion for data with a non-normal distribution was set based on a p-value of$\mathrm{Sig.} < 0,05$. If normality is not met, comparative hypothesis testing is conducted using non-parametric tests. A conclusion regarding a significant improvement in numeracy literacy is drawn if the value is$\mathrm{Asymp.\,Sig}\ (2-\mathrm{tailed}) < 0,05$. This is followed by the calculation of the N-Gain Score, which determines the extent of effectiveness using the following N-Gain formula: (Wahab et al., 2021) :

$$\mathrm{N-Gain} = \frac{\mathrm{Skor\ Post\ Test} - \mathrm{Skor\ Pre\ Test}}{\mathrm{Skor\ Ideal} - \mathrm{Skor\ Pre\ Test}}$$

The N-Gain criteria are shown in Table 10.

Table 10. N-Gain Level Criteria

Average	Criteria
$g > 0,7$	High
$0,3 \leq g \leq 0,7$	Medium
$0,0 < g \leq 0,3$	Low
$g \leq 0$	Failed

RESULTS AND DISCUSSION

Results

The development process for this educational media utilized the ADDIE model framework, resulting in an interactive media product based on Scratch. This media integrates elements of the *Discovery Learning* syntax, which includes stimulation, problem identification, data collection, data processing, verification, and generalization (Khasinah, 2021) . In line with field findings, seventh-grade students still struggle to distinguish the characteristics of quadrilaterals and tend to memorize formulas without understanding their meaning, leading to low basic numeracy literacy. The final product focuses on quadrilateral geometry (squares, rectangles, trapezoids, parallelograms, rhombuses, and kites) with an emphasis on numeracy literacy indicators. Prior to this, the researcher analyzed existing facilities to ensure that the school had the necessary device specifications and a stable internet connection to access the Scratch platform smoothly. During the design phase, a concept map for mathematics learning was developed, integrating the *Discovery Learning* approach.

Designing a storyboard for the Scratch platform to ensure it is interactive and capable of visualizing changes in two-dimensional shapes was also necessary at this stage. Subsequently, research instruments were developed, consisting of an expert validation sheet, a practicality questionnaire, and a numeracy literacy assessment instrument in essay format. Before the ability test questions were officially used to collect data at School B, the draft instruments were first pilot-tested on 30 junior high school students outside the research sample who had already covered quadrilateral geometry material.

Table 11. Test Instrument Validity Results

Validity Scores	Criteria	Reliability Score	Criteria	Difficulty Index Score	Criteria	Discriminant Power	Criteria
0.605	High	0.752	High	0.65	Medium	0.465	Good
0.768	High			0.78	Medium	0.581	Good
0.624	High			0.63	Medium	0.491	Good
0.623	High			0.89	Easy	0.458	Good
0.698	High			0.80	Easy	0.578	Good
0.753	High			0.74	Medium	0.520	Good

Based on the data in Table 11, the results of the pilot test on 6 essay questions produced an instrument that met the methodological prerequisites. Validity analysis using Product Moment correlation yielded a coefficient of determination ((r_{xy})) ranging from 0.605 to 0.768, which overall falls into the high category and is statistically significant at the $0.\propto = 0{,}05$. For reliability testing using Cronbach's Alpha, the results yielded a value of $0r_i = 0{,}752$, proving that this test instrument has a high level of reliability for measuring the construct of numeracy literacy ability. Regarding the difficulty index, four items were categorized as moderate and two as easy. The discrimination indices, ranging from 0.458 to 0.581, indicate a good ability to distinguish between high and low student performance. Based on the results of the validity, reliability, difficulty, and discriminant power data, the six contextual essay items assessing numeracy literacy were found to meet statistical criteria and can therefore be used as a data collection instrument for the pre-test and post-test phases at School B.

This was followed by the development phase, which transformed the conceptual design into a media product on the Scratch platform by arranging a sequence of visual code blocks to visualize the properties of two-dimensional shapes, the concept of perimeter, and the discovery of the formula for the area of quadrilaterals in a guided manner. To ensure data accuracy, the product was evaluated by three expert validators. Validators 1 and 2 were lecturers specializing in educational media and mathematics content, while Validator 3 was a practicing teacher at one of the schools. The scoring results from the validators are presented in Table 12 and Table 13.

Table 12. Media Validation Sheet Results

	Validator 1	Validator 2	Validator 3	Average total
Number of questions	13	13	13	13
Total score **(K)**	64	63	60	62.33
Maximum score for the criterion **(N_k)**	65	65	65	65
Percentage **(N)**	98.46%	96.92%	92.31%	95.90%
Interpretation	Highly Valid	Highly Valid	Highly Valid	Highly Valid

Table 13. Results of the Material Validation Sheet

	Validator 1	Validator 2	Validator 3	Total Average
Number of questions	20	20	20	20
Total score **(K)**	99	96	94	96.33
Maximum score for the criterion **(N_k)**	100	100	100	100
Percentage **(N)**	99.00%	96.00%	94.00%	96.33%
Interpretation	Highly Valid	Highly Valid	Highly Valid	Highly Valid

Based on the validation data in Table 12 and Table 13, the average percentage for media suitability was 95.90% and for content suitability was 96.33%, categorizing the developed Scratch media as Highly Valid. The strongest aspect lies in the media's validity, with teachers noting that the presented material is very easy to understand, making it applicable to solving everyday problems, and that the language used is easily comprehensible to students. However, regarding the content validity test data, the validators suggested adding the missing representations of fold symmetry and rotational symmetry in the properties of quadrilaterals, which had not been concretely visualized in the initial draft of the media. Additionally, the absence of labels on one of the quadrilaterals also required revision before implementation. As part of the integration of these revisions, the researcher made improvements in accordance with the suggestions and feedback from the validators. After the Scratch media was validated and revised, the researcher conducted a small-group trial with 6 junior high school students of the same grade level. Student response data was measured using a readability questionnaire covering three main assessment aspects, with the score summary presented in Table 14.

Table 14. Readability Test Results

Small Group Assessment Indicators	Score (K)	Maximum Score (N_k)	Percentage (N)	Criteria
Language	100	120	83.33%	Valid
Visual	103	120	85.83%	Valid
Attractiveness and ease of use	50	60	83.33%	Valid
Overall average	84.33	100	84.33%	Valid

Based on Table 14, the results from the small group yielded an overall average percentage of 84.33%, categorized as Valid. Notes from this phase include the need to slightly reduce the duration of the instructional text. Through a series of expert validations, product revisions, and readability tests on a small group, the draft on the Scratch platform was declared fully valid and ready for use in a broader implementation phase. The practicality of the platform was tested by administering a feedback questionnaire to students after their engagement with the platform during the learning process. This questionnaire served to assess students' perceptions regarding ease of use, learning materials, interest and motivation, and perceived benefits.

Table 15. Questionnaire Response Scores

Question Aspect	**Number of Items**	**Total Score** (f)	**Maximum Score** (N)	**Practicality Percentage** (P)	**Practicality Category**
Ease of Use	3	289	360	80.27%	Practical
Learning materials	3	292	360	81.11%	Practical
Interest and motivation	3	287	360	79.72%	Quite practical
Perceived benefits	3	287	360	79.72%	Quite practical
Total average	3	288.75	360	80.20%	Practical

Based on the data in Table 15, the average score calculated from all aspects resulted in a value of 288.75 out of a maximum total score of 369, yielding an overall percentage of 80.20%. In accordance with the practicality criteria, the Scratch medium meets the Practical criteria.

Furthermore, the effectiveness of the media in systematically improving students' numeracy literacy skills was measured by conducting a comprehensive comparison between the results obtained from the pretest administered before using the media and the posttest conducted after using the media. In the initial stage of hypothesis testing, the researcher conducted an assessment using SPSS to evaluate the normality of the test data, which served as the basis for determining the suitability of subsequent statistical analyses.

Table 16. Normality Test of Student Scores

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest Score	,163	30	,041	,956	30	,247
Posttest Score	,198	30	,004	,903	30	,010

The normality test was conducted using the Shapiro–Wilk test because the sample size was $n < 50$. The test results showed that the pretest data were normally distributed $(p = 0{,}247 > 0{,}05)$, whereas the posttest data were not normally distributed $(p = 0{,}010 < 0{,}05)$. Since one of the data groups did not meet the normality requirement, the hypothesis testing was switched to the non-parametric Wilcoxon test. The statistical hypotheses tested were as follows:

$H_0 : \mu_1 = \mu_2$ (There is no difference in numeracy literacy skills before and after using the Scratch learning medium)

$H_1 : \mu_1 \neq \mu_2$ (There is a difference in numeracy literacy skills before and after using the Scratch learning medium)

Hypothesis testing to measure the effectiveness of using the Scratch learning medium was conducted using the non-parametric Wilcoxon test in Table 17.

Table 17. Wilcoxon Test

Test Statistics[a]	
	Posttest Score - Pretest Score
Z	-4.704[b]
Asymp. Sig. (2-tailed)	,001

Hypothesis testing to measure the effectiveness of using Scratch media was conducted using the non-parametric Wilcoxon Signed Ranks Test. This test was selected based on the results of a prior normality test, which indicated that the data were not normally distributed. Based on the statistical analysis, the p-value $(\mathrm{Z} = -4{,}704)$ was $0.001 \mathrm{p} < 0{,}001 < \propto = 0{,}05.$ Therefore, the null hypothesis $((\mathrm{H}_0))$ was rejected, and the alternative hypothesis $((\mathrm{H}_\mathrm{a}).)$ was accepted. These results indicate that there is a statistically significant difference in students' numeracy literacy skills before and after the implementation of the Scratch medium.Z s also indicate that there is a direction of change, with post-test scores being significantly higher than pre-test scores. Thus, it can be concluded that the use of the Scratch medium is effective in significantly improving students' numeracy literacy. To measure the level of effectiveness and the magnitude of improvement in students' numeracy literacy after using the Scratch medium, an analysis was conducted using the N-Gain Score method.

Table 18. N-Gain Score

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Standard Deviation
NGain_Score	30	0.00	1.00	,6344	,26289
Valid N (listwise)	30				

Based on the data analysis results in Table 8, the mean N-Gain value was 0.6344 with a standard deviation of 0.26289. The minimum recorded N-Gain value was 0.00 and the maximum value reached 1.00 for a sample of 30 students. In accordance with the criteria for classifying N-Gain effectiveness, this achievement of 0.6344 falls within the range of$0{,}3 \leq \mathrm{g} \leq 0{,}7$, which is categorized as moderate effectiveness. These results indicate that the Scratch learning medium can provide a consistent and effective positive contribution in stimulating improvements in students' numeracy literacy skills in geometry.

Discussions

The development of the Scratch interactive learning medium in this study holds positive potential and can shift the paradigm from one based on rote memorization toward a more meaningful conceptual understanding. The primary obstacle faced by students is the abstract nature of geometry material. In static learning on a blackboard or in textbooks, the approach is not sufficiently adaptive to facilitate the visualization of the reconstruction of two-dimensional shapes. In this interactive Scratch learning medium, cognitive barriers are addressed through the provision of dynamic, interactive visual objects that students can manipulate directly. From a cognitive psychology perspective, this interactive visual presentation can help optimize students' memory function by balancing information into visual and auditory components.

The trend toward improved students' numeracy literacy skills post-intervention is demonstrated by the results of the non-parametric Wilcoxon statistical test, which confirms a statistically significant difference in academic performance between the pre-test and post-test. This effectiveness is reinforced by an average N-Gain of 0.6344, which can be classified as moderate. This index indicates that the Scratch learning medium contributes positively. This moderate level of effectiveness is also believed to stem from the Discovery Learning model, which serves as the foundation for designing activities within the medium. The characteristics of the test questions also focused on cognitive level C4, which requires contextual reasoning aligned with the components of the PISA assessment standards. Students' success in solving these reasoning challenges is confirmed by qualitative data from response questionnaires, which were significantly influenced by multimedia elements such as animations, the sequencing of content, and interactivity. These visual stimuli also contributed to students' learning motivation and interest during the problem-solving process.

Methodologically, this research and development effort aims to provide preliminary evidence regarding the impact of using interactive learning media, going beyond merely meeting the product validity criteria set by experts. The research subjects' familiarity with a highly digital ecosystem also serves as a key factor facilitating the implementation of this Scratch-based media in the field. However, the researchers acknowledge fundamental limitations in the effectiveness design of this study. The use of a One-Group Pretest-Posttest Design without including a control group as a comparison class constitutes the primary limitation in drawing robust, " " conclusions. Without a control class, the recorded increases in numeracy literacy scores and N-Gain scores cannot be absolutely claimed as the sole result of the Scratch-based media. Other external factors, such as students' emotional effects, test conditioning bias, or routine instructional interactions in the classroom, have the potential to influence the variability in students' scores. Therefore, the results of this study are limited to the scope of the sample studied and cannot be generalized to the broader population. In addition to limitations in the experimental design, this development study is also limited to the scope of the tested material, focusing solely on quadrilateral geometry. This limitation in the scope of the material was implemented to align with the duration and focus of the analysis of basic numeracy literacy indicators in schools. These methodological and content limitations can serve as an important foundation for future research that examines the testing of Scratch learning media, moving toward a full-scale experiment that can include a control group to more strictly isolate confounding variables.

CONCLUSION

Based on the research results and discussion, it can be concluded that the development of Scratch-based interactive learning media on quadrilateral geometry material meets the criteria for a quality product and has positive potential to support mathematics learning at the secondary school level. The Scratch media was categorized as highly valid, with an average media feasibility percentage of 95.90% and content feasibility of 96.33%, as assessed by experts and practitioners. The Scratch media also met practical criteria, with a student response questionnaire achievement rate of 80.20% during the field trial phase. Regarding the implementation of the Scratch media, it demonstrated a positive contribution to improving students' numeracy literacy at the class level under study. This was evidenced by the Wilcoxon test, which showed a statistically significant difference between pre- and post-intervention scores $((Z = -4{,}704; p < 0{,}001),$), and was further supported by an average N-Gain of 0.6344, which falls into the moderate category.

Given that this study has a scope limitation in the form of a One-Group Pretest-Posttest Design without involving a control group, the generalizability of this product's effectiveness remains limited to the characteristics of the sample studied. Based on these limitations, it is recommended to test the product on a larger scale by applying a full experimental method involving a control class so that the level of the media's effectiveness can be isolated and measured more rigorously. Additionally, it is suggested to develop and expand the scope of content in the Scratch interactive media, not limited to quadrilaterals but also covering other abstract mathematical topics such as triangles, geometric transformations, or three-dimensional shapes to test the consistency of the media's effectiveness across a more comprehensive range of content. Furthermore, the Scratch media can also serve as an alternative for interactive learning in understanding abstract geometric concepts.

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