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Development of Learning Media Based on Scratch Educational Games for Straight Line Equation

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Abstract. *Rapid technological developments in the 21st century have encouraged the use of digital media in mathematics learning. Using technology-based interactive learning materials is one way to enhance student learning results. This study was conducted at a public junior high school in Rambipuji, Jember, East Java, Indonesia, to develop and test Fly and Count, a Scratch-based learning medium that is valid, practical, and effective in enhancing learning outcomes. The ADDIE development model, which comprises the phases of analysis, design, development, implementation, and evaluation, was applied in this study. A validation sheet, a practicality questionnaire, and a learning outcome test on the subject of straight line equation were among the tools utilized. The results showed that the media was highly valid according to subject matter experts (87.14%) and valid according to media experts (66.66%). The practicality test showed very practical responses from teachers (88%) and students (90.33%). The effectiveness test showed an increase in student learning outcomes with an N-Gain score of 0.69 (moderate category). Thus, Fly and Count is declared valid, practical, and effective for use as a learning medium for straight line equation.*

Keywords: *educational games, learning media, straight line equation, scratch*

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Introduction

Advancements in information and communication technology are causing significant changes in education in the twenty-first century (Ishak et al., 2021; Singh et al., 2025). In addition to speeding up the flow of information, technology influences how people, particularly students, interact, acquire knowledge, and learn (Vaknin-Nusbaum & Rachevski, 2024). These developments necessitate an update to learning strategies that utilize technology's ability to produce more current learning procedures. The transition from conventional media to interactive digital media, reflecting the transformation of learning in the digital age, can be implemented through the use of digital educational games that combine entertainment and education to present material interactively (Rasti-Behbahani & Shahbazi, 2022; Vlachopoulos & Makri, 2017). The traits of the digital native generation, who are used to utilizing digital gadgets in their everyday lives, make this medium ideal (Ishak et al., 2021).

Educational games have been proven effective in mathematics learning, a subject often considered difficult and boring by most students (Russo et al., 2025), as they make learning

more engaging and enjoyable (Chowdhury et al., 2024). One platform with potential for developing educational games is Scratch, a visual programming platform developed by the MIT Media Lab, designed to allow users to easily create animations, interactive stories, and educational games through easy-to-use code blocks (Ouahbi et al., 2015; Wen et al., 2023). Scratch was chosen because it has an intuitive, drag-and-drop interface, making it suitable for teachers without advanced programming skills (Chowdhury et al., 2024). This platform is also free, accessible both online and offline, and features an active global community that makes it easy to share and draw inspiration from other users (Robles et al., 2025).

Scratch is crucial for learning mathematics because it can deliver content as an engaging and dynamic instructional game (Fang et al., 2023). According to Nadiyah and Faaizah (2015) and Waiyakoon et al. (2015), scratch allows students to study enjoyably, overcome difficulties, and receive instant feedback from learning activities, all of which contribute to improving mathematics learning outcomes. Previous studies have shown the potential of Scratch as an interactive learning medium (Haliza, 2023; Muhtarom et al., 2022; Siregar, 2024). However, some Scratch-based media that is still available still have limitations, some of which include not fully integrating educational aspects with game flow, a lack of feedback in the form of scores without clear visual reinforcement, and media testing that only evaluates validity and practicality aspects without involving effectiveness testing. This is the rationale behind the need to create new educational materials that are valid, practical, and effective.

Based on interviews with mathematics teachers at SMPN 02 Rambipuji, it is evident that eighth-grade students experience difficulties in learning mathematics, particularly in straight line equation. Teachers still employ conventional media in delivering instruction, such as the Snakes and Ladders game. This media is not digital-based and does not provide sufficient variety to support the learning process in the current digital era. Scratch is suitable for straight line equation material because it can provide strong visual feedback (colors, animations, movements) that help students recognize errors or the consequences of incorrect parameters directly, rather than just scores or right-wrong answers (Nadiyah & Faaizah, 2015; Vourletsis & Politis, 2022). Additionally, Scratch as an interactive project medium can increase motivation, engagement, and learning outcomes beyond just conceptual understanding (Maassen et al., 2025).

However, to date, there are still few Scratch-based media specifically designed for learning straight line equation with integrated educational aspects and game elements that are validated, practical, and proven effective in improving student learning outcomes. Therefore, this study aims to develop a Scratch-based educational game called Fly and Count that is

valid, practical, and effective in improving learning outcomes. This game adapts the Flappy Bird concept, similar to Flappy Chem by Lutfi et al. (2023), but features four characters that can be selected and used consistently throughout the game. Additionally, Fly and Count offer visual feedback in the form of emojis and scores for students' answers. With this design, this media is expected to support the improvement of mathematics learning outcomes in straight line equation.

Method

This study employed the Research and Development (R&D) design, focusing on the creation and testing of educational game-based learning media called Fly and Count, based on Scratch. This media is designed to support mathematics learning in the subject of straight line equation for eighth-grade junior high school students. The five stages of the ADDIE development model analysis, design, development, implementation, and evaluation are used because of the model's systematic structure, which arranges each stage in a sequential and interconnected manner from analysis to evaluation, ensuring that the development process proceeds in a planned and directed manner (Karim et al., 2025). Furthermore, it is adaptable, enabling researchers to modify or repeat certain steps at any moment, as well as make changes at any level if flaws are discovered, resulting in a successful and tested product (Detienne et al., 2023).

Analysis

The analysis stage was conducted to identify learning needs and problems that occurred in the field. The researcher conducted interviews with mathematics teachers in grade VIII at SMPN 02 Rambipuji. Additionally, an analysis of the curriculum and student characteristics was conducted to ensure that the learning objectives were relevant and appropriate to the learning context.

Design

Based on the analysis results, researchers began designing the Fly and Count media. This design includes gameplay, visual design, user navigation, and the compilation of questions in accordance with the curriculum. To clarify the interactive structure between game components, researchers compiled flowcharts and storyboards. In addition, the researchers also developed research instruments, consisting of expert validation questionnaires, teacher and student practicality questionnaires, and straight line equation questions.

Development

At this stage, the media was developed according to the design that had been prepared. Researchers utilized the Canva platform to create visual assets, including bird characters, backgrounds, question mark icons, and other game elements. The programming process was carried out using the Scratch platform, which employs a block-based coding approach. After development is complete, functionality testing is conducted to ensure that all scripts are functioning properly. If errors (bugs) are found, researchers debug the problematic code. Once the media is complete, it is validated by two validators, namely subject matter experts and media experts. Assessment uses a Likert scale questionnaire (1–5), and the results are analyzed using a percentage formula:

$$\% \text{ validity} = \left(\frac{Total\ score}{Maximum\ score}\right) \times 100\%$$

With score interpretation presented in Table 1.

Table 1. Interpretation of the validity score

Range (%)	Category
$80\% < v \leq 100\%$	Very valid
$60\% < v \leq 80\%$	Valid
$40\% < v \leq 60\%$	Less valid
$20\% \leq v \leq 40\%$	Invalid

Source: (Wahid & Jalil, 2023)

Implementation

The implementation stage was carried out after the media was revised based on input from validators. The implementation was divided into two stages: limited testing and main testing. Limited testing was conducted on five eighth-grade students to assess the flow of the game, the clarity of instructions, and the visual display. The results of this stage served as the basis for revisions prior to the class-scale trial. After improvements were made, the main trial was conducted with 30 eighth-grade students from SMPN 02 Rambipuji. This process included administering a pretest, conducting lessons using the Fly and Count media, administering a posttest, and distributing practicality questionnaires to teachers and students. Data from this stage was used to assess the practicality and effectiveness of the media, which showed that Fly and Count was easy to use, liked by teachers and students, and contributed positively to student learning outcomes. Practicality was analyzed from the results of teacher and student questionnaires, which were calculated using the formula:

$$\% \text{ practiicality} = \left(\frac{Total\ score}{Maximum\ score}\right) \times 100\%$$

The interpretation of practicality is presented in Table 2.

Table 2. Interpretation of practicality score

Mean (%)	Category
80% < $p \leq$ 100%	Very practical
60% < $p \leq$ 80%	Practical
40% < $p \leq$ 60%	less practical
20% $\leq p \leq$ 40%	Not practical

Source: (Wahid & Jalil, 2023)

Evaluation

The evaluation stage aims to measure the effectiveness of the media in improving student learning outcomes. The instruments used are pre-tests and post-tests, each consisting of 12 multiple-choice questions that cover indicators C1 to C4 in Bloom's Taxonomy. The choice of multiple-choice tests was based on the consideration that this format allows for quick, objective, and consistent assessment of learning outcomes, especially in calculating the improvement in learning outcomes through the N-Gain score. The assessment was not only based on the students' final answers, but also took into account the students' thinking process or steps in determining their answers. The analysis was carried out by calculating the N-Gain Score:

$$\text{N Gain} = \frac{Posttest\ Score - Pretest\ Score}{Ideal\ Score - Pretest\ score}\%$$

N-Gain interpretation is presented in Table 3.

Table 3. N-Gain score criteria

N-Gain Score	Interpretation
0,70 ≤ g ≤ 1,00	High Improvement
0,30 ≤ g ≤ 0,70	Medium Improvement
0,00 ≤ g ≤ 0,30	Low Improvement
g = 0,00	No Improvement
-1,00 ≤ g < 0,00	There is a decrease

Source: (Amalia, 2023)

The categories of interpretation of N-Gain effectiveness are presented in Table 4.

Table 4. Interpretation of the effectiveness of the N-Gain score

Presentation	Interpretation
< 40%	Not effective
40%-55%	Less effective
56%-75%	Moderately effective
>76%	Effective

Source: (Amalia, 2023)

All data were analyzed descriptively and quantitatively to determine the validity, practicality, and effectiveness of the media. Learning media are considered effective if their use can improve student learning outcomes, particularly as indicated by an increase in posttest scores compared to pretest scores (García-Cabrera et al., 2025; Singh et al., 2025). Thus, this media is expected to support interactive learning in line with the demands of the 21st century.

Results and Discussion

The product resulting from this research is an interactive learning medium based on the educational game Scratch called Fly and Count. This media was developed to support mathematics learning in straight line equation for eighth-grade junior high school students in the even semester. The development process followed the ADDIE stages systematically, starting with needs analysis and ending with evaluation of the medium's effectiveness.

Analysis

The results of interviews with mathematics teachers at SMPN 02 Rambipuji indicate that eighth-grade students struggle to learn straight line equation. Additionally, the learning media used are still conventional and do not incorporate interactive technology. However, UNESCO recommends digital-based learning (Weinhandl et al., 2025). This suggests that students require media that is enjoyable, easily accessible through digital devices, and capable of presenting material and questions in an interactive format.

Design

In response to this problem, researchers designed the Fly and Count media by adapting the concept of the Flappy Bird game. The design involved two main aspects, namely content design and display design. In terms of content design, researchers compiled material on straight line equation sourced from Tohir's 2022 eighth-grade mathematics textbook, along with 12 mathematics questions divided into three levels based on the difficulty levels of Bloom's Taxonomy. These indicators included: C1 (Remembering), which measured students' ability to recall facts, concepts, or formulas that had been learned; C2 (Understanding), which measured students' ability to explain, interpret, or give examples of the concepts learned; C3 (Applying) assesses students' ability to apply mathematical concepts or formulas in solving routine problems, and C4 (Analyzing) measures students' ability to analyze problems, find relationships between concepts, and choose the right solution strategy. In terms of display design, the media is designed with attractive visuals and simple navigation to support students' learning process.

The Media Fly and Count is equipped with a home page, main menu, character selection, level system, score, sound, navigation, and a map of the material to be displayed in the game. Players control a bird character to touch question mark (?) elements that will display math questions. To ensure that the game flow is clear and aligned with learning needs, researchers compiled a flowchart that shows user interactions in the game and a storyboard that illustrates the transitions between layers.

Additionally, the researchers developed research instruments to support the data collection process. These instruments included an expert validation sheet used to assess the validity of the content and appearance. Additionally, a practicality questionnaire was developed for teachers and students to assess the ease of use of the media, the comprehensibility of the instructions, and the visual appeal of the Fly and Count game. To determine the effectiveness of the media, the researchers compiled pretest and posttest questions in the form of multiple-choice questions based on Bloom's Taxonomy. The application of this design resulted in an initial prototype of the Fly and Count media that was ready to be tested at the validation and implementation stages. The design was carried out systematically and thoroughly so that the media developed was not only visually appealing but also meaningful.

Development

This stage involves creating digital game media using the Scratch platform, which is available for free at https://scratch.mit.edu. The game "Fly and Count" was developed based on a previously created design. Development included the creation of visual assets designed with block-based coding. This programming process yielded interactive and structured gameplay, aligning with the previously designed flowchart and storyboard. After the game was completed, functionality tests were conducted to ensure that all game elements worked as intended. At this stage, the researchers performed a series of debugging to fix errors and ensure that the game flow was not interrupted during play.

Validity Test

Next, the media is validated by subject matter experts and media experts. Subject matter experts assess the suitability of the material, questions, and language. In terms of material, the assessment indicators include the suitability of the material to the learning objectives, the accuracy of the material concepts, the consistency of the material presentation, and the completeness of relevant sample questions for each sub-topic. In terms of questions, the indicators include the suitability of the questions to the learning indicators, the clarity and precision of the questions, the clarity of the images or graphics used, the existence of one

correct answer, the consistency and logic of the answer choices, and the arrangement of answer choices in a logical or chronological order. Additionally, the questions are also evaluated in terms of their cognitive level. In terms of language, the indicators assessed include the suitability of the language with the rules of good and correct Indonesian, the absence of taboo language, and writing that complies with the Standard Indonesian Spelling System (EYD).

Meanwhile, media experts assess aspects of display quality, readability, navigation, and ease of use. In terms of display quality, assessment indicators include color composition, layout, animation used in the game, image quality, and audio quality. In terms of readability, indicators include the proportionality of font size in the text, the clarity of text instructions, and the suitability of text color to the background. In terms of navigation, indicators include the size, layout, and number of navigation icons that are proportional. Finally, in terms of ease of use, the indicators include the clarity of the instructions for use, the completeness of the menus presented, ease of access to the media, and the smoothness of the operation of the learning media. The assessment was conducted using a Likert scale to evaluate the suitability of the media from various aspects. The assessment results are presented in Table 5.

Table 5. Expert validation results

No	Validator	%	Category
1	Materi	87,14%	Very valid
2	Media	66,66%	Valid

The material expert validator gave a score of 87.14%, which is categorized as very valid. Meanwhile, the media expert gave a score of 66.66%, which falls into the valid category. This indicates that the media is suitable for use with some minor revisions, particularly in terms of display and navigation aspects.

Implementation

Based on the validation results, several suggestions or inputs were provided by the material and media validators. In terms of material, the validators suggested adding the form of equations of lines parallel to the x-axis and y-axis, removing several unnecessary examples of line equations, and making several other suggestions. Meanwhile, in terms of media, the validators noted that several buttons were not functioning properly, the layout of the material still left empty spaces, the instruction menu needed to be displayed at the beginning, the position of the icons still covered part of the content, and several other suggestions. All of this input has been followed up with revisions.

After revisions based on validator input, the media was implemented in two stages: limited testing and main testing. Limited testing was conducted on five eighth-grade students to evaluate the smoothness of gameplay and the clarity of instruction. Student feedback was used

as the basis for media improvements prior to field testing. In the limited trial, the Scratch game media was tested to ensure smooth gameplay, text readability, and the students' initial response to media navigation. From the interview results, all five students demonstrated an understanding of how to play the game effectively and provided positive responses, although two students required assistance with controlling the bird correctly. The suggestion given, which was to clarify the text size, was used as material for improvement before the field trial.

The main trial was conducted on 30 students in class VIII-D of SMPN 02 Rambipuji and one mathematics teacher. The activity was conducted in two meetings: the first day was dedicated to the pretest, and the second day was used for the media presentation, posttest, and student response questionnaires. The implementation process ran smoothly without any significant technical obstacles, and all students were able to play the game on their respective devices. The teacher also participated in observing the use of the media and provided an assessment of the media from the teacher's perspective through a questionnaire.

The implementation process ran smoothly, and no significant technical obstacles were encountered. All students were able to access and play the game individually on their mobile devices. This process served as the basis for measuring the practicality and effectiveness of the media on student learning outcomes.

Practicality Test

Practicality instruments are used to determine the ease of use of Fly and Count media from both the teacher and student perspectives (Karim et al., 2025). Based on the teacher's practicality questionnaire, three aspects are assessed: learning, materials, and benefits. In the learning aspect, the indicators assessed include the suitability of the material to the curriculum, the suitability of the material title to the content presented, and the ease of understanding the material contained in the media. The material aspect covers the ease of understanding the illustrations in the media, the relevance of the learning material to the material that students must learn, the clarity of the material description, the completeness of the material, the accuracy of the presentation, and the use of language appropriate to the age of the students. Meanwhile, in terms of benefits, the indicators assessed include the media's ability to attract students' attention, the ease of using the media in individual, group, and classroom learning, and the flexibility of the media that can be used at any time.

Meanwhile, the student practicality questionnaire consists of ten indicators. These indicators include: ease of use of the media, interesting learning media, easy-to-understand language, effectiveness of the media in classroom learning, enjoyment of learning using the media, no boredom while using the media, ability of the media to help understand material that

has not been mastered, increased motivation to learn mathematics after using the media, use of media as an alternative to independent learning, and ease of understanding material through the use of media. Both questionnaires were used to determine the extent to which Fly and Count media are easy to use, interesting, and support teaching and learning activities from the perspective of teachers and students. The results of the teacher and student response questionnaires are presented in Table 6.

Table 6. Results of the response questionnaire

No	Respondent	% Practicality
1	Teacher	88 %
2	Student	90,33 %
Average		89,16 %

Based on Table 6, the Scratch educational game media obtained a practicality percentage of 89.16%, which is classified as very practical. Mathematics teachers also provided input regarding the use of media, particularly in the game section. Teachers suggested adding a pause when the bird is in the air before the game starts, so that students have time to prepare, and the game does not proceed too quickly. This suggestion has been followed up by adding a pause duration at the beginning of the game to make the media more comfortable for students to use. The results of the development of the revised "Fly and Count" educational game based on suggestions and comments from students and mathematics teachers at SMPN 02 Rambipuji are presented in the following image.

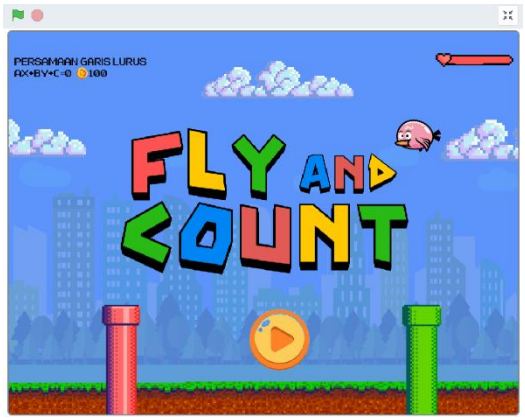

Figure 1. Home page

The Fly and Count game home page features a simple yet attractive interface design with visual elements reminiscent of Flappy Bird. In the center of the screen is the game title "FLY AND COUNT" displayed in colorful fonts that are eye-catching and attract students' attention. At the top right is a heart icon that indicates the player's lives, while at the top left is information about the learning material, namely the general form of a straight line equation $Ax + By + C = 0$, along with a coin icon that shows the score or points that the player will collect during the

game. At the bottom center is an orange circle button with a triangle “play” icon that serves as the button to start the game.

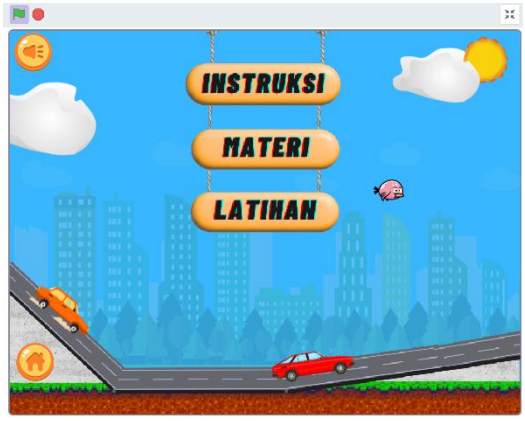

Figure 2. Main menu

This page features three main navigation buttons. These buttons direct players to pages according to their respective functions. The menu display is designed to be simple yet functional for easy operation by junior high school students. As shown in Figure 1, the background illustrates a city landscape with cars and clouds, creating an engaging and dynamic visual atmosphere that supports the theme of the learning media.

Figure 3. Instruction page

Figure 4. Material map

Translation:
Knowing the equation of a straight line
Straight line equation is a linear equation that describes the relationship between coordinate points on a straight line.

Translation:
Which of the following equations is a straight line equation?

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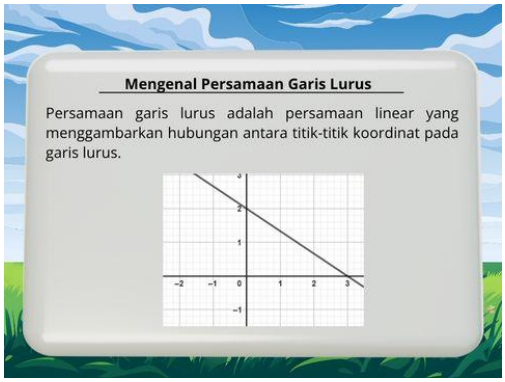

Figure 5. Material page

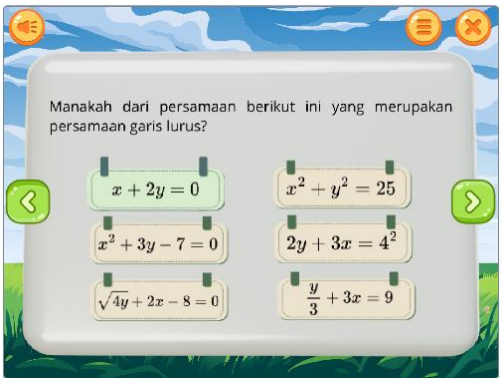

Figure 6. Short quiz

The instruction page functions as a guide for users on how to play the Fly and Count game. It explains that Fly and Count is a game where players control a bird to keep flying while solving straight line equation problems. Additionally, there are three main menus: Materials, Exercises, and Instructions. The materials menu directs users to a concept map that contains four subtopics: Understanding straight line equations, Gradient of straight line equation, Determining straight line equations, and Relationship Between Lines. The section "Understanding straight line equation" describes is a straight line equation as the relationship between coordinate points on a straight line.

This material page plays a crucial role as a means of independent learning in relation to the selected map topic. Each sub-topic, such as recognizing straight line equations, understanding gradients, determining equations, and analyzing the relationship between lines, is presented through concise explanations and visual illustrations. Students can reread or replay the material as needed. This flexible learning flow enables students to learn at their own pace, supporting independent learning.

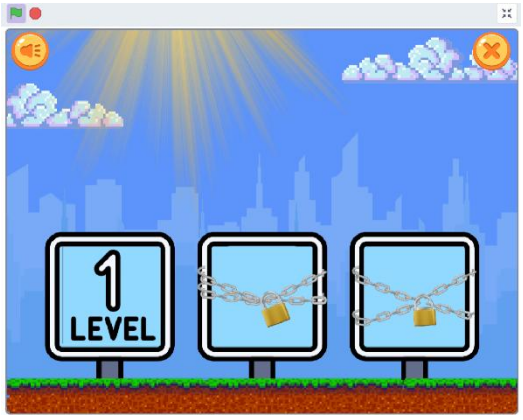

Figure 7. Level view

The level selection page in the Fly and Count game displays three level boards arranged horizontally. At the initial display, only Level 1 can be played, indicated by a board with a large number "1" on it, while Levels 2 and 3 are still locked with padlock and chain icons. This

design creates the impression of a gradual progression, requiring students to complete the problems in the previous level before proceeding to the next level. This level selection is designed to support gradual learning based on the difficulty level of the problems. With the level-locked system, this game encourages students to complete challenges in sequence, fostering continuous learning motivation as they must work hard to unlock the next level.

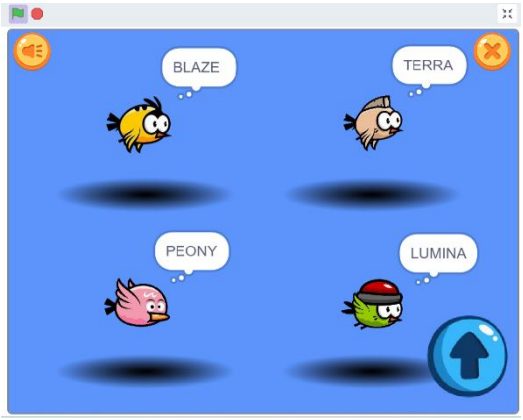

Figure 8. Character selection page

The character selection page in the Fly and Count game displays four bird characters with distinct designs and identities: Blaze, Terra, Peony, and Lumina. The naming of these characters not only provides visual variety but also adds a sense of personalization, allowing players to choose according to their preferences. This aligns with the principles of interactive learning design, which emphasize the importance of visual appeal and learner control. The character selection feature is also an innovation, as it provides several bird characters to choose from, rather than just one.

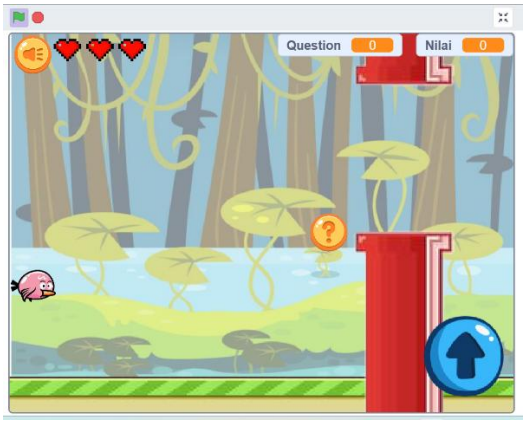

Figure 9. Game gameplay

This view displays the game's progression. The player controls a bird character that must fly to avoid pipe obstacles and hit the question mark element (?) to reveal a math problem. At the top of the screen are the life element (heart icon), the number of problems (Question) that have been accessed, and the score obtained. The blue button with an arrow icon at the bottom

right serves as a control to move the character upwards. The background design varies with each level to maintain the player's enthusiasm.

Figure 10. Question and feedback display

This screen appears when the player successfully hits the question mark symbol, and a math question is displayed. The question consists of multiple-choice answers that the player must select, with an interactive system that provides immediate feedback in the form of an expression icon indicating whether the answer is correct or incorrect. At the top, there is an indicator showing the number of questions that have been answered (Question) and the score obtained (Score). This display is designed to strengthen student engagement and facilitate active learning through instant feedback. Additionally, the gameplay flow is streamlined into a single, cohesive experience, incorporating updated questions from previous media.

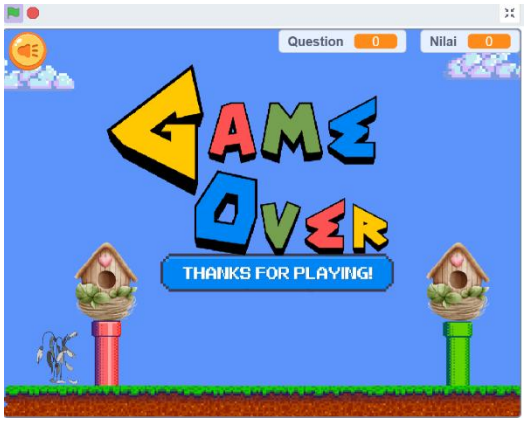

Figure 11. Game over page

The page shown in Figure 11 displays the "Game Over" screen that appears when the player runs out of lives or the bird falls to the ground. This screen displays the message "Thanks for playing!" as a thank-you and a closure for the user. This page also displays the player's score and the number of questions they have answered.

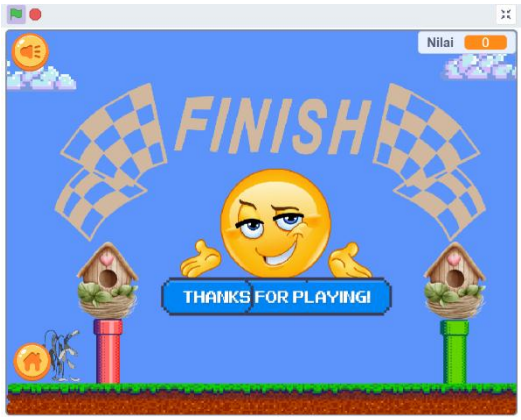

Figure 12. Finish page

This display is the end of the fly and count game, when the player has completed all the questions. This page also displays the value obtained by the player in answering the questions as feedback on their performance. The cheerful visual design, featuring a smiling emoji and finish flags, provides a sense of accomplishment and positive reinforcement for learners.

Evaluation

Effectiveness Test

An effectiveness analysis was conducted based on pretest and posttest results, which demonstrated an increase in student learning outcomes. The average N-Gain Score was 0.69 (moderate category), indicating that this media helped students better understand the material on straight line equation. Overall, the Fly and Count media was considered valid, practical, and effective. A summary of the final results is presented in Table 7.

Table 7. Summary of analysis results

Analysis	Result	Criteria
Material validation	87,14%	Very valid
Media validation	66,66%	Valid
Student and teacher responses	89,16%	Very practical
Learning outcomes	0,69	Moderately effective

The validation results indicate that the Scratch-based Fly and Count learning media possess a high level of validity, as assessed by both subject matter experts (87.14%) and media experts (66.66%). This high validity indicates that the content and presentation of the media align with the learning objectives, competency indicators, and sound instructional design principles. In the Fly and Count game, the presentation of straight line equation is arranged by conceptual stages, accompanied by exercises, thereby helping students understand the relationship between the material and its application. In addition, the appropriateness of the language, visual display, and clear navigation also reinforces the validity of the media (Mayer, 2021).

In terms of practicality, Fly and Count is considered very practical by teachers (88%) and students (90.33%). This high level of practicality shows that the media is easy to use, accessible, and can be integrated into the learning process without requiring complex technical training. This practicality is also influenced by the advantages of Scratch as a visual programming-based platform, which allows the creation of educational games with a simple and interactive interface. Teachers can easily modify media components according to class needs, while students can operate them without significant difficulty. The positive response from teachers and students is also supported by constructivist theory, which emphasizes the importance of interaction and active engagement in the learning process (Rey et al., 2019). In this context, Fly and Count provides a game-based learning experience that allows students to learn through exploration and direct feedback.

The effectiveness of the Fly and Count media is demonstrated by an increase in student learning outcomes with an N-Gain score of 0.69, which is classified as moderate. These results indicate that the media can have a significant impact on improving student learning outcomes. This effectiveness aligns with Mayer's multimedia learning theory, which posits that learning is more effective when information is presented through a structured combination of visual and verbal elements (Rey et al., 2019). This game applies the principle of segmenting, where material is presented in small pieces that allow students to process information gradually and independently. This helps reduce cognitive load and increases students' focus on the learning content (Chang & Yang, 2023; Liu, 2024).

These findings also support previous research results that show the effectiveness of Scratch-based media in improving student learning outcomes (Belessova et al., 2024; Ghani et al., 2022; Korkmaz, 2016; Panjaburee et al., 2024). Scratch-based learning media can improve learning outcomes through enjoyable interactive experiences. Compared to conventional media, Fly and Count has advantages in terms of interactivity, immediate feedback, and suitability for the characteristics of the digital generation.

However, this study also has limitations. The Fly and Count display is still simple. In addition, the time required for preparation and installation is relatively longer than conventional media. However, these limitations do not diminish the media's contribution to improving learning outcomes. Overall, Fly and Count can be an alternative interactive media that not only supports mathematics learning but also encourages teachers to integrate creative technology into teaching and learning activities. Schools are also expected to expand the application of digital media such as this as a step towards 21st-century learning transformation.

Conclusion

The development results indicate that the Fly and Count learning media possess high quality. The validity of the media is shown by a score of 87.14% from material experts (very valid) and 66.66% from media experts (valid). The practicality of the media is classified as very practical, with an average score of 89.16% from teachers and students. The effectiveness of the media is evident in the increase in learning outcomes, with an N-Gain of 0.69 (considered quite effective). This media can create a learning experience that is both fun and interactive, and pedagogically meaningful.

The use of game-based learning media like this can continue to be developed and tested in a broader context, encompassing various subject matters, learner backgrounds, and platforms. For future research, it is suggested that the development of media into an Android application be considered, making it more easily accessible not only through a browser but also as a standalone application that can be practically used on various devices.

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