The Development of Interactive Problem-Solving-Based Learning Media Supported by Scratch to Improve Fifth-Grade Elementary Students' Mathematical Critical Thinking Skills

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ARMADA
JURNAL PENELITIAN MULTIDISIPLIN

e-ISSN: 2964-2981

ARMADA : Jurnal Penelitian Multidisiplin

https://ejournal.45mataram.ac.id/index.php/armada

Vol. 04, No. 07 Juli, 2026

Page: 3117-3131

DOI:

https://doi.org/10.55681/armada.v4i7.3178

Article History:

Received: Mei 02, 2026

Revised: Juni 24, 2026

Accepted: Juli 18, 2026

Abstract *: This study aimed to identify valid, practical, and effective Scratch-assisted learning media based on problem solving and analyse students' learning trajectories during its use. The study employed a Research and Development approach using the Plomp model, comprising preliminary investigation, design, realisation, testing, evaluation, revision, and implementation. The participants were 15 Year 5 pupils at SDTK Pelita Hati. Data were collected through expert validation sheets, teacher and pupil questionnaires, mathematical critical-thinking tests, and Hypothetical Learning Trajectory analysis. The results showed that the media achieved very high validity, with an average score of 4.5 from content and media experts. Its practicality was also very high, indicated by scores of 4.5 from the teacher and 4.52 from pupils. The media improved mathematical critical-thinking ability, with the mean score rising from 39.67 in the pre-test to 78.67 in the post-test and an N-Gain of 0.65, categorised as moderate. The learning trajectory showed gradual development from problem identification and strategy formulation to problem solving and critical conclusion drawing. Therefore, Scratch-assisted media is suitable for improving primary pupils' mathematical critical-thinking skills.*

Keywords : Interactive Learning Media; Problem Solving; Scratch; Mathematical Critical Thinking; Learning Trajectory.

Abstrak *: Penelitian ini bertujuan mengidentifikasi karakteristik media pembelajaran interaktif berbantuan Scratch berbasis pemecahan masalah yang valid, praktis, dan efektif, serta menganalisis lintasan belajar siswa selama penggunaannya. Penelitian menggunakan pendekatan Research and Development dengan model Plomp yang mencakup investigasi awal, desain, realisasi, pengujian, evaluasi, revisi, dan implementasi. Subjek penelitian terdiri atas 15 siswa kelas V SDTK Pelita Hati. Data dikumpulkan melalui lembar validasi ahli, angket respons guru dan siswa, tes kemampuan berpikir kritis matematis, serta analisis Hypothetical Learning Trajectory. Data dianalisis secara deskriptif kuantitatif dan kualitatif. Hasil penelitian menunjukkan bahwa media memiliki validitas sangat tinggi dengan skor rata-rata 4,5 dari ahli materi dan media. Kepraktisan media juga sangat tinggi, ditunjukkan oleh skor respons guru 4,5 dan siswa 4,52. Media efektif meningkatkan kemampuan berpikir kritis matematis, dengan nilai rata-rata meningkat dari 39,67 pada pretest menjadi 78,67 pada posttest dan N-Gain sebesar 0,65 dalam kategori*

sedang. Lintasan belajar menunjukkan perkembangan bertahap dari identifikasi masalah, perumusan strategi, pelaksanaan pemecahan masalah, hingga penarikan kesimpulan kritis. Dengan demikian, media berbantuan Scratch layak digunakan untuk meningkatkan kemampuan berpikir kritis matematis siswa sekolah dasar.

***Kata Kunci** : Media Pembelajaran Interaktif; Pemecahan Masalah; Scratch; Berpikir Kritis Matematis; Lintasan Belajar.*

INTRODUCTION

The field of education is continuously evolving in response to changes in students' characteristics and needs, which develop alongside advancements in time and technology (Indiyanti & Sholihah, 2021). These changes are addressed through curriculum reform as a fundamental guideline for implementing education in schools. The Merdeka Curriculum has been widely adopted by the government through various initiatives, such as Sekolah Penggerak (Driving Schools), Guru Penggerak (Driving Teachers), and the establishment of professional learning communities. These efforts aim to ensure the effective and comprehensive implementation of the Merdeka Curriculum. This curriculum emphasizes student-centered learning and promotes open access to learning resources through the integration of technology and digitalization (Rahayu et al., 2022). Therefore, learning media should incorporate technological tools to foster creativity and innovation.

Learning media refer to all tools and resources used by teachers to support the learning process and facilitate students' understanding of instructional content (Khalil & Wardana, 2022). Hendi et al. (2020) define learning media as any instruments used to assist instruction in delivering structured and purposeful information aligned with learning objectives. Based on these definitions, learning media play a crucial role in facilitating effective learning. However, in practice, instructional media used by teachers still tend to be textbook-oriented and have not fully adapted to innovative digital approaches. This is supported by previous studies indicating that learning media often lack attractiveness and engagement for students (Sudihartinih et al., 2021; Ningrum et al., 2023; Rismayanti et al., 2022).

This phenomenon is further supported by observations and interviews conducted with a mathematics teacher and fifth-grade students at SDTK Pelita Hati. Student interviews revealed that teachers had used PowerPoint as a learning medium; however, students tended to feel bored because they only passively viewed presentation slides. Meanwhile, teacher interviews indicated that some educators still lack the ability to effectively utilize advanced technology to optimize interactive learning media. The media used remains limited to PowerPoint, which has limitations in developing students' critical thinking skills. Deviana & Sulistyani (2021) also found that the use of interactive, problem-solving-based learning media remains a challenge for teachers who have not yet fully mastered educational technology. This indicates that interactive mathematics learning media are still not widely implemented, despite evidence showing that the use of technology in learning media can improve educational quality (Khalil & Wardana, 2022; Wahyuni & Ananda, 2022; Monica & Pramudiani, 2022).

Based on the findings from observations and interviews, as well as previous research, it is essential to develop innovative learning media that leverage digital technology. One such innovation is the Scratch application. Scratch is a programming language that enables users to easily create interactive stories, games, and animations, as well as share their creations online (Rusilowati et al., 2019). Scratch is simple and user-friendly, making it suitable for elementary school students. Despite its simplicity, Scratch is considered an effective learning medium (Sudihartinih et al., 2021). Its use is expected to provide a more engaging learning experience for students. Mathematics learning, which was previously perceived as monotonous due to passive slide-based instruction, can become more interactive and challenging by actively involving students

in problem-solving activities. The following are examples of mathematics games that can be developed using the Scratch application.

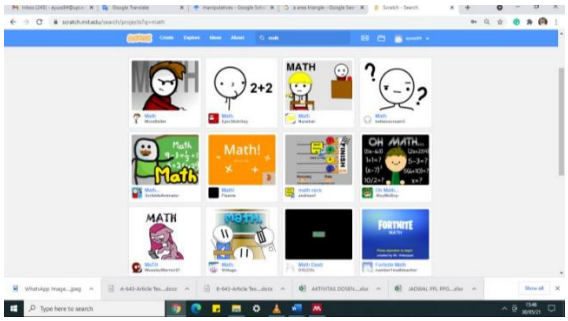

Figure 1. Examples of Mathematics Games Available at https://scratch.mit.edu/search/projects?q=math
(Source: Sudihartinih et al., 2021)

The use of innovative instructional media such as Scratch has been shown to improve students' mathematical critical thinking skills (Agung et al., 2023). Mathematical critical thinking is an essential cognitive skill that students need to develop in order to face future academic and real-life challenges (Monica & Pramudiani, 2022). It refers to the process of reasoning and drawing conclusions about what to believe and what actions should be taken. In a mathematical context, critical thinking involves processing information through knowledge, reasoning, and mathematical proof to solve problems effectively (Indiyanti & Sholihah, 2021). This skill plays a vital role in mathematics learning, as students with high achievement are generally considered to possess strong critical thinking abilities (Hidayah et al., 2023).

However, observations of fifth-grade students at SDTK Pelita Hati indicate that their mathematical critical thinking skills remain low. A preliminary test administered to 28 students showed an average score of 58.21, with a classical mastery level of only 39.29%. Only 11 students achieved scores above the Minimum Learning Mastery Criteria (KKTP), set at 75. In addition, students experienced difficulties in identifying key information, analyzing problems, applying logical reasoning, and drawing conclusions in mathematical problem-solving tasks. These findings suggest the need for more innovative and interactive learning media to enhance students' critical thinking skills. This study aims to develop a problem-solving-based interactive learning medium supported by Scratch to improve students' mathematical critical thinking skills. Several previous studies have explored Scratch-based learning media. Sunarti & Rusilowati (2021) developed Scratch-based STEM learning media, while Nurhasanah et al. (2023) designed Scratch-based teaching materials for quadrilaterals and triangles, both of which showed positive results in mathematics learning. Negoro et al. (2023) examined the relationship between technology-based media and critical thinking skills, and Safitri et al. (2021) found that inquiry-based modules can enhance critical thinking abilities.

Unlike previous studies, this research focuses specifically on problem-solving-based interactive learning media supported by Scratch, requiring deeper student engagement. Scratch is used as the main platform to design interactive learning experiences that are more creative, contextual, and relevant to digital-era learning needs. This study is expected to produce an innovative digital learning product that is easy for teachers and students to use, particularly in the implementation of the Merdeka Curriculum. It can also serve as an alternative solution for teachers who face difficulties in developing interactive learning media. The relationship between Scratch-based problem-solving learning media and mathematical critical thinking skills is important to investigate due to curriculum changes and the demands of the digital era. The Merdeka Curriculum emphasizes student-centered and differentiated learning (Aprima & Sari, 2022). Students who prefer active learning are less suited to passive, text-based instruction and require more engaging and problem-oriented learning experiences (Fahlevi, 2022).

Scratch-based problem-solving learning media can enhance critical thinking by engaging students in structured stages such as understanding problems, planning solutions, implementing strategies, and evaluating results. Scratch also allows mathematical concepts to be presented through interactive simulations and animations, enabling students to explore multiple solution strategies independently. This aligns with critical thinking skills that involve analyzing, evaluating, and justifying decisions (Indiyanti & Sholihah, 2021; Monica & Pramudiani, 2022). In addition, Scratch provides immediate feedback, allowing students to correct errors and refine their solutions through reflection. This iterative process strengthens their ability to think logically and systematically (Agung et al., 2023; Hidayah et al., 2023). Previous studies also support the effectiveness of combining problem-solving models with digital media in improving higher-order thinking skills. Agung et al. (2023) found that Scratch-based Problem-Based Learning improved students' critical thinking skills. Khalil & Wardana (2022) also reported that Scratch-based learning media enhances HOTS in elementary students.

Furthermore, Hendi et al. (2020) and Hidayah et al. (2023) confirmed that interactive digital learning media significantly improve students' critical thinking abilities. Although students' low critical thinking skills are a central issue, the development of appropriate learning media is essential because instructional media play a key role in creating meaningful learning experiences. The limitations in current teaching practices indicate the need for more engaging and innovative digital learning tools. Therefore, based on these issues, this study focuses on "The Development of Interactive Problem-Solving-Based Learning Media Supported by Scratch to Improve Fifth-Grade Elementary Students' Mathematical Critical Thinking Skills."

METHODS

This study employed a Research and Development (R&D) approach aimed at producing an interactive problem-solving-based learning medium supported by Scratch that is valid, practical, and effective in enhancing the mathematical critical thinking skills of fifth-grade students at SDTK Pelita Hati. The participants consisted of one teacher and 15 fifth-grade students. The research was conducted in the second semester of the 2025/2026 academic year. The development process followed the Plomp model, which includes five systematic phases: preliminary investigation, design, construction (realization), evaluation and revision, and implementation. The developed learning media was designed with key characteristics such as problem-solving-oriented content, interactive visual presentation, and instructional support intended to stimulate students' critical thinking abilities. Data collection techniques involved questionnaires and tests. These instruments included expert validation sheets to assess product validity, user response questionnaires to measure practicality, and pretest–posttest assessments to evaluate the effectiveness of the media in improving students' mathematical critical thinking skills.

RESULTS AND DISCUSSIONS

Research Results

Results Of The Plomp Model Stages

The Preliminary Investigation phase represents the initial step of the Plomp development model, which focuses on identifying learning needs, student characteristics, learning materials, and problems encountered in mathematics instruction. This stage was carried out through classroom observations, interviews with teachers, and document analysis of learning resources used at SDTK Pelita Hati. The observation results showed that mathematics learning on the topics of angles and plane figures was still predominantly delivered through lectures and textbook-based instruction. The learning process remained largely teacher-centered, resulting in limited student engagement in knowledge construction. Students mostly received information passively rather than actively participating in problem-solving activities. This condition led to difficulties when students were confronted with tasks requiring reasoning and critical thinking.

Analysis of students' mathematical critical thinking skills revealed that most students struggled to identify key information, analyze problems, provide logical justification for their answers, and draw conclusions from their solutions. When given contextual problems, students

tended to rely heavily on teacher guidance and were not yet able to independently develop problem-solving strategies. These findings indicate that students' mathematical critical thinking skills still need significant improvement. Interviews with teachers further indicated that learning media were still limited to textbooks, worksheets, and verbal explanations. The use of technology-based interactive media had not been optimally implemented. Teachers noted that students showed higher engagement when learning involved visual elements such as images, animations, and interactive activities. Based on this needs analysis, there is a strong requirement for learning media that supports active, engaging, and problem-solving-oriented instruction. Therefore, an interactive Scratch-supported problem-solving learning media was developed for the topic of angles and plane figures, with the expectation of improving fifth-grade students' mathematical critical thinking skills at SDTK Pelita Hati. The Design phase involved planning the learning media based on findings from the preliminary investigation stage. At this stage, the Scratch-based interactive learning media was designed, including interface layout, menu structure, learning content, learning activities, research instruments, and the Hypothetical Learning Trajectory (HLT).

The media design began with the creation of a flowchart illustrating menu navigation and system interaction. The media consists of three main menus: Play, Material, and About. The Play menu includes two main activities, namely Creating Plane Figures and Starting an Adventure, both designed to develop conceptual understanding and problem-solving skills. The Material menu provides interactive explanations of angles and plane figures, while the About menu contains information about the developer. Learning materials were developed in alignment with fifth-grade mathematics learning objectives, covering the introduction of angles, types of angles, and various plane figures along with their properties. The materials were presented in a gradual sequence supported by illustrations, animations, and problem-solving exercises. In addition, research instruments were developed, including expert validation sheets, teacher and student practicality questionnaires, and tests of mathematical critical thinking skills. These instruments were used to evaluate the validity, practicality, and effectiveness of the developed media.

The Design phase also produced an initial Hypothetical Learning Trajectory (HLT), which includes learning objectives, learning activities, and predicted student responses during the learning process. This HLT serves as a guide for implementation and as an analytical framework for examining students' learning trajectories.

Overview Of Scratch-Based Learning Media

The developed interactive learning media emphasizes student autonomy through a structured navigation system that allows full control over the learning process. Students are not passive recipients but active participants who interact directly using keyboard and mouse inputs to control characters, construct geometric shapes through algorithmic logic, and determine their learning pathways. This interactivity is strengthened by immediate feedback, where every student action—such as answering quizzes, arranging code blocks, or completing tasks—is responded to instantly through score updates, correctness indicators, and animations. This creates a dynamic learning environment that enables students to continuously evaluate their understanding of mathematical concepts. The integrated navigation system allows students to learn at their own pace, providing flexibility to switch between learning modes, materials, and evaluation activities. In the "Creating Plane Figures" mode, students construct logical sequences using block-based coding, which the system translates into geometric visualizations. In the "Start Adventure" mode, students engage in real-time decision-making while navigating challenges and collecting items to earn scores. This structure ensures that students have full control over their learning experience, thereby increasing motivation and engagement.

The pedagogical strength of this interactivity is reflected in the seamless transition between learning materials and evaluation activities. After studying the content, students are directed to assessment tasks that require critical thinking and quick decision-making. Feedback provided through True/False responses serves not only as confirmation but also as a reflective tool that helps students evaluate their understanding independently. By integrating input mechanisms, immediate feedback, and self-directed navigation, the media transforms abstract mathematical concepts into an engaging, measurable, and student-centered learning experience suitable for fifth-grade

learners. The main interface of the learning media is designed with a fantasy adventure theme to attract fifth-grade students, who generally prefer colorful and dynamic visual environments. The background features a castle setting with gray stone walls and a large dark-brown gate, creating an adventurous atmosphere that encourages students to explore the learning content further.

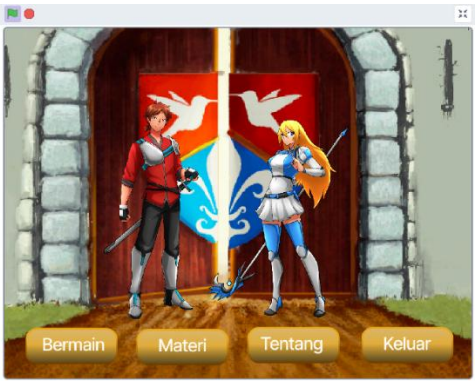

Figure 2. Main Menu

When students click the Play button on the main page, they are directed to the game mode selection screen. This page is designed with an outdoor natural environment featuring a dense green forest background, a reddish-brown pathway, and a distant red-roofed castle located on the right side of the screen. This visual setting reinforces the adventure theme that underlies the learning media. In the top-right corner, there is a gold castle icon that functions as a navigation button to return to the main menu. On this page, students are presented with two game mode options displayed as brown diamond-shaped buttons with white text, namely Create Plane Shapes and Start Adventure.

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Create Plane Shapes Mode

The first mode, Create Plane Shapes, presents a creative exploration activity that encourages students to think systematically. The interface in this mode uses a background resembling textured cream-yellow paper, creating the impression of an interactive canvas or digital sketchbook where students can construct and explore geometric concepts.

Figure 3. Create Plane Shapes Menu

At the top-center of the screen, a short instruction appears in a speech bubble stating, “Press the pencil and draw, press 0 to stop,” accompanied by a pencil sprite that students can control using the keyboard. It is important to note that in this mode, the construction of angles and sides of plane shapes is not carried out through manual drawing or physical measurement tools, but rather through block-based programming commands. Students are required to arrange logical scripts, such as move blocks to define side lengths and turn blocks to determine angle measurements. Through this approach, the accuracy of shape construction, including dimensions and symmetry, is fully governed by the program logic created by the students. This eliminates limitations related to manual drawing skills, such as uneven lines or unstable hand movements. In other words, if the resulting shape is inaccurate, it reflects an error in the student’s programming logic rather than a limitation in drawing ability.

At the bottom-left section, a male character in red armor reappears in a circular profile icon with a dialogue bubble stating, “Create plane shapes using the pencil.” This activity encourages students to independently construct various geometric shapes in a logical and measurable way. It is designed to foster critical thinking and conceptual understanding of geometry through interactive, exploratory, and programming-based learning.

Start Adventure Mode

The second mode, Start Adventure, represents the main problem-solving component of the learning media. In Level 1, for example, students enter a maze environment with a dark gray background and lighter gray pathways that guide the character’s movement. Along the maze path, various red geometric shapes such as triangles, squares, and rhombuses are placed as collectible items. In the top-left corner, a Score indicator displays the points earned by the student, while the bottom-right corner features a black-and-white checkered flag marking the finish line. The player character is represented by a small male figure in red attire, which students can control to navigate through the maze. Level 2 introduces a more challenging and visually enriched environment. The background changes into a bright green field resembling grassland, while the maze path becomes wider and more complex. Additional visual elements appear, such as pixel-style green trees as decorative features and blue slime-like creatures that function as obstacles to be avoided. Red geometric shapes, including triangles, squares, and rhombuses, remain distributed along the path as collectible objects. The Score indicator is still located in the top-left corner, and the finish line is positioned on the right side of the screen to indicate the end of the level. Additional levels are also available with increasing difficulty. When students click the Materials button on the main page, they are directed to a learning interface that presents mathematical content in an interactive and step-by-step manner through a series of slides.

Figure 4. Materials Menu

The Materials page features a pixel-art night castle background with a fantasy theme, accompanied by a female guide character on the left side. Learning content is presented on a

parchment-style scroll, with a title "Angle Material" at the top and a castle icon for navigation. After completing the learning slides, the system automatically transitions to a quiz section using the same visual design, with questions displayed on the scroll to indicate a shift from learning to assessment.

Figure 5. Quiz In Materials Menu

The quiz is designed in a True or False format, where students evaluate a given mathematical statement by deciding whether it is correct or incorrect. For example, one item states: *"An angle is a region formed by two straight lines that intersect at a point."* At the bottom of the parchment interface, two gold-colored buttons are provided: "True" on the left and "False" on the right, allowing students to respond directly. This format is simple yet effective for assessing conceptual understanding while simultaneously training students' critical thinking skills in evaluating mathematical statements. When students click the About button on the main page, they are directed to a page containing information about the developer of the learning media. This page maintains the same visual theme as the home screen, featuring a castle gate background with gray stone walls and a dark red wooden door to ensure visual consistency. A gold castle icon in the top-right corner functions as a navigation button to return to the main menu.

The main content is displayed in a centered rectangular information card with rounded corners and a light yellow color. This card contains two main sections of information. The interactive learning media was developed using the Scratch platform as a final thesis project by Ni Kadek Ayu Sudiasih from the Graduate Program in Mathematics Education, Universitas Pendidikan Ganesha, Singaraja, in 2026. It is designed for fifth-grade elementary school students, focusing on angles and plane figures, and incorporates a problem-solving approach across all features to enhance students' mathematical critical thinking skills.

Overall, the media adopts a consistent fantasy-adventure theme with an anime-inspired visual style from the beginning to the end. This design choice is not merely aesthetic but serves a pedagogical purpose by increasing students' intrinsic motivation. The castle environments, armored guide characters, parchment-style elements, and pixel-art graphics create an engaging and immersive learning atmosphere that differs from conventional instructional materials. The color palette dominated by gold, red, blue, and bright green provides a visually balanced and appealing experience suitable for fifth-grade students.

Learning Media Validation Results

Material Expert Validation Results

The material expert validation was conducted to evaluate the relevance and suitability of the content, the correctness of mathematical concepts, and the extent to which the learning media aligns with indicators of students' mathematical critical thinking skills.

Table 1. Material Expert Validation Results

No	Assessment Aspect	Score
1	Alignment of material with learning objectives	5
2	Accuracy of mathematical concepts	5
3	Suitability of material with students' level	4
4	Clarity of material presentation	4
5	Alignment of questions with critical thinking indicators	5
6	Relevance of examples to daily life	4
7	Ease of understanding the material	4
8	Appropriateness of language use	5
9	Suitability of learning evaluation	4
10	Clarity of usage instructions	5
	Total	45
	Average	4.5
	Category	Highly Valid

Source: Research Data Processed

Based on Table 1, the total score achieved is 45 with an average score of 4.5. These findings show that the Scratch-based interactive learning media is categorized as highly valid. This indicates that the content is well aligned with the learning objectives, suitable for the characteristics of fifth-grade elementary school students, and effective in supporting the development of students' mathematical critical thinking skills.

Media Expert Validation Results

Media expert validation was carried out to assess the feasibility of the designed learning media. The evaluated aspects include visual design, animation quality, interactivity, navigation system, and the overall ease of use of the Scratch-based learning media.

Table 2. Media Expert Validation Results

No	Assessment Aspect	Score
1	Attractiveness of media display	5
2	Appropriateness of color combination	4
3	Quality of images and animations	5
4	Ease of media use	4
5	Clarity of navigation	4
6	Suitability of font size	5
7	Media interactivity	5
8	Alignment with student characteristics	4
9	Clarity of buttons and menus	4
10	Appropriateness of Scratch utilization	5
	Total	45
	Average	4.5
	Category	Highly Valid

Source: Research Data Processed

Based on Table 2, the total score reached 45 with an average value of 4.5. These results show that the Scratch-based interactive learning media falls into the highly valid category. The developed media has an appealing design, is user-friendly, and is well suited to the characteristics of elementary school students.

Learning Media Practicality Test Results

Teacher Practicality Test Results

Table 3. Teacher Practicality Test Results

No	Assessment	Score
1	The media is easy to use in learning activities	4
2	The media helps explain the material	5
3	The media increases student engagement	4
4	The media display is attractive	5
5	The media helps students understand concepts	4
6	The usage instructions are easy to understand	4
7	The media aligns with learning objectives	5
8	The media makes learning more enjoyable	5
9	The media is easy to operate	4
10	The media is feasible for classroom use	5
	Total	45
	Average	4.5
	Category	Very Practical

Source: Research Data Processed

Based on the results of the teacher practicality test, the average score achieved was 4.5, which is classified as highly practical. This suggests that the Scratch-based learning media is user-friendly and effectively supports teachers in delivering mathematics instruction.

Student Practicality Test Results

The results of the student practicality test were collected through a student response questionnaire administered after students used the Scratch-based learning media.

Table 4. Student Practicality Test Results

No	Assessment	Average Score
1	The learning media is interesting	4.6
2	The media is easy to use	4.4
3	Animations help in understanding the material	4.5
4	Learning becomes enjoyable	4.7
5	The questions are easy to understand	4.3
6	The media makes me more active in learning	4.4
7	The media helps in understanding plane shapes	4.5
8	The media display is not boring	4.6
9	I am interested in learning using Scratch	4.5
10	The media is feasible for use in learning	4.7
	Total	45.2
	Average	4.52
	Category	Very Practical

Source: Processed Research Data

Based on Table 4, the mean score obtained is 4.52, which is categorized as highly practical. These findings show that the Scratch-based interactive learning media is engaging, easy to operate for students, and effective in enhancing their interest in learning mathematics.

Average Scores of Pretest and Posttest

To evaluate the effectiveness of the Scratch-assisted, problem-solving-based interactive learning media in improving students' mathematical critical thinking skills, an analysis of pretest and posttest results was carried out. The pretest was conducted before students used the learning media, while the posttest was administered after the learning process using the Scratch-based media had been completed. The average scores of the students' pretest and posttest are presented in the following graph.

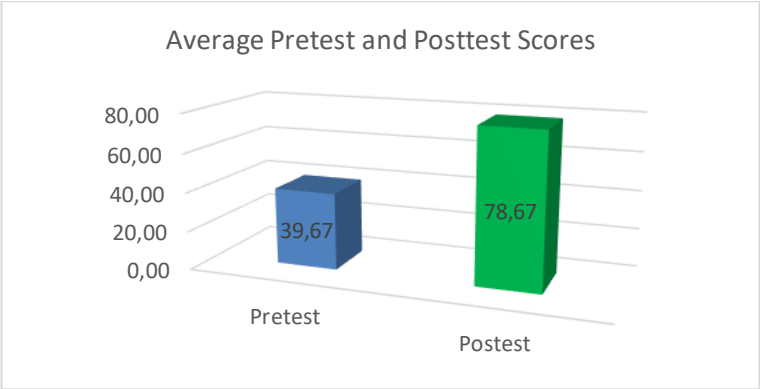

Figure 6. Average Pretest and Posttest Scores

Based on the pretest and posttest results, there is a clear improvement in students' mathematical critical thinking skills after using the Scratch-based learning media. The average pretest score, which was 39.67, increased significantly to 78.67 in the posttest. These results suggest that the Scratch-assisted, problem-solving-based interactive learning media is effective in helping students understand the concepts of angles and plane shapes, thereby improving their mathematical critical thinking abilities.

Effectiveness of Scratch-Based Learning Media

The effectiveness of the Scratch-assisted, problem-solving-based interactive learning media was evaluated using pretest and posttest results of students' mathematical critical thinking skills. The data were further analyzed using the N-Gain formula to measure the extent of improvement in students' mathematical critical thinking skills after using the Scratch-based learning media.

Table 5. N-Gain Results

Student	Pretest	Posttest	N-Gain	Category
S-1	45	85	0.73	High
S-2	45	80	0.64	Medium
S-3	45	80	0.64	Medium
S-4	40	80	0.67	Medium
S-5	40	80	0.67	Medium
S-6	45	80	0.64	Medium
S-7	35	80	0.69	Medium
S-8	40	75	0.58	Medium
S-9	45	80	0.64	Medium
S-10	40	75	0.58	Medium
S-11	30	70	0.57	Medium
S-12	40	75	0.58	Medium
S-13	40	80	0.67	Medium
S-14	40	80	0.67	Medium
S-15	25	80	0.73	High
Average	39.67	78.67	0.65	Medium

Source: Processed Research Data

Based on Table 5, the mean pretest score is 39.67, while the mean posttest score increases to 78.67. These findings demonstrate an improvement in students' mathematical critical thinking skills after the implementation of the Scratch-assisted, problem-solving-based interactive learning media. In addition, the N-Gain analysis shows an average score of 0.65, which is classified as moderate. This indicates that the Scratch-based learning media is effective in enhancing the mathematical critical thinking abilities of fifth-grade students at SDTK Pelita Hati.

Instrument Testing

Validity Test

The validity test was carried out to assess the validity level of the instrument used to measure students' mathematical critical thinking skills. This test employed the product-moment correlation method by comparing the calculated value (r_count) with the critical value (r_table). An instrument is considered valid when r_count is greater than r_table. Based on 15 student respondents, the r_table value obtained was 0.5140.

Table 6. Validity Test

Item	r_count	r_table	Validity
Item_1	0.891	0.5140	Valid
Item_2	0.891	0.5140	Valid
Item_3	0.891	0.5140	Valid
Item_4	0.891	0.5140	Valid
Item_5	0.891	0.5140	Valid
Item_6	0.540	0.5140	Valid
Item_7	0.908	0.5140	Valid
Item_8	0.741	0.5140	Valid
Item_9	0.908	0.5140	Valid
Item_10	0.772	0.5140	Valid
Item_11	0.908	0.5140	Valid
Item_12	0.727	0.5140	Valid
Item_13	0.948	0.5140	Valid
Item_14	0.490	0.5140	Valid
Item_15	0.891	0.5140	Valid
Item_16	0.891	0.5140	Valid
Item_17	0.891	0.5140	Valid
Item_18	0.540	0.5140	Valid
Item_19	0.690	0.5140	Valid
Item_20	0.741	0.5140	Valid

Source: Research Data Processing

Based on Table 6, all items show r_count values higher than the r_table value (0.5140); therefore, every item is classified as valid. These findings indicate that the instrument used to measure students' mathematical critical thinking skills is suitable for use in this study to assess the critical thinking abilities of fifth-grade students at SDTK Pelita Hati.

Reliability Test

The reliability test was conducted to examine the consistency of the instrument used to measure students' mathematical critical thinking skills. This test employed the Cronbach's Alpha coefficient with the assistance of SPSS version 22 software. An instrument is considered reliable when the Cronbach's Alpha value exceeds 0.70.

Table 7. Reliability Test

Reliability Statistics	Cronbach's Alpha	N of Items
	0.960	20

Source: SPSS 22 Output

Based on Table 7, the Cronbach's Alpha value is 0.960 with a total of 20 items. This value exceeds the threshold of 0.70, indicating that the instrument used to measure students' mathematical critical thinking skills is highly reliable. Therefore, the instrument demonstrates a very high level of internal consistency and is appropriate for use in this study.

Analysis of Hypothetical Learning Trajectory (HLT)

This section presents a comparison between the Hypothetical Learning Trajectory (HLT) designed at the planning stage and the Actual Learning Trajectory (ALT) that occurred during implementation. The analysis primarily focuses on students' thinking processes in developing their understanding of angles and plane figures through the use of Scratch-based media.

Table 8. Analysis of Thinking Process per Activity

Activity	HLT (Predicted Thinking Process)	ALT (Actual Implementation)
Activity 1: Exploring Angles	Students are expected to engage in trial and error by rotating objects in Scratch to understand angle magnitude.	Students encountered difficulties with the clockwise rotation direction but were able to reflect and correct their understanding after using the animation simulation.
Activity 2: Analyzing Plane Figures	Students are expected to identify the properties of plane figures through interactive simulations.	Students not only identified the properties but were also able to verbally express relationships among the sides of plane figures.

Based on the findings obtained, the learning process progressed through four interconnected stages: action, formulation, validation, and institutionalization. During the action stage, students interacted directly with the Scratch-based learning media and independently explored possible solutions when they encountered difficulties. This finding differed from the initial Hypothetical Learning Trajectory, which predicted that students would tend to be passive. The Actual Learning Trajectory instead showed that students demonstrated strong initiative by experimenting with various simulation features available in Scratch. In the formulation stage, students gradually developed their own patterns of mathematical thinking. For example, when identifying different types of angles, they no longer relied solely on memorized definitions but constructed their understanding through visual experiences provided by Scratch animations, such as recognizing that a more upright configuration represented a right angle.

During the validation stage, students confirmed their understanding through the immediate visual feedback generated by Scratch. When their answers or approaches were incorrect, the simulations encouraged them to reconsider, revise, and improve their problem-solving strategies. Finally, the institutionalization stage facilitated the transition from informal visual understanding to formal mathematical knowledge. At this stage, the teacher guided students in connecting their experiences with Scratch simulations to established mathematical concepts. For instance, the idea of object rotation in Scratch was formally related to the concepts of angles and degrees.Overall, the comparison between the Hypothetical Learning Trajectory (HLT) and the Actual Learning Trajectory (ALT) shows that the learning process of Grade V students at SDTK Pelita Hati developed in a structured manner. Initially, students demonstrated limited procedural understanding; however, through a series of Scratch-based learning activities, their thinking progressed toward more analytical and inferential abilities.

CONCLUSIONS

Based on the research and development findings, the interactive problem-solving-based learning media supported by Scratch for Grade V students at SDTK Pelita Hati met the criteria of validity, practicality, and effectiveness in enhancing students' mathematical critical thinking skills. The material expert validation produced an average score of 4.5, which was categorized as highly valid, while the media expert validation also obtained an average score of 4.5 and was classified in the same category. In terms of practicality, the teacher assessment resulted in an average score of 4.5, indicating that the media was highly practical, while the students' responses reached an average score of 4.52, which was also categorized as highly practical. The effectiveness of the developed media was demonstrated by the increase in students' mean score from 39.67 on the pretest to 78.67 on the posttest, representing a 98.31% improvement from the initial score.

The N-Gain score of 0.65, which falls within the moderate category, further indicates that the learning media effectively supported the improvement of students' mathematical critical thinking skills. These findings were consistent with the Hypothetical Learning Trajectory, which described students' gradual progression from basic conceptual understanding to higher-order thinking processes, including analyzing information, evaluating problem-solving strategies, and drawing conclusions. Through exploratory activities using Scratch, students were able to engage actively with mathematical problems, test different strategies, receive immediate feedback, and refine their understanding. Therefore, the developed Scratch-supported interactive problem-solving media can be considered valid, practical, and effective in facilitating the development of mathematical critical thinking skills among Grade V students at SDTK Pelita Hati.

ACKNOWLEDGMENTS

The authors would like to express sincere gratitude to all individuals and institutions who contributed to the completion of this research. Appreciation is extended to colleagues who provided valuable suggestions, guidance, and encouragement throughout the research process. Special thanks are also given to all participants and respondents for their willingness and time in supporting this study. In addition, gratitude is directed to the institutions that facilitated and supported the implementation of this research. All forms of assistance and collaboration greatly contributed to the success and smooth completion of this work.

REFERENCES

Agung, G. H., Amalia, I. R., Faizah, N. A., & Satrio, A. (2023). Problem Based Learning berbantuan Scratch bernuansa etnomatematika Cagar Budaya Kota Semarang terhadap kemampuan berpikir kritis siswa. *Prisma*, 2(1), 670–675.

Aprima, D., & Sari, S. (2022). Analisis penerapan pembelajaran berdiferensiasi dalam implementasi Kurikulum Merdeka pada pelajaran matematika SD. *Cendikia: Media Jurnal Ilmiah Pendidikan*, 13(1), 95–101.

Deviana, T., & Sulistyani, N. (2021). Analisis kebutuhan pengembangan e-modul matematika HOTS berorientasi kearifan lokal daerah di kelas IV sekolah dasar. *JP2SD: Jurnal Pemikiran dan Pengembangan Sekolah Dasar*, 9(2), 158–172.

Fahlevi, M. R. (2022). Kajian project based blended learning sebagai model pembelajaran pasca pandemi dan bentuk implementasi Kurikulum Merdeka. *Sustainable*, 5(2), 230–249.

Hendi, A., Caswita, & Haenilah, E. Y. (2020). Pengembangan media pembelajaran interaktif berbasis strategi metakognitif untuk meningkatkan kemampuan berpikir kritis siswa. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 4(2), 823–834.

Hidayah, N., Utami, R. E., & Albab, I. U. (2023). Pengembangan media pembelajaran berbantu Smart Apps Creator untuk meningkatkan kemampuan berpikir kritis matematis siswa. *Imajiner: Jurnal Matematika dan Pendidikan Matematika*, 5(2), 156–166.

Indiyanti, & Sholihah, U. (2021). Pengembangan media presentasi berbasis animasi untuk meningkatkan kemampuan berpikir kritis matematis siswa MTs. *Jurnal Inovasi dan Riset Akademik*, 2(6), 792–803.

Khalil, N. A., & Wardana, M. R. (2022). Pengembangan media pembelajaran matematika menggunakan aplikasi Scratch untuk meningkatkan higher order thinking skill siswa sekolah dasar. *Jurnal Kiprah Pendidikan*, 1(3), 121–130.

Monica, T., & Pramudiani, P. (2022). Pengembangan multimedia interaktif berbasis Google Slide dalam meningkatkan kemampuan berpikir kritis siswa materi luas bangun datar kelas IV sekolah dasar. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 6(2), 2228–2239. https://doi.org/10.31004/cendekia.v6i2.1457

Negoro, R. A., Rusilowati, A., & Aji, M. P. (2023). Scratch-assisted waves teaching materials: ICT literacy and students' critical thinking skills. *Journal of Turkish Science Education*, 20(1), 189–210.

Ningrum, N. I., Akhdinirwanto, R. W., Fatmaryanti, S. D., Eko, & Kurniawan, S. (2023). Pengembangan media pembelajaran fisika berbantuan Scratch untuk meningkatkan

kemampuan problem solving peserta didik. *Jurnal Pendidikan Fisika dan Sains*, 6(1), 32–41.

Nurhasanah, E., Bernard, M., & Fitriani, N. (2023). Pengembangan bahan ajar saintifik berbantuan Scratch pada materi segiempat dan segitiga. *Jurnal Pembelajaran Matematika Inovatif*, 6(4), 1537–1546. https://doi.org/10.22460/jpmi.v6i4.18406

Rahayu, R., Rosita, R., Rahayuningsih, Y. S., Hernawan, A. H., & Prihantini, P. (2022). Implementasi Kurikulum Merdeka Belajar di Sekolah Penggerak. *Jurnal Basicedu*, 6(4), 6313–6319. https://doi.org/10.31004/basicedu.v6i4.3237

Rismayanti, T. A., Anriani, N., & Sukirwan. (2022). Pengembangan e-modul berbantu Kodular pada smartphone untuk meningkatkan kemampuan berpikir kritis matematis siswa SMP. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 6(1), 859–870.

Rusilowati, A., Subali, M. P. A., & Negoro, R. A. (2019). Development of teaching materials for momentum assisted by Scratch: Building the pre-service teacher's skills for 21st century and industry revolution. *Journal of Physics: Conference Series*, 1567(2), 022010. https://doi.org/10.1088/1742-6596/1567/2/022010

Safitri, W. L., Darma, Y., & Haryadi, R. (2021). Pengembangan modul pembelajaran dengan metode inkuiri segi empat dan segitiga siswa SMP. *Jurnal Numeracy*, 8(1), 25–40.

Sudihartinih, E., Novita, G., & Rachmatin, D. (2021). Desain media pembelajaran matematika topik luas daerah segitiga menggunakan aplikasi Scratch. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 5(2), 1390–1398.

Sunarti, S., & Rusilowati, A. (2021). Pengembangan bahan ajar digital gerak melingkar berbantuan Scratch berbasis Science, Technology, Engineering, and Mathematics. *Unnes Physics Education Journal*, 9(3), 1–8.

Wahyuni, D. Q., & Ananda, R. (2022). Pengembangan media pembelajaran matematika interaktif berbasis Android pada materi bentuk aljabar. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 6(1), 859–872.